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SYRIAN ARAB REPUBLIC

AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN

PART I - REPORT

TIPTON AND KALMBACH-SCHICK INTERNATIONAL
DENVER SALT LAKE CITY

MARCH, 1979

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SYNOPSIS

As formulated herein, the Akkar Plain Project is an irrigation development planned to exploit the land, surface water and groundwater resources of an underdeveloped area of Western Syria adjacent to the Mediterranean Sea. The plan will provide for the development of modern irrigation and drainage facilities so that the entire cultivated area of the Plain, consisting of approximately 17,000 hectares, will be adequately drained; approximately 6,380 hectares will be served by a surface irrigation system enabling a net irrigation area of 6,000 hectares to be double-cropped; and approximately 5,290 hectares will be served by wells enabling a net irrigation area of 4,970 hectares to be double-cropped. The plan also includes the infrastructure development required to maximize the benefits of the irrigation development.

The Project Area, consisting of approximately 23,000 hectares, is bounded by the Mediterranean Sea on the west, the Syrian Ansariye Mountains on the east, the international Syrian-Lebanon boundary at the Janoubi River on the south and an undefined limit on the north, arbitrarily set approximately four kilometers north of the Tartous-Homs highway. The principal city near the Project Area is the port city of Tartous. About 1,000 square kilometers of the Syrian Ansariye Mountains are drained through the area by the Janoubi and Abrache Rivers which flow across the Akkar Plain into the sea. The region is almost entirely agricultural today, as for centuries past. Dry land farming is presently carried out on the Plain on approximately 13,450 hectares and, in addition, approximately 3,550 hectares are irrigated from streams or wells. Grain crops are generally grown on the dry land area and vegetables, which are in great demand in Syria, are the chief crops in the irrigated area. Because of its Mediterranean climate; i.e., cool wet winters and mild dry summers, full agricultural development of the Plain cannot be achieved without storing the excess winter surface flows and making them available to the crops during the dry summer season.

The Syrian Arab Republic Government recognized the agricultural potential of the Akkar Plain and requested the United States Agency for International Development to assist them in undertaking a feasibility study of the area. In October 1977, AID called upon the joint venture of Tipton and Kalmbach-Schick International to conduct a study to determine the feasibility of developing the surface and groundwater resources of the Project Area. The studies which have been made include an inventory of the land resources; regional hydrology of the area including climate, runoff and occurrence of groundwater; existing agricultural restraints including drainage, fertility, pests and agronomic practices; and the present condition of the agricultural infrastructure including transportation, communications, education, health and marketing.

In brief, these studies, which are described in more detail in the accompanying report, have disclosed that:

1. With the application of sufficient water for irrigation and the necessary fertilizers to preserve their productivity, the better soils of the Akkar Plain are capable of producing high yields of vegetables and feed grains, and the poorer soils are capable of producing economic yields of forage and cereal grains for animal husbandry. Generally infertile, the soils have high cation exchange capacity and thus react well to fertilizers. The relatively shallow soils are predominately clay loams and clays and have high water-holding capacity. The following land areas were classified using basically the system of the U.S. Bureau of Reclamation:

Classification	Area (hectares)
1	971
2	9,574
3	6,981
5	2,450
Total - Arable	19,976
6	2,707
Total - Classified	22,683

The land capability, which is a combination of the physical factors expressed in the land classification considered together with the appropriate land use, was classified as follows:

Capability Class	Area (hectares)
I	971
II	9,574
III	6,981
IV	2,450
VI	1,447
VIII	1,260
Total - Classified	22,683

2. The climate is suitable for double-crop agriculture if irrigation water is available during the dry summer months.

3. The Project Area is transected by the Abrache, Arouse, Kalife and Abo Falat Rivers and the Janoubi River forms the southern boundary of the area. Short-term runoff records are available for the Abrache, Arouse, Kalife and Janoubi Rivers. The flows of the Abrache and Arouse Rivers, which vary from year to year and are virtually unused, could be used for irrigation of lands of the Akkar Plain. The average annual combined flow of the Abrache and Arouse Rivers during the period of 1965 to 1972 was 110 million cubic meters. The majority of runoff occurs during the six-month period of October through March.

4. Groundwater occurs at relatively shallow depth throughout the Project Area. The Plain is underlain by Cretaceous limestone at depth over most of the area and at the surface in the northwest, northeast, and perhaps in the valley of the Arouse. Unconformably overlying the Cretaceous is a series of Tertiary deposits of extrusives and various facies of marine limestones, limey sandstones, and marls. Essentially the entire Plain area east of the Arouse River has basalt at the surface, and no wells visited were reported to have penetrated into limestone. West of the Abrache River most of the area has marine calcareous sediments at the surface, but basalt layers have been found at depth. Between the Abrache and Arouse, alternating limestones and basalts predominate, with the surficial rocks being largely basalt in the north and limestone in the south.

   Productive wells have been found in nearly all types of formations, but no measured data are available to determine the horizons from which wells produce. Most of the drilled wells and some of the dug wells penetrate confined aquifers. It is believed that permeability is primarily in individual but discontinuous layers or beds with restricted and/or discontinuous vertical permeability. Permeability in the limestones probably is due largely to solution channels and fractures. In the basalts it is believed that permeability derives from cooling joints and from old weathered surfaces.

Pumping tests or recovery tests were carried out at 25 wells and the transmissivity of the aquifer was derived from the data. The transmissivity values so obtained varied from a few square meters per day to over 2,400 square meters per day. Specific capacity determinations were carried out at 69 wells. The specific capacity varied from less than 1 liter per second per meter to 53 liters per second per meter. Over two-thirds of the wells on which data are available have a specific capacity of less than 2 liters per second per meter. From inspection of specific capacity and discharge, it is apparent that many of the existing wells could produce more water than they presently produce.

Replenishment of the groundwater reservoir is derived from direct infiltration of rainfall, infiltration from stream beds and underflow originating in the mountains to the north. The infiltration of precipitation on the Project Area could be as much as 43 million cubic meters per year and the underflow originating in the mountains could be as much as 90 million cubic meters per year.

It is estimated that the present groundwater withdrawal of approximately 400 drilled wells and 150-200 dug wells irrigating 2,500 hectares on the Plain is on the order of 14 million cubic meters per year.

5. Inadequate surface drainage and flooding of lands by flow from the Janoubi River are major problems to the farming community of the Akkar Plains. Most of the area is annually subjected to temporary inundation which limits root development of winter crops and causes delay of planting of spring crops until too late to make the best use of natural precipitation. In addition, about 850 hectares of arable land are flooded two out of three years by waters from the Janoubi River and one year out of ten years at least 1,300 hectares are flooded.

6. The present infrastructure in the Project Area is inadequate to meet the needs of the people.

7. Under Phase I of the proposed plan of development, channel improvement and flood control works along the Janoubi River and surface drainage works benefiting the entire Project Area would be constructed. These features could be constructed quickly, would yield benefits in the first season following their construction, and the benefits are largely independent of other works. The proposed works are:

   a. Sixty-three kilometers of new drains.
   b. Eight kilometers of subsurface drains.
   c. One hundred twenty kilometers of improved existing drains.
   d. Ten kilometers of Janoubi River channel improvement.

Concurrent with the above construction, an Agricultural Service Center would be established to disseminate information and knowledge to the cultivators which will enable them to enhance their production under the existing agricultural structure.

8. Under Phase II, Stage 1, of the proposed plan of development, the surface irrigation system would be constructed. The proposed works are:

   a. A diversion dam on the Arouse River at Berge Arab which diverts the flow of the Arouse River into the Abrache Basin via the diversion structure and canal.

   b. The Rihaniyeh Dam on the Abrache River which could create a storage reservoir having a total capacity of 77 million cubic meters and an estimated annual yield of 68 million cubic meters.

   c. A canal system from Rihaniyeh Dam to the irrigated area consisting of concrete-lined canals and appurtenant structures. A portion of the service area lies above the main canals and water would be pumped from the main canal into a secondary canal to serve this area. Approximately 97 kilometers of main and secondary canals are included in the system.

The irrigation system would command a gross farm area of 6,380 hectares and net irrigated area of 6,000 hectares of land of Land Capability Classes I, II and III. The annual water requirement at the head of the canal system is 65.2 million cubic meters. The Classes I and II lands will be double-cropped and produce primarily vegetables and some wheat, dry beans and vetch. The Class III lands will also be double-cropped and produce wheat, sorghum, maize, dry beans and vetch.

The investigation of storage sites in the Project Area was not included in the terms of reference of this study, and earlier investigations have not revealed an economic site. The Rihaniyeh site shown in this study has not been investigated, and the surface water system portion of the Development Plan cannot be finalized until further investigations are undertaken to determine the most economical storage site on the Abrache River.

In addition to the surface irrigation system, the following infrastructure facilities are included in Phase II, Stage 1:

   a. Farm-to-Market Roads--To improve existing roads and to construct new roads required for transporting products to market and for access to educational and other facilities.

   b. Educational Facilities--To upgrade existing schools and to construct new facilities to improve the standard of the school system.

   c. Health Care Center--To provide improved health facilities and care and thus increase the productivity of farm management and labor.

d. Dairy--To utilize production from Land Capability Class IV and improve the general diet of the people in the Project Area.

e. Processing Plants--To process food, dairy products and livestock and thus obtain maximum return from products produced in the Project Area.

f. Grading and Packing Facilities--To provide uniform grading and better packing of project products and thus improve their price structure.

g. Small Grain Storage--To provide storage for the volume of small grains which will exceed the capacity of the on-farm storage.

9. Under Phase II, Stage 2, of the proposed plan of development, the groundwater irrigation system would be constructed. Although scheduled in Phase II, Stage 2, the further development of groundwater should be started in the early stages of the Development Plan. The works consist of re-equipping wells which are being operated below their potential; deepening existing wells; drilling new shallow wells by cable tool methods; and drilling new exploratory and production wells in the deep aquifers by rotary drilling methods.

The groundwater irrigation system as included in the Development Plan will command a gross farm area of 5,290 hectares and a net irrigated area of 4,970 hectares of land of Land Capability Classes I, II, and III. The annual gross pumping to serve this area is approximately 54.0 million cubic meters. The cropping pattern for this portion of the project is the same as the pattern of the surface water system.

The investigation of the groundwater resource was not included in the terms of reference of this study as it was understood that the resource had been identified in previous investigations. This was not the case and the total development of the groundwater resource cannot be planned until the resource is quantified. The groundwater development shown in the Development Plan utilizes only 40 percent of the preliminary estimate of the groundwater resource.

10. The capital cost of the physical works, facilities, equipment and services necessary for the implementation of the development plan is about SP 343.09 million as follows:

Feature	Estimated Capital Cost (SP x 10^6)
Phase I - Channel Improvement and Drainage System	11.38
Phase II, Stage 1 - Surface Irrigation System	276.90
Phase II, Stage 2 - Groundwater Irrigation System	22.62
Phases I and II - Infrastructure	32.19
Total Capital Costs	343.09

Approximately 47 percent of the capital costs of the project works and 15 percent of the capital costs of the infrastructure would be incurred in foreign currency.

11. The estimated annual costs of operation and maintenance of the project works is about SP 4.14 million as follows:

Feature	Estimated Cost (SP x 10^6)
Phase 1 - Channel Improvement and Drainage System	0.02
Phase II, Stage 1 - Surface Irrigation System	1.25
Phase II, Stage 2 - Groundwater Irrigation System	2.87
Total Annual Cost	4.14

12. Evaluation of project benefits was made for each segment of the project, for each phase of the project, and the total project, including the determination of the economic internal rates of return (EIRR) and the benefit-cost ratios. The summary of the analyses follows:

Project Phase	Segment	EIRR	Benefit-Cost Ratio @ 8% Discount Rate
I	Channel Improvement	12.0	1.5
I	Drainage System	32.8	4.6
I	Total Phase I	27.7	3.9
II	Stage 1, Surface Irrigation	8.1	1.0
II	Stage 2, Groundwater Irrigation	75.6	4.5
II	Stage 1 and Stage 2	12.4	1.5
I and II	Total Project	13.0	1.6

In summary, based on the assumptions used in the study, the Development Plan of the Akkar Plain is feasible from all technical and economic considerations. The surface irrigation system proposed as Phase II, Stage 1, of the plan is feasible if an economically feasible storage site is available. No feasible storage site has yet been investigated; but one site, based on surface inspection, appears to be feasible. It is recommended that:

1. An Akkar Plain Authority be set up within the Ministry of Agriculture to administer the project.
2. Geotechnical studies be initiated at an early date to determine the economic feasibility of providing storage of surface flows on the Abrache River.

3. The Janoubi River channel improvements and the surface drainage system of the Project Area be implemented at an early date.

4. Rehabilitation of existing wells be initiated at an early date to more efficiently use the existing facilities.

5. Additional wells be drilled to exploit the known shallow aquifer in areas which appear to have surplus groundwater supplies.

6. Exploration of the deep Cretaceous limestones be carried out to test the hypothesis of a large underflow of groundwater under the Akkar Plain resulting from drainage of the mountain area.

CHAPTER I

INTRODUCTION

The Akkar Plain is situated on the Mediterranean seacoast of Syria north of Lebanon; see Figures I-1 and I-2. While agriculture has been practiced for centuries on the Akkar Plain, the area has never reached its apparent potential. The Syrian Arab Republic Government (SARG), as part of an extensive program to develop the needed agricultural expansion throughout the country, commissioned a study of the area by the Public Administration Services, a United States consulting firm. It was concluded from the study that the potential exists for intense double-cropping irrigated agriculture on the Akkar Plain. A further study was therefore recommended to investigate the feasibility of the works required for such development. The United States Agency for International Development was requested by SARG to finance such a study, and AID in turn called upon the joint venture of Tipton and Kalmbach-Schick International to investigate the feasibility of agricultural development of the area by utilizing the existing water resources. The Ministry of Agriculture was designated by SARG as the cooperating agency and assigned the additional responsibilities of furnishing all counterpart and supporting staff, transportation, office space, and laboratory facilities.

Agriculture continues as the main economic enterprise on the Akkar Plain, but has never been able to reach its full productivity because of arid conditions occurring during the summer growing season. Approximately 75 percent of the land area is presently cultivated. General field crops are grown on the rainfed areas and intensive cultivation of vegetable crops is made where water is readily available from open pit wells, drilled shallow wells, and by use of small diversions and pumping from the project area rivers. The surrounding higher arid hills are used for olive groves and grazing.

The scope of work to evaluate the technical and economic feasibility of a project on the Akkar Plain included those investigations necessary to develop preliminary designs of irrigation and drainage systems, required subsurface water studies, and examination of all necessary project infrastructure improvements. Important items to be considered in the investigations included land classification to delineate the areas of irrigable lands; studies of surface and subsurface drainage requirements; potential cropping patterns; irrigation water requirements; increase in crop productivity under irrigation; plans to utilize available water resources, both surface and subsurface; and the determination of economic viability. It was considered in the project terms of reference that previous work had shown surface water storage to be feasible and that sufficient groundwater studies had been made so that no new data were required in the fields of surface water and groundwater. After field work was initiated in October 1977, questions arose concerning the adequacy of some of the previous work for use in the study, and the assumption that future investigations would be successful had to be made to enable this study to proceed. These assumptions must be examined further before implementation of a complete development program is undertaken.

Much of the basic data used in the study pertaining to precipitation, temperature, wind and surface runoff were obtained from government records. The data for the land resource, including land classification and land capability, were obtained from the field investigations carried out during the study as were the data on the occurrence of groundwater. The data of the storage site on the Abrache River at Yazdieh, the potential for storage on the Arouse River, and the diversion potential from the Arouse River to the Abrache River Basin were derived from a study published in French by Sofrelec in 1977 entitled "Regularisation de l'AFRINE de l'ABRACHE et de l'ARROUSE."

Numerous individuals of the staff of the Ministry of Agriculture and of the staff of AID in Damascus rendered valuable information and advice when requested. The assistance and counsel of the individuals were particularly helpful in bringing to this study, as a result of their wide range of knowledge of local conditions, a

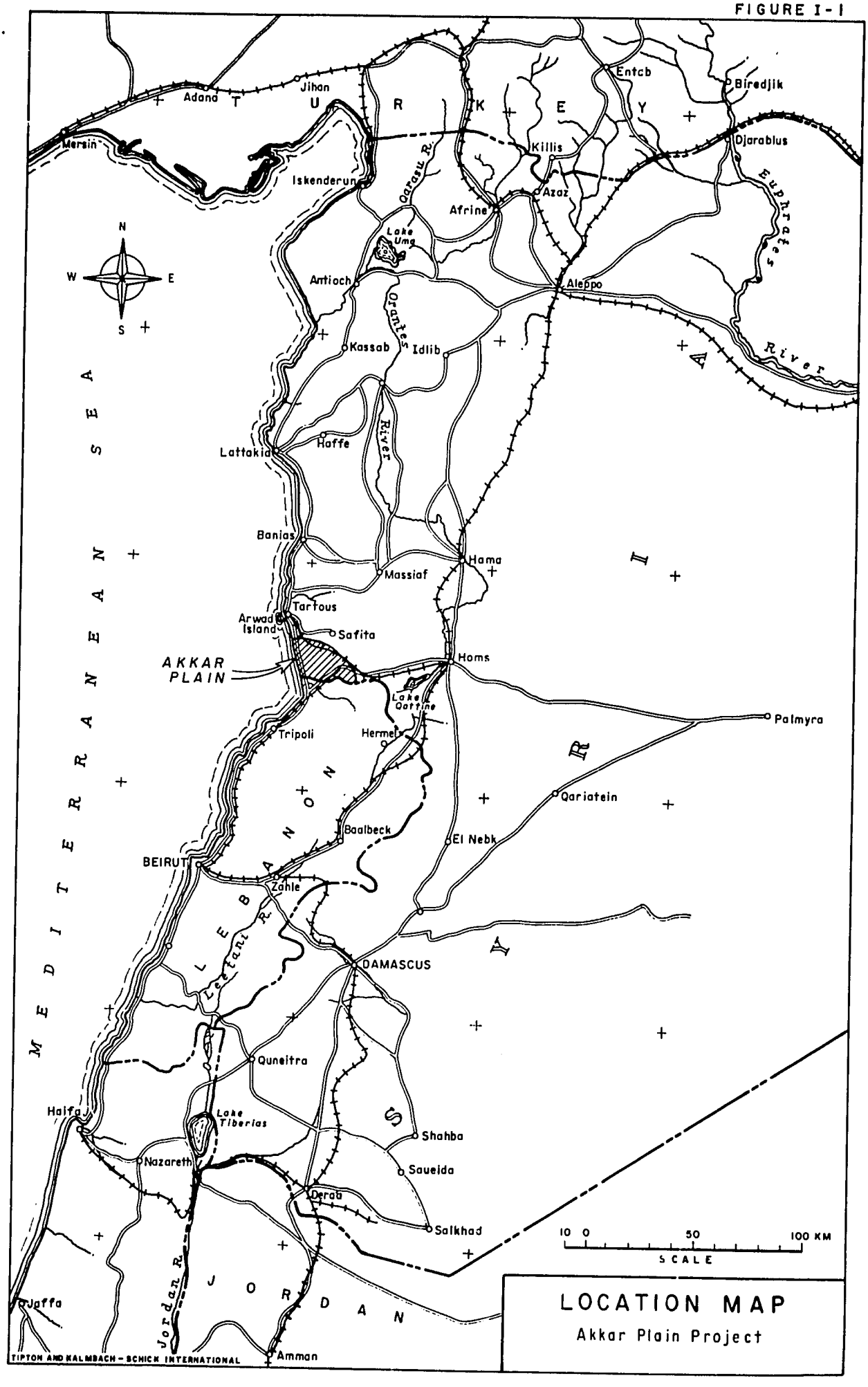
breadth of concepts and ideas concerning future planning that could not have been achieved without their help. Notwithstanding the valuable contribution of the individuals and agencies mentioned above, Tipton and Kalmbach-Schick International is solely responsible for the contents of this Report and the conclusions and recommendations contained herein.

The chapter which follows describes briefly the general setting of the Project Area for the reader who may not be familiar with the Akkar Plain of western Syria, its climate and land and water resources. The chapter on the present state of development describes the present status of agriculture in the Project Area and includes estimates of the area presently cultivated, cropping patterns, yields and value of production and the agricultural infrastructure. Then there follows a chapter describing the potential for development of agriculture of the Project Area. This is followed by a chapter describing the Development Plan. A separate chapter is devoted to the description of the project works. This is followed by a chapter which describes the economic evaluation of the project, which is followed by a chapter which explains one method of financing the project. This is followed by a concluding chapter which contains the conclusions and recommendations.

Many of the costs and benefits used in the Report were originally derived in U.S. Dollars (U.S. $) and in some instances are shown in the Report in U.S. $ instead of Syrian Pounds (SP). The rate of exchange used throughout the Report to convert U.S. $ to SP is U.S. $ 1 = SP 3.9.

An endeavor has been made to limit the text of the report to a discussion of the more important results of the study, with a minimum of detail as to how such results were derived. Greater detail on specific technical subjects and costs are contained in the appendices forming Part II of the Report.

FIGURE I-1



LOCATION MAP

Akkar Plain Project

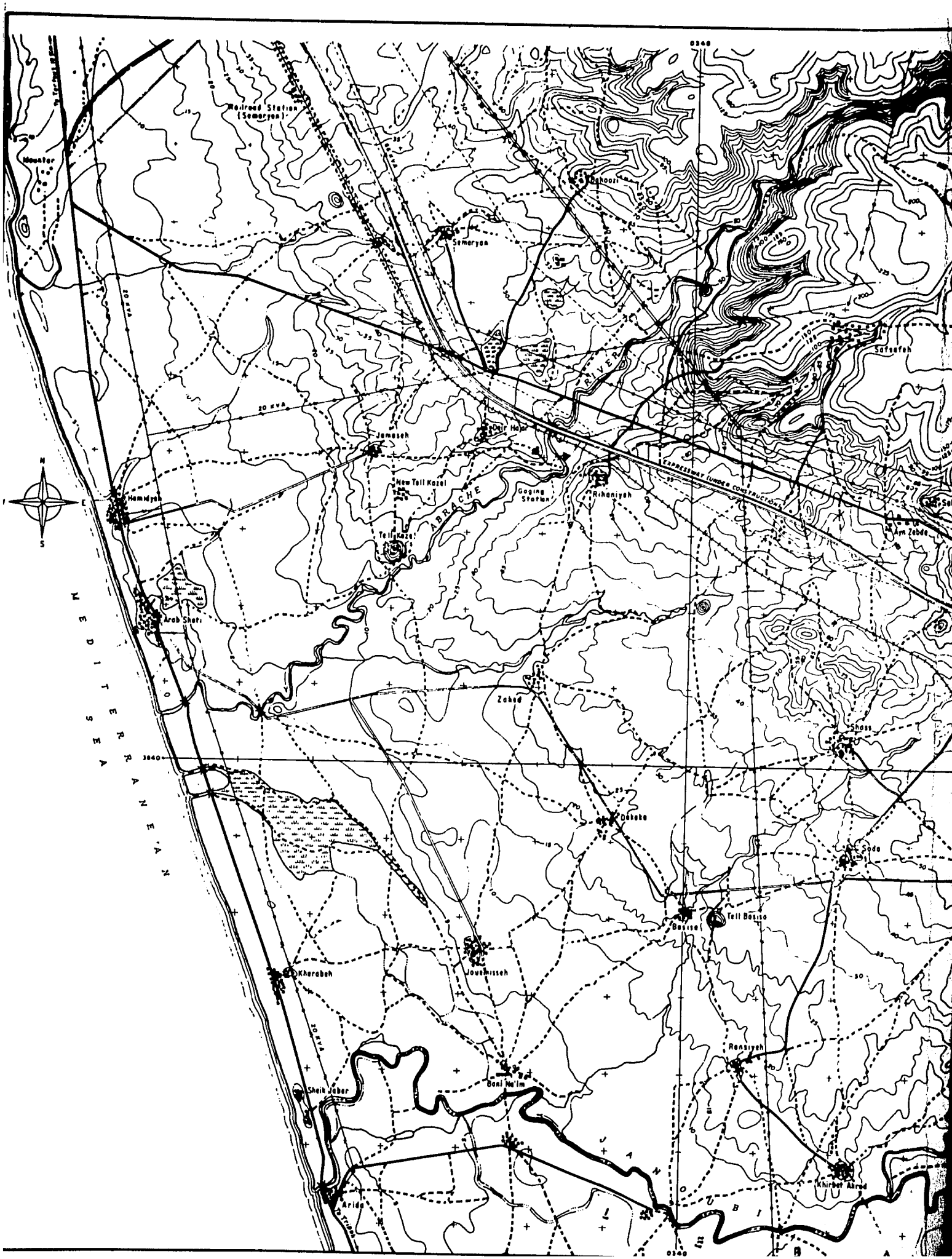
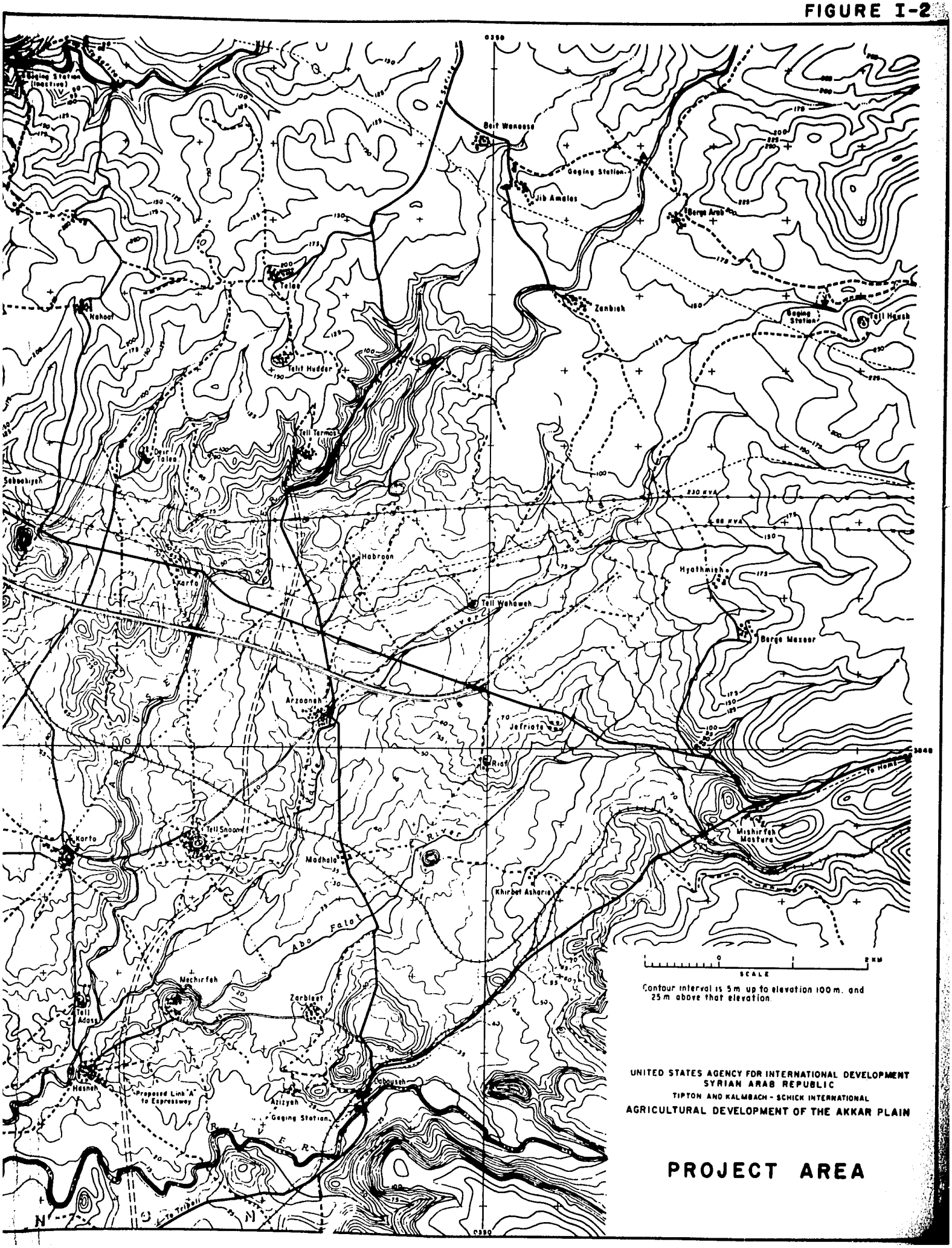

Railroad Station (Semeryan)
Semeryan
Jameseh
Dair Hajar
New Tell Kazel
Tell Kazel
Gaging Station
Rihaniyeh
Hamidyeh
Arab Shati
Zaked
Dakeke
Tell Basiso
Basiso
Khirbet Akrad
Ranisyeh
Bani Na'im
Sheik Jaber
Aridg
Khirbeh
Jouhnisseh
Shass
Soda
Safsafeh
Am Zebde
EXPRESSWAY (UNDER CONSTRUCTION)
ABRACHE
RIVER
MEDITERRANEAN
SEA
20 KVA
3040
0340

FIGURE I-2


Gaging Station (inactive)
Bait Wanasa
Gaging Station
Jib Amelas
Berge Arab
Telas
Nahoot
Zenbish
Gaging Station
Tell Haush
Tell Hudder
Tell Termos
Deir Telas
Sabbahiyeh
230 KVA
66 KVA
Habroon
Hyathmish
Karfa
Tell Wahawah
River
Berge Mazear
Arzaoneh
Jefriata
Riaf
To Homs
Karfa
Tell Snoonit
Madhala
River
Mishirfeh Mastura
Khirbet Asharia
Abo Falat
Mechirfeh
Zarbiset
Tell Adass
Hasneh
Proposed Link "A" to Espressway
Azizyah
Gaging Station
Labouseh
RIVER
To Tripoli
SCALE
Contour interval is 5 m up to elevation 100 m. and 25 m above that elevation.
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
PROJECT AREA

CHAPTER II

AKKAR PLAIN PROJECT AREA

DESCRIPTION OF THE PROJECT AREA

The project service area consists of about 23,000 hectares of land on the Akkar Plain located in western Syria. Boundaries of the area consist of the Mediterranean Sea on the west, the mountains on the east, the international boundary at the Janoubi River on the south, and an undefined limit on the north, arbitrarily set approximately four kilometers north of the Tartous-Homs highway.

About 1,000 square kilometers of the Syrian Ansariye Mountains are drained through the area by the Janoubi and Abrache Rivers which flow across the Plain into the sea. The Abo Falat and Kalife Rivers are tributaries to the Arouse River, which is in turn a tributary to the Janoubi River.

Topographically, the Plain consists of low rolling hills and flat valleys with several prominent tells, or ancient village mounds, rising as much as 25 meters above the surrounding terrain. The surface altitude ascends from sea level on the west side to 75 meters on the east, where it rises into the mountains. The foothills of the mountains break up the topography on the northeastern side of the Plain, limiting the land use principally to olive groves.

Communication lines, electric lines, oil pipelines, and two highways traverse the Project Area. Syria's main port cities of Tartous and Lattakia serve the Homs-Damascus area via the facilities crossing the Plain. The coastal highway on the west side of the project connects the port cities of Syria with Lebanon on the south and Turkey on the north.

ADMINISTRATIVE DIVISIONS

Syria is divided into major administrative areas, called Mohafazat, equivalent to states or provinces in many other countries. Each Mohafaza has an administrative chief or governor who is responsible for the local governmental affairs. Most of the Akkar Plain area is in the Tartous Mohafaza; the eastern end of the Plain is in the Homs Mohafaza.

A Mohafaza is divided into Manatik or districts, each of which is called Mantika. Each Mantika is subdivided into several Nawahi; singular is Nahia. The Project Area is in the Tartous Mantika and includes parts of the Nawahi of Hamidyeh and Safsafeh. Manatik and Nawahi have minor roles in the actual government control as they form mainly an administrative breakdown of the physical area for the Mohafaza leaders.

Government-Sponsored Organizations

SARG has been emphasizing agricultural cooperatives in the past few years as a way to increase productivity and economic stability. Cooperatives assist the farmer members in obtaining credit, organizing farming operations, obtaining farm inputs, providing market information on crops and livestock, and in developing land resources. Prices of production inputs are reduced in some cases when members purchase through the cooperatives. The number of cooperative organizations in Syria increased from 471 in 1962 to 3,385 in 1976. Tartous Mohafaza had 283 cooperatives in 1976 with a membership of 25,772. Generally, a village has its own cooperative, but in some cases two or three small villages are included in one cooperative.

DEMOGRAPHY

The population of Syria was 6,305,000 people in 1970, according to the census report, with a density of 34 persons per square kilometer. Tartous Mohafaza had 302,000 people in 1970 with a density of 160 persons per square kilometer. The population of the Project Area was estimated at 18,000 persons in 1978, or a density of 81 persons per square kilometer.

The Akkar Plain Project economic area includes thirty-two villages located in Hamidyeh and Safsafeh Nawahi. Economic activity of these villages is principally related to the production of agricultural crops. The population of the Tartous Nahia is dependent on the Plain for food products, but its principal economic activity is connected with enterprises outside the Plain.

The average number of persons per household was 9.8 persons, based on interviews with farmers in 1978. A farm family household includes everyone living in the same house with the farm operator, which often includes grandparents and other relatives.

COMMUNICATIONS

Present communications on the Plain include radio, television, and telephone. Radio programs are received in all villages on personal transistor receiving units from stations within Syria and from Lebanon and Cyprus. Television reception is restricted to those villages with electrical power, including Hamidyeh, Arab Shati, and Sheik Jaber. Television programs are received from the same areas as the radio programs.

Telephone service has been installed in the Project Area at Hamidyeh, Safsafeh, Arab Shati and Karto. Tartous has the nearest telegraph service for public use. No other telecommunication service is available to villages on the Plain.

GEOLOGY

The area of interest is dominated by the Ansariye Mountains which trend in a north-south direction, paralleling the Mediterranean coastline. The mountains are formed by a huge anticline with a major fault on the eastern flank. On the western side of the anticline, the strata dip gently toward the Mediterranean and are cut by a number of lesser faults. The core of the mountains is Jurassic limestone, which is quite karstic, covered with a section of upper Cretaceous limestone (Turonian and Cenomanian) which is also karstic. On the western flank of the anticline, the Akkar Plain, Tertiary limestone and basalts are deposited against an unconformity within the Cretaceous, probably as marine terrace deposits. Various

facies of the Pliocene limestone and several types of extrusives, along with some recent alluvial deposits, constitute the surface rocks of the Project Area.

The Tertiary sedimentary deposits range in facies from limey sandstones, clastic limestones, and marls, to quite pure, white to blue limestones. Some of the limey sandstones along the Mediterranean Sea are mapped as Quaternary in age.

The crystalline rocks range from very hard, black, columnar-jointed basic rock, which may be a dike at Karto, to soft, reddish material at other locations, which appears rhyolitic but is probably paleo-weathered basalt. No petrographic examinations were made; the rocks are all mapped as basalts.

Some faulting is present on the Plain and some apparent facies changes may actually represent faults. Knowledge of the subsurface was gained only through translation of the farmers' recollection of the lithology of their wells. In many instances no reasonable correlation from well to well could be made; whether this is because of faulty information, rapid facies changes, or faulting is not known.

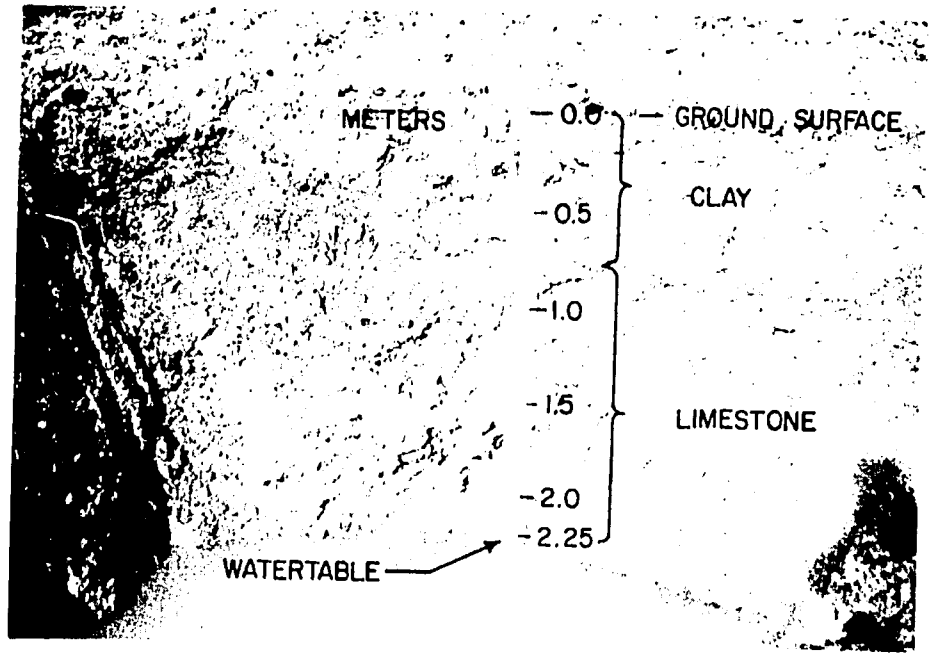
The slopes of the mountains are relatively steep, dropping 100 meters in less than one kilometer in some places. In the central portion of the Plain, north of Shass, the topography is typified by low basalt hills; but south and west of the hills, the Akkar Plain slopes gently and regularly toward the sea.

CLIMATE

The climate of the Akkar Plain area is well suited to agriculture, but the arid summers require supplemental irrigation to maximize productivity. Temperatures are moderately high in the summer and mild in the winter. Precipitation is very heavy in the winter months and is essentially nil for three to four months in the summer. High winds are typical of the area and can be a problem with some field and tree fruit crops.

The only long-term weather data available which reflect the climate of the Plain were obtained from the Tartous weather station. The average annual precipitation during 23 years of record is 860 millimeters, of which 772 millimeters falls in the six-month period of October through March. The average monthly humidity ranges

Sandy limestone rock, boulders and outcrops
are a feature of the western portion of the Akkar Plain



Soil Profile of Land Class 5sd
Class 5 are lands with a severe drainage deficiency. The soils are massive clays which swell when wet and shrink when dry, forming deep wide cracks.

from 65 to 73 percent. Weather stations have recently been installed within the Project Area at Karto and Hamidyeh and just outside the area at Safsafeh. The following tabulation shows the annual (and six-month winter) rainfall in millimeters at those stations and at Tartous.

	Tartous	Hamidyeh	Karto	Safsafeh
1973	536 (496)	534 (446)		
1974	753 (708)	799 (757)		
1975	748 (729)	826 (769)	817 (719)	916 (660)
1976	1129 (987)	990 (802)	839 (662)	1108 (917)
1977	1155 (754)	913 (747)	708 (614)	846 (702)

Rainfall during the April-September summer months is usually less than 150 millimeters, most of which occurs in individual storms of limited areal extent. In June 1977, Tartous had 269 millimeters, most of which occurred in one storm. The other three stations within a 30 kilometer radius recorded only about 30 millimeters.

The mean annual temperature at Tartous is 20°C, ranging from 12.3° in January to 26.7° in August. Minima and maxima are shown below for a fifteen-year record.

Minimum of record	January	-1° C
Mean monthly minimum	January	3.4° C
Mean daily minimum	February	3.1° C
Maximum of record	June	41.0° C
Mean monthly maximum	May	35.1° C
Mean daily maximum	August	30.2° C

The wind is an agricultural problem on the Plain. Only maximum monthly wind data are available at Tartous. Maximum monthly measurements range from a 10-year average of about 9 meters per second (33 kilometers per hour) in July to 16.3 meters per second (58 kilometers per hour) in December. In October and November, when citrus is ripening, maximum wind speeds are about 40 kilometers per hour. Wind direction is from both the northeast and west from November through February and the southwest for the remainder of the year.

SOIL CHARACTERISTICS

A general World Soil Map places the Akkar Plain in the two dominant soil orders of aridisols and vertisols. Aridisols are soils without horizons of clay accumulation, that are low in organic matter, and generally are dry for six or more months of the year. Aridisols are especially responsive to irrigation and make up much of the irrigated lands throughout the world. Vertisols (previously called grumosols) are characterized by a high content of swelling-type clay. The clay in vertisols swells when moist and shrinks when dry. Deep, wide cracks develop in these soils during the dry season from May to November on the Akkar Plain. Inadequate drainage and poor physical soil conditions are constraints limiting crop production on the vertisols.

Bottomlands bordering the major streams are formed by alluvial deposits and are deep, medium-textured soils of excellent structure and fertility. Alluvial bottomlands are capable of being very productive when they are well-drained and not subject to flooding.

Large, undulating land areas have lacustrine deposits over sandy limestone and basalt bedrock. These deposits form productive soils except where they are shallow. Rolling hills and steeper areas have residual soils formed principally from decomposed basalt and to some extent from decomposed limestone. These residual soils are well-drained and are generally used for olive groves.

Basalt, limestone, and sandy limestone are the predominant bedrock materials, although much of the arable lands are of transported soils of alluvial or lacustrine origin. Limestone and sandy limestone are the predominant underlying rocks in the western portion of the Plain. The eastern portion of the Plain is largely underlain by basalt.

Detailed Soils Investigation

Soil examinations were made by boring to depths of 160 centimeters or more, to barriers preventing auger penetration. Occasionally, the presence of rock or dense clay layers limited borings to shallower depths; but road and railroad cuts, surface wells, and drainage cuts frequently made observation of deep soil conditions possible. One to five soil examinations were made in each square kilometer in the

Project Area. At each boring, observations were made of the land use, slope, relief, and subsurface drainage. Soils were examined in the field or laboratory for texture, depth to gravel or to fractured rock, presence of bedrock, reaction (pH), salinity, soil structure, compaction, and fertility of the soil material.

During the progress of the survey, samples of representative soil profiles were collected throughout the Project Area. Samples were sent for laboratory analyses to confirm the field determinations. Numerous mechanical analyses were made at Lattakia Soil Laboratory to check the field estimate of soil texture. Soil pH was determined for the same samples. The analyses indicate the Akkar Plain soils to be predominantly fine textured with the clay percentage exceptionally high. The pH values show the soils to be near neutral or slightly basic.

Granular structure of the clay, after saturated soils have dried to field moisture capacity and less, is an unusual characteristic. This granulation of the dry clay permits drainage to be more effective than normally would be expected in heavy soils. An exception to the above characteristic is found in the heavy bottom-land soils on the west side of the Plain. These soils consist of clays with compact massive structure which expand when wet and shrink when dry to form wide cracks in the surface.

Soil Laboratory Analyses

Tests were made for organic matter, cation exchange capacity, electrical conductivity, and pH (soil reaction) in the Damascus Soil Laboratory. The organic matter is low compared with a fertile irrigated soil in the western United States, but compares favorably with soils from the Southern Great Plains of the United States. The cation exchange capacity (sum total of exchangeable cations that a soil can adsorb) is very high in comparison with normal United States soils. This is the result of the high clay content of Akkar Plain soils and indicates that the soils have the ability to retain nutrients for plant growth.

No evidence of saline or alkali soils was discernible on the Akkar Plain. A thin white coating was occasionally observed on the surface, but apparently this was residual silt left on soil particles after seepage of surface moisture or residue from

large fertilizer applications. The tests from the soil laboratories in both Damascus and the United States indicated little or no salinity in the samples submitted. The electrical conductivity (EC) of a saturated extract of less than 4 millimhos per centimeter represents a concentration of soluble salts that is not considered harmful to most plants. Conductivity measurements of soil samples made in both Damascus and the United States were all less than one millimho per centimeter.

Laboratory measurements of pH and alkalinity for nearly all the samples tested indicate alkalinity (sodic soils) is not present in amounts harmful to plants. Measurement of alkalinity by a laboratory in the United States was made by determining the amount of calcium carbonate (lime) in the earth samples. The relative amount of calcium carbonate is expressed as an alkalinity index varying from 0-20. Soils with an alkalinity index of 4 or less are considered satisfactory for plant growth, but soils with an alkalinity index of 6 require the addition of 18 kilograms per hectare of elemental sulfur. Soils with greater indices require additional treatment. Results of the twelve samples submitted to the laboratory are shown in Table II-1 and indicate that ten of the samples have an alkalinity index of 2 or less, which is considered non-sodic. The remaining two samples have an alkalinity index of 4 and 6. The pH values of most of the soil samples submitted to the laboratories are less than 7.5. Soils having pH values of less than 7.5 contain little alkaline-earth carbonates.

Tests for elements essential for plant growth were made on samples collected from representative soil areas and the results are shown in Table II-1. The amounts of the various elements in the samples were determined and the total amounts of the elements in the top 30 centimeters of soil per hectare were projected and are shown in Table II-1. The soils are very deficient in nitrogen, phosphorus, and potassium, the major plant nutrients. Likewise, deficiencies in the minor plant nutrients are indicated, particularly of sulfate sulfur and zinc. Large amounts of fertilizer are recommended by the laboratory to meet the plant requirements necessary to attain maximum crop yields. Up to 258 kilograms per hectare of nitrogen, 191 kilograms per hectare of phosphate, and 247 kilograms per hectare of potash are recommended.

The quantities of nutrients recommended are those necessary to be applied if soil deficiencies are to be completely overcome. However, in practice it is the aim

Table II-1
Analyses of Akkar Plain Soils

Item	Unit	Sample Number											
		F-7-2	I-7-2	G-9-4	J-11-2	J-13-1	J-15-1	L-12-1	N-10-1	M-14-1	P-15-1	Q-11-1	R-14-1
Reaction	pH	7.5	7.8	7.9	7.4	7.4	8.1	7.3	7.1	6.7	7.7	6.9	7.7
Soluble Salts	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alkalinity	index	1	6	2	2	1	4	2	2	0	2	0	1
Organic Mat.	%	1.4	3.2	1.8	1.2	0.9	1.5	0.6	0.6	0.8	0.7	0.5	0.5
Organic N	kg/ha	55.	70.7	59.5	52.7	46	57.3	29.2	29.2	38.2	33.6	24.7	24.7
Nitrate N	kg/ha	nil	11.2	11.2	11.2	33.7	33.7	nil	nil	nil	nil	nil	nil
Available P	kg/ha	33.6	26.9	48.2	40.3	67.2	82.9	38.1	33.6	35.8	38.1	35.8	29.2
Available K	kg/ha	190.4	101.	112.3	101.	89.8	123.5	56.1	78.6	67.4	78.6	67.4	89.8
Sulfate Sulfur	kg/ha	39.3	46.	39.3	46.	39.3	112.3	52.8	46.	52.8	32.6	39.3	39.3
Zinc	kg/ha	.16	.54	.53	.26	.22	.34	.17	.12	.13	.18	.17	.13
Manganese	kg/ha	6.2	2.7	3.1	9.2	4.1	4.1	4.0	7.9	9.3	5.0	6.2	7.6
Copper	kg/ha	2.1	2.6	3.1	3.4	3.1	3.1	3.4	3.1	3.5	3.7	3.5	4.6
Boron	kg/ha	.67	.11	.56	.56	.90	.67	.34	.79	.45	1.12	.45	.67
Iron	kg/ha	16.2	2.1	6.4	12.2	13.9	7.6	13.5	13.0	13.9	10.5	14.4	17.7
Magnesium	kg/ha	707	662	448	640	763	2077	2436	2436	2762	2156	2717	2324
Calcium	kg/ha	5726	19760	12799	8196	6624	12125	5726	6175	6400	7298	5614	5052
Sodium	kg/ha	157	121	98.8	151.6	198.7	206.6	217.8	229.0	223.4	184.	196.5	174.
Chlorine	kg/ha	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4

to fertilize only that portion of the soil area in which the roots are concentrated. Band placement of fertilizer for row crops, in a ring around trees, and small applications at intervals throughout the season for close growing crops can reduce fertilizer amounts by as much as three-fourths of the laboratory recommendations and still achieve optimum yields. Severe foliage burning may occur if the full amount of the recommended fertilizer is applied in limited areas or without adequate mixing in the surface soil. In practice the average farmer usually uses less fertilizer than the laboratory recommends. However, some over-fertilization with nitrogen and phosphate was observed on the Akkar Plain during the 1978 growing season.

The use of complete fertilizers containing the major plant nutrients appears to be widespread, and their benefits are well known in the Akkar Plain. However, micronutrient deficiencies are not as well known, even though their deficiency can be equally restricting to crop yields. As little as 0.6 kilograms per hectare per year of boron can maintain the boron level for maximum crop yields in boron-deficient soils. Similarly, zinc, manganese, and copper, the other minor elements indicated as deficient in the soil tests can be maintained at an optimum level with small amounts of the element being added each crop year. Six to 11 kilograms per hectare of zinc and from 1.1 to 1.7 kilograms per hectare of boron are recommended for all soils. Sulfate sulfur could be supplied most economically by using a sulfate fertilizer such as ammonium sulfate. All fertilizer recommendations should be tested at research stations prior to full distribution to farmers on the Plain, as laboratory recommendations are frequently affected by outside factors, including cultural methods used by the individual farmers and varieties selected.

LAND CLASSIFICATION

Characteristics of land resources include soils, topography, and drainage as they are related to the productivity of the complete landscape. The characteristics of the soil alone are not fully indicative of the economic productivity of the area. For example, land having topographic deficiencies, even though the soil appears to be highly productive, must be classified to show the crop constraint. Also, land has a drainage requirement regardless of micro-area productivity if surface or subsurface water is a limiting constraint to crop production.

Modified U.S. Bureau of Reclamation specifications of soil, relief, and drainage characteristics determining each class of land were used in the study and are defined in Table II-2. The location and extent of each class of land is shown on the Land Classification Map, Figure II-1, and the area in each class and subclass is summarized in Table II-3. Five land classes are shown on the map. Land Class 1 soils have good depth, texture, and structure, no drainage or topographic deficiencies, and no alkali or salinity problems. Class 2 may have slight to moderate deficiencies in soil, topographic, or drainage conditions. Class 3 lands have moderate to severe limitations, and lands with massive clay soils and flat topography that restrict effective drainage are in Class 5. Class 6 lands are not suitable for irrigation development. Subclasses are used to indicate the reason land is placed in a class lower than Class 1. This is shown by adding letters "s" for soil, "t" for topography, "r" for rock, and "d" for drainage deficiencies to the right of the land class numbers 2, 3, 5, and 6. The subclasses used are st, sd, and std.

Typical soil profiles for Land Classes 1, 2, 3, and 5 are shown in Figure II-2. Texture of soil horizons, presence of rock, depth of bedrock if encountered, textural analyses if made of a particular profile, and present land use are shown on four typical soil profiles for each major class of land.

Table II-2
Land Classification Criteria for Irrigable Soils

Characteristic	Class 1	Class 2	Class 3	Class 5
Texture	Fine sandy loam to friable clay loam.	Sandy loam to clay loam.	Loamy sand to friable clay.	Clay loam to massive clay.
Depth				
To alluvial fractured rock	> 75 cm	> 45 cm	> 30 cm	> 30 cm
To permeable bedrock	> 2.0 m	> 1.5 m	> 1.0 m	> 1.0 m
Exchangeable sodium	< 10 percent	< 20 percent	< 30 percent	< 30 percent
Reaction	pH < 8.0 0-1 m	pH < 8.0 0-70 cm	pH < 8.0 0-35 cm	pH < 8.0 0-35cm
Maximum EC of saturation extract	4 millimhos/cm	8 millimhos/cm	12 millimhos/cm	12 millimhos/cm
Slope	0-3 percent	0-5 percent	0-10 percent	0-10 percent
Relief	Gently undulating	Moderately undulating	Rolling	Gently undulating to rolling.
Surface and subsurface drainage	Little or no surface drainage requirements anticipated. No subsurface drainage required.	Some surface drainage anticipated. No subsurface drainage anticipated.	Major surface drainage is anticipated. Limited subsurface drainage anticipated.	Major surface drainage will be required. Subsurface drainage not feasible.

Class 6--Lands not meeting standards of irrigable classes.

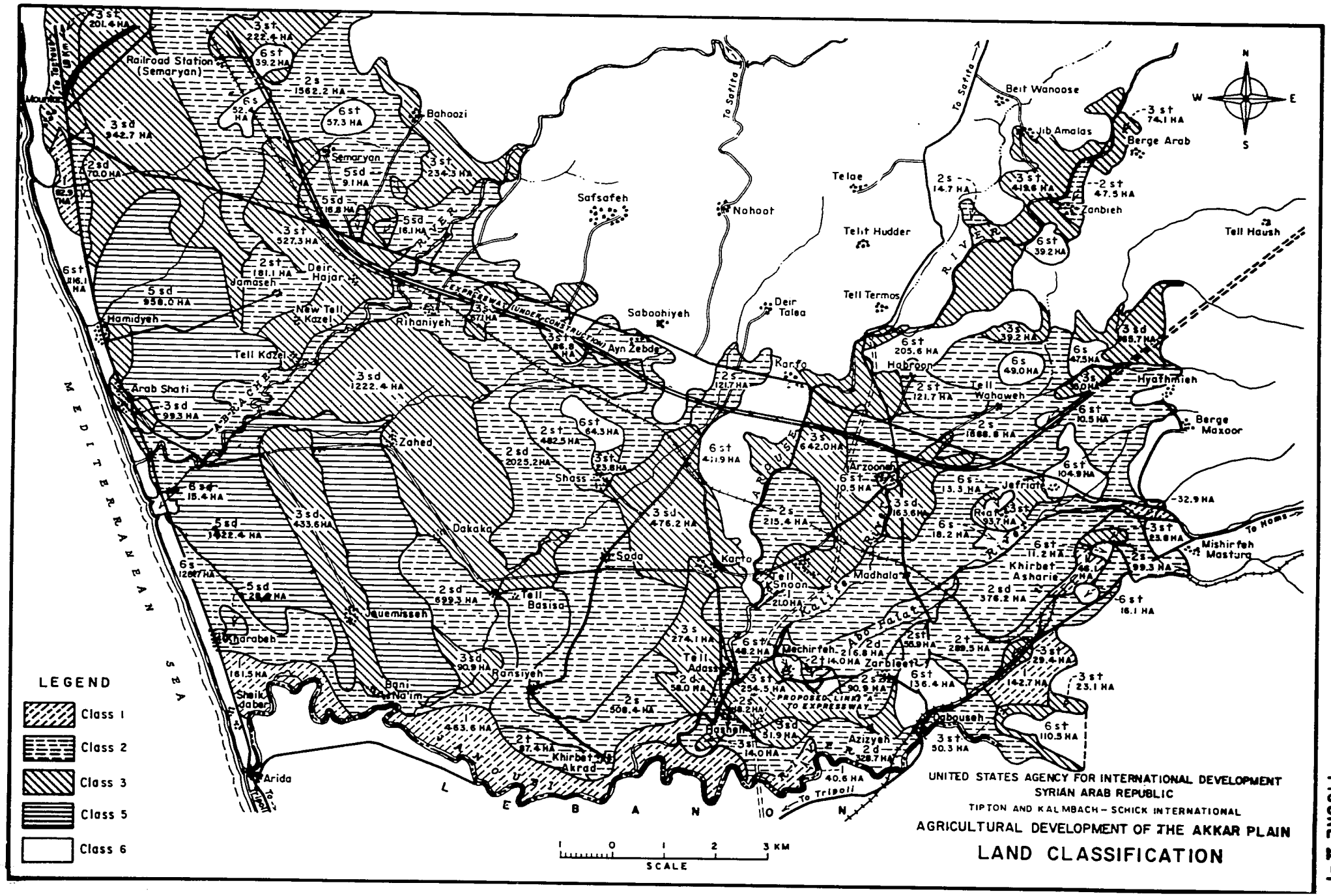
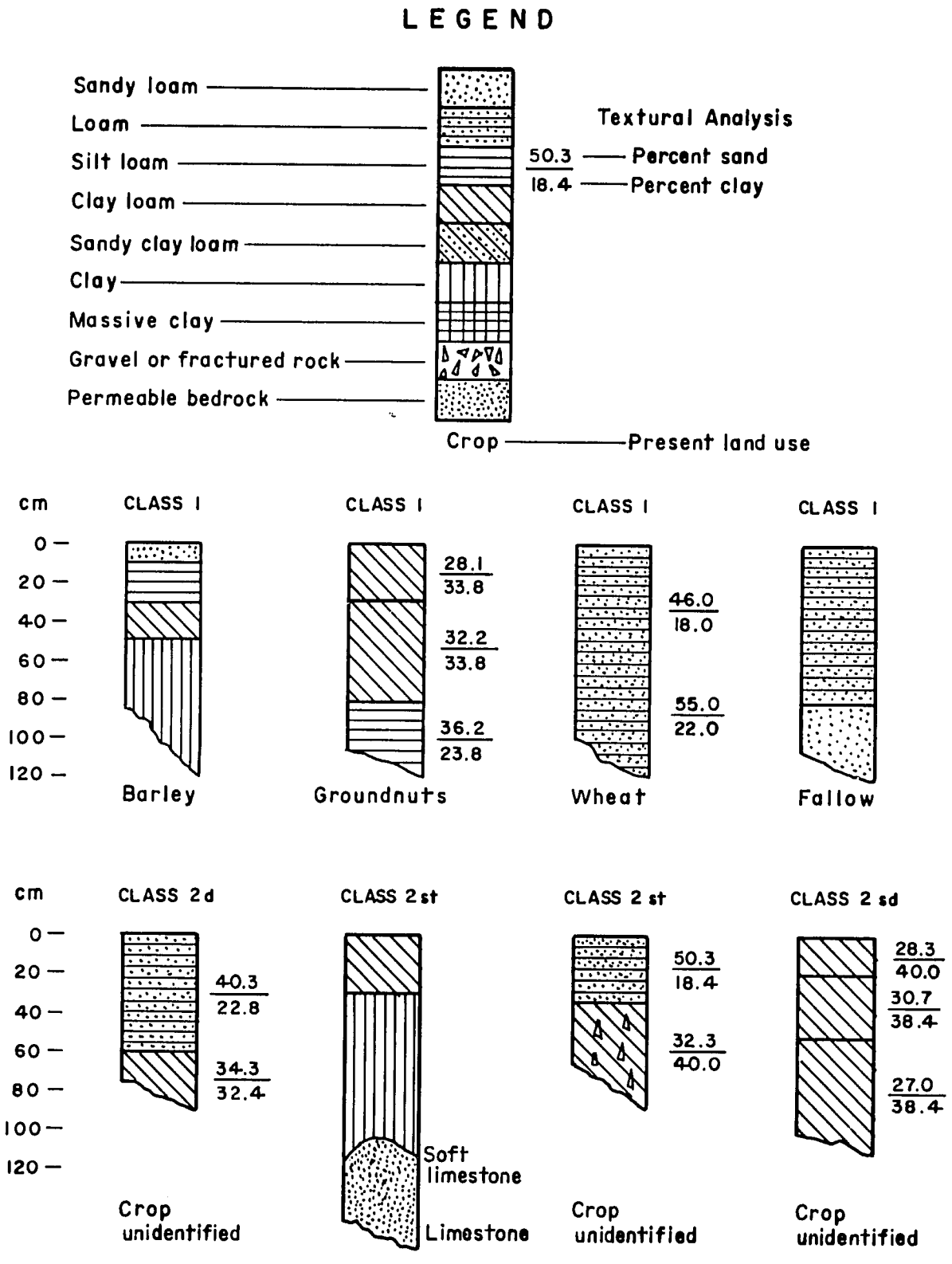

LEGEND
Class 1
Class 2
Class 3
Class 5
Class 6
SCALE
1 0 1 2 3 KM
MEDITERRANEAN SEA
LEBANON
Railroad Station (Semaryan)
Semaryan
Bahoozi
Safsafeh
Nahoot
Telae
Telit Hudder
Tell Termos
Deir Talea
Saboohiyeh
Ayn Zebda
Rarfa
Habroon
Tell Wahaweh
Arzoonah
Jefriate
Riah
Madhala
Khirbet Asharie
Mishirfeh Mastura
Berge Maxoor
Hyathmieh
Tell Haush
Berge Arab
Jib Amalas
Beit Wanoose
Zanbieh
Deir Hajar
Jamaseh
New Tell Kazel
Rihaniyeh
Tell Kazel
Hamidyeh
Arab Shati
Zahed
Shass
Dakaka
Soda
Karfa
Tell Snoon
Tell Basisa
Jouemisseh
Kharabeh
Sheikh Jaber
Bani Na'im
Ransiyeh
Tell Adass
Mechirfeh
Zarbiseh
Bashah
Khirbet Akrad
Arida
Tabouseh
Azizyah
PROPOSED LINK "A" TO EXPRESSWAY
EXPRESSWAY (UNDER CONSTRUCTION)
To Safita
To Homs
To Tripoli
To Tartous
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
LAND CLASSIFICATION

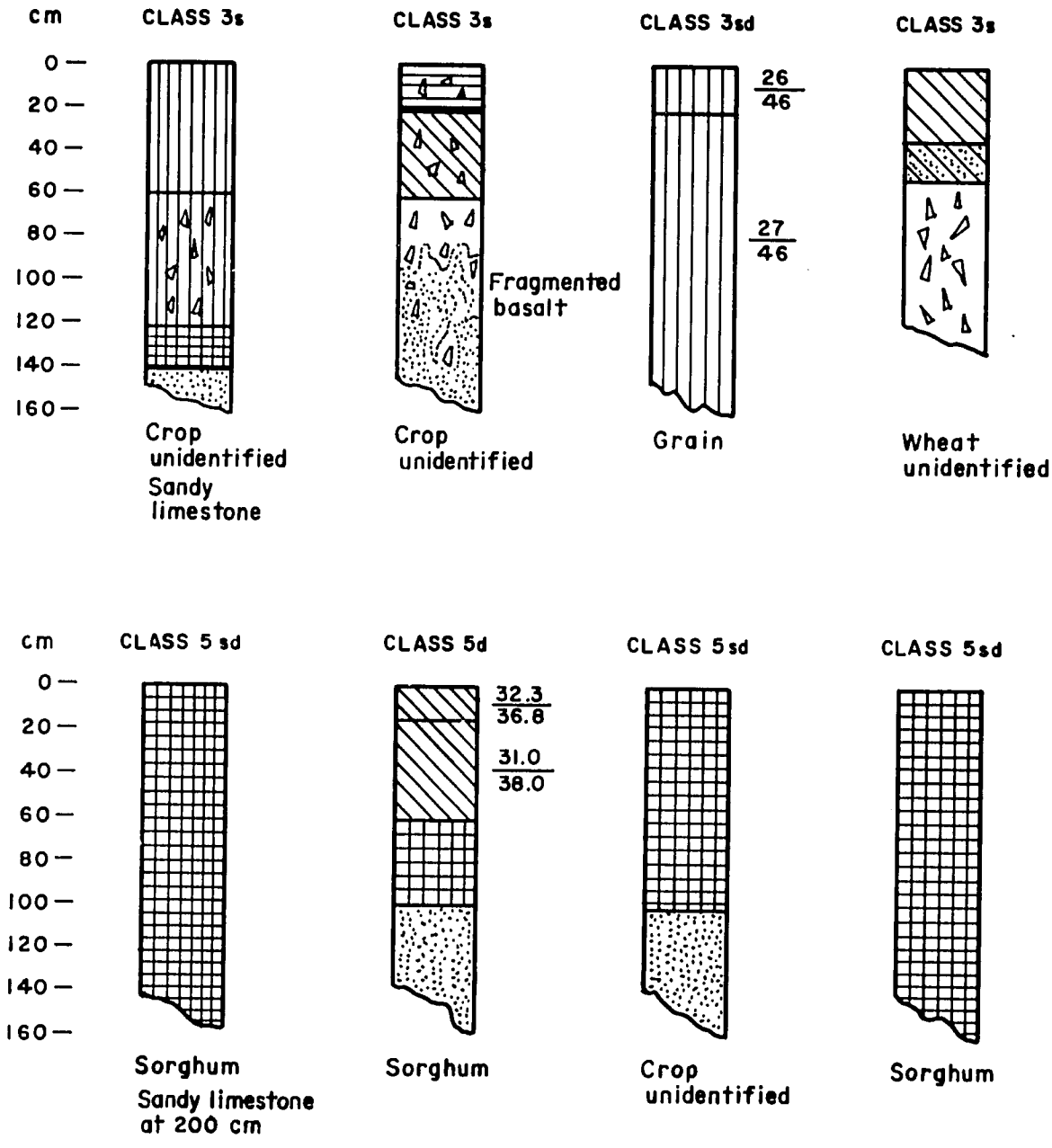
FIGURE II-1



TYPICAL SOIL PROFILES

Akkar Plain Project

TIPTON AND KALMBACH - SCHICK INTERNATIONAL



TYPICAL SOIL PROFILES
(CONTINUED)
Akkar Plain Project

Table II-3
Akkar Plain Land Classification by Class and Subclass

Land Class	Subclass (ha)	Class (ha)
1		971
2t	391	
2d	603	
2s	4,520	
2sd	3,171	
2st	889	
Subtotal		9,574
3s	1,071	
3sd	3,646	
3st	2,264	
Subtotal		6,981
5sd		2,450
6s	309	
6sd	15	
6st	2,383	
Subtotal		2,707
Grand Total		22,683

LAND CAPABILITY

Land capability is directly related to soil, topography, and drainage conditions, as is land classification; but it is further restricted by climate and other land use limitations. With the land classification serving as a basis, the crops best adapted for each land class can be assessed in determining land use recommendations. Land capability is a combination of the physical factors expressed in the land classification, considered together with the appropriate land use.

Eight classes are set up under the land capability classification. Lands having the greatest capabilities in response to good management and use and which have the least limitations are in Capability Class I. Those lands with the least capabilities and greatest limitations are in Class VIII. Six capability classes are recognized

in the Akkar Plain classification Figure II-3; land area in each category is summarized in Table II-4.

Table II-4
Land Area by Capability Class

Capability Class	Land Area (ha)	Percent of Akkar Plain
I	971	4
II	9,574	42
III	6,981	31
IV	2,450	11
VI	1,447	6
VIII	1,260	6
TOTAL	22,683	100
Special Capability Class		
Citrus (This area duplicates portions of Class I and II above)	1,400	6

Lands in Class I have few limitations which restrict their use. The soils are deep and well drained, have high natural fertility or are highly responsive to fertilizers, and the topography is nearly level. The capacity to retain and yield available moisture for plant use is favorable, and the lands need only the usual cultural practices to maintain productivity.

Vegetable crops are presently grown over a wide range of soils with the availability of water being the main consideration. With development of the Akkar Plain, vegetables will continue to be dispersed over a wide range of soils, but the Class I soils will produce the greatest yields under full irrigation development. Improved drainage would allow the vegetables to be planted earlier, which would result in greater utilization of the spring and early summer rains. The principal benefit would come from greater yields with very little change in land area used for crops.

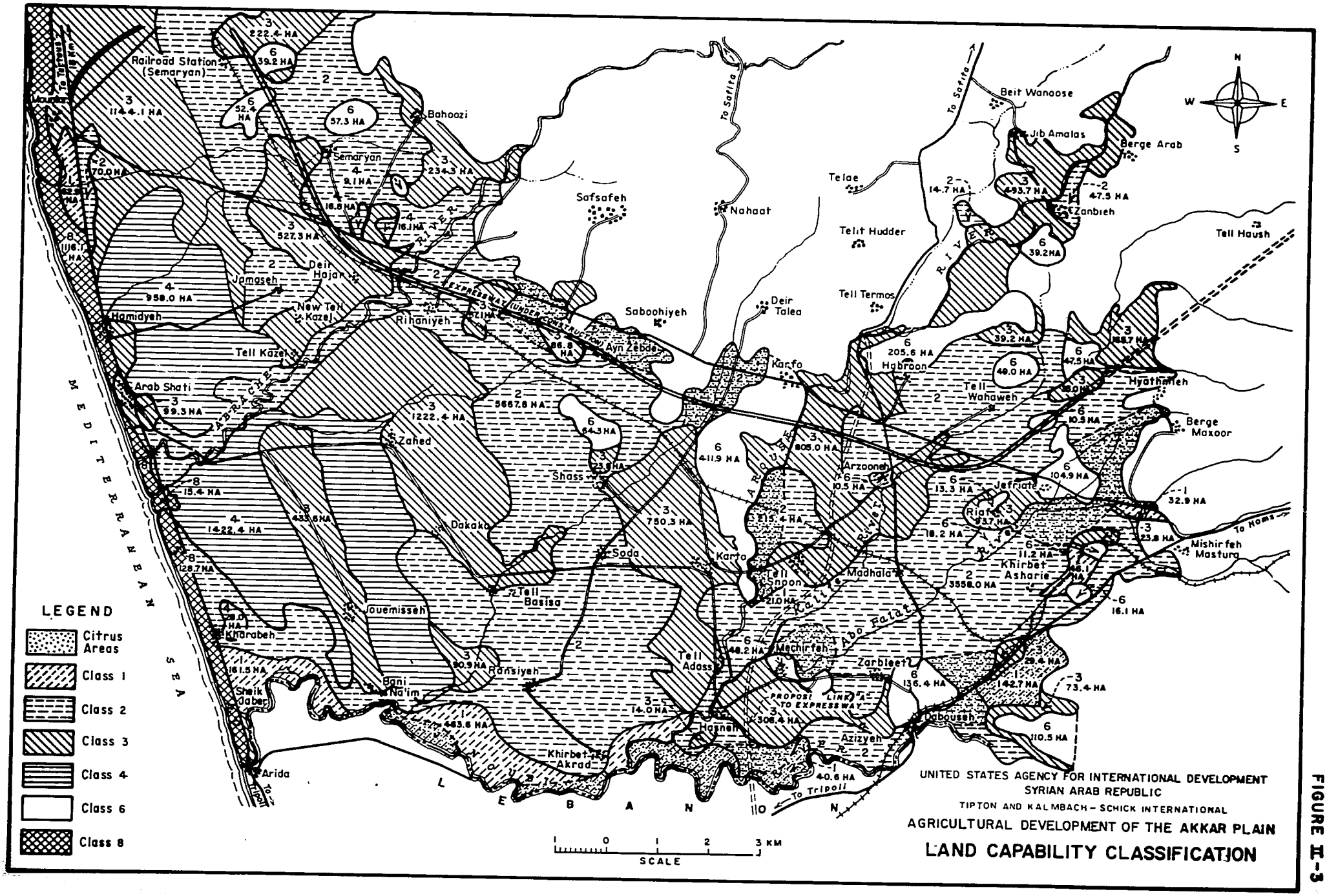

LEGEND
Citrus Areas
Class 1
Class 2
Class 3
Class 4
Class 6
Class 8
MEDITERRANEAN SEA
LEBANON
Railroad Station (Semaryan)
Bahoozi
Semaryan
Deir Hajar
Jamaseh
New Tell Kazel
Hamidyeh
Tell Kazel
Arab Shati
Rihaniyeh
Zahed
Dakaka
Jouemisseh
Khirbeh
Sheik Jaber
Bani Na'im
Arida
Tell Basisa
Soda
Shass
Ayn Zebde
Saboohiyeh
Safsafeh
Nahaat
Deir Talea
Karfa
Karta
Tell Snoon
Madhala
Tell Adass
Mechirfeh
Zarbleet
Hasneh
Khirbet Akrad
Ransiyeh
Dabousseh
Azizyeh
Habroon
Tell Wahaweh
Arzooneh
Jefriate
Riat
Khirbet Asharie
Mishirfeh Masturq
Hyathmeh
Berge Maxoor
Tell Haush
Zanbieh
Jib Amalas
Berge Arab
Beit Wanoose
Telae
Telit Hudder
Tell Termos
PROPOSE LINK TO EXPRESSWAY
EXPRESSWAY UNDER CONSTRUCTION
To Tripoli
To Safita
To Homs
SCALE
0 1 2 3 KM
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
LAND CAPABILITY CLASSIFICATION

FIGURE II-3

Class II lands have a wide choice of crops but are limited by one or more factors, such as gentle slopes, a moderate erosion hazard, a few rocks in the plow zone, or inadequate soil depth with somewhat restricted drainage. Physical limitations in this capability class prevent the land from being as economically productive with the vegetable crops suited to Class I lands.

Lands in Class III have severe limitations which reduce the choice of crops and/or require special cultural practices. Limitations in use result from such factors as moderately steep slopes, high erosion hazards, very slow permeability, shallow or restricted root depth, low water holding capacity, and low fertility.

Class IV lands can be used for cultivation but have a severe drainage limitation and a poor physical soil structure. Very few crops are suitable to the severe constraints of these lands. Except for micro-areas, these soils are suited only for shallow-rooted forage and cereal crops.

Classes V to VIII lands are generally not suited for cultivation. Classes V and VII are not used in the Akkar Plain classification. Class VI lands have severe limitations in soil depth, presence of rock outcrops, or steep slopes that restrict their use largely to pasture or olive trees. Class VIII are lands not capable of productive agricultural use and consist of the tidal flats, sandy beaches, and dunes along the coast.

Land Use by Capability Classes

In the land capability classification, lands are delineated as to suitability for irrigated crop production. Suggested crops and recommended land use practices are determined for each capability class. From the standpoint of land use, Capability Class I lands are suitable for all the principal crops grown in the Akkar Plain. Drainage is adequate for citrus on these soils and citrus crops are suited where there is natural wind protection or where windbreaks can be provided.

Suggested crops for the wet season in Class II lands include wheat, barley, vetch, beans, and cole crops. The growing season for grains and vetch carries over into the summer dry season. Principal crops suggested for the dry season are tomatoes, eggplant, green beans, dry beans, lentils, melons, squash, and maize. Citrus is

also suitable for Capability Class II lands when protection from heavy winds is present or can be provided and where surface drainage is not a constraint.

For sustained cropping, Capability Class II lands require special management practices. Land conditions common to Capability Class II are moderate topographic limitations of slope and relief, limited soil depth, and a higher percentage of clay than Class I. The topographic deficiency would influence irrigation practices under gravity irrigation methods. The heavier soil restricts land tillage, water penetration, and adequate drainage through the soil profile. Under these restrictions, root development is inhibited and nutrients are less available to the plant.

Capability Class III lands have severe limitations which reduce the choice of crops because drainage is impeded or because they are heavy, shallow, or low in fertility. Likewise, the above limitations restrict growing tubers, root vegetables, tomatoes, melons, squash, and cole crops. The slopes of Capability Class III lands require strict control of irrigation water to control erosion. Shallow-rooted cereal and forage crops are best suited for these lands.

Lands in Capability Class VI are subject to inadequate drainage which limits their use to sorghum, forage, and pasture which receive water by capillary action from the high water table. Tillage is difficult on these soils of massive, heavy clays, except for a limited time when moisture conditions are favorable. It is difficult to till and prepare seed beds in these soils unless the moisture content is precisely correct. When the moisture content is not correct, a change in structure creates large blocks or clods. Owing to the impermeable nature of the massive clay, the penetration of irrigation water is restricted and root development is very poor. However, cultivated crops are successfully grown at the present time in micro-areas where water is pumped from shallow wells for irrigation.

Irrigation is not recommended on Class IV land because of the restricted drainage.

Capability Class VI lands have one or more severe limitations that make them unsuited for cultivation or irrigation. Land use is limited to rainfed pasture and olive groves. The land is generally rough, steep, and hilly with soils that are shallow, rocky, and usually excessively drained. Olives are suited to well-drained

soils, and they tolerate shallow, rocky soil without severely limiting production. Vegetation used for pasture is limited by the availability of natural precipitation for which olives and forage plants compete.

Citrus production is desirable, and SARG is interested in developing as many groves as possible on the Akkar Plain. Strong winds and shallow soils with restricted drainage make most of the Akkar Plain unsuitable as prime land for citrus groves. Several groves have already been planted on the Plain, and some of them are mature enough to be in production. Windbreaks are planted on all sides of the citrus groves to protect them from the strong winds.

A special capability class was formulated to facilitate the location of areas best suited for citrus production. Some areas, mostly in Class II lands, have natural windbreaks provided by hills or sharp drops in topography. Where the natural windbreak areas also have reasonably well-drained soils, it is conceivable that citrus could be produced with less land wasted for windbreaks and with less chance of fruit damage; these lands were put in the citrus capability class. Some Capability Class I soils were included in this subclass because of the soil characteristic advantages; it is assumed that windbreaks would have to be grown to protect the groves. Availability of irrigation water was not included as a criterion for the citrus subclass. Approximately 1,400 hectares in small individual areas over the entire Plain are reasonably well suited for citrus production, assuming water is available for irrigation.

Nematodes are present in all classes of soil. Yields are expected to be reduced by at least five percent owing to the damage by nematodes to the roots of citrus even with the application of insecticides. This problem could be more acute if adequate treatment is not applied prior to planting.

AREAL SURFACE DRAINAGE

Inadequate surface drainage is a major problem on the Akkar Plain. This problem occurs throughout the winter season during periods of high intensity storms. The primary surface drainage problem is found on the low flat lands located on the western side of the Plain.

The average annual precipitation on the Akkar Plain, as recorded at the Tartous weather station, is 860 millimeters. Approximately 60 percent of the precipitation occurs in December, January, and February. Major storms occur two to four times per month during this period with a storm duration of three to four days. Storms range in intensity from about 60 millimeters to over 100 millimeters. Above normal precipitation which occurred in 1977 and 1978 while field investigations were being conducted provided specialists with an excellent opportunity to observe existing drainage problems and devise corrective measures.

In addition to the Janoubi and Abrache Rivers, there are eight other major and minor drainages that currently channel surface flood waters from the Akkar Plain to the Mediterranean Sea. During heavy storms, runoff in each of these channels overflows and causes considerable flood damage to the adjacent farmlands. The degree of flooding is dependent upon the severity of the storm. The maximum accumulative flow from the eight drainages during the large winter storms in 1977-78 was estimated to be 31 cubic meters per second. The largest of the drainage ways is the Ramit Laha drain which flowed approximately 16 cubic meters per second. When the Janoubi River was also flooding, the Ramit Laha increased in flow to about 68 cubic meters per second.

There are many surface drainage problems on the Akkar Plain as a result of the general flatness and undulating characteristics of the topography and the inadequate number and size of the drainage channels. The soil is totally saturated each year after the first major winter storm and surface drainage problems immediately begin to appear. It is estimated that 44 percent of the total rainfall is runoff. Flow quantities were estimated from rainfall-runoff relationship curves assuming very wet soil conditions, slow infiltration rates, and a storm rainfall intensity of 60 to 100 millimeters. An average runoff of about 35 millimeters occurs following each major storm. Such storm runoff would not be a major problem if the surface configuration of the area were conducive to good drainage.

Capability Class I - Fertile level lands, producing a variety of vegetable crops are features of Class I.

Capability Class II - A wide expanse of lands with gentle slopes but irregularity of relief that requires special tillage and irrigation practices are features of this class.

Capability Class III - View of Tel Basisa shows land in this class is very gravelly and the topography is irregular.

Capability Class VI - View of olive groves. Primitive tillage practices are still used on some of these lands.

ON-FARM DRAINAGE

A major on-farm surface drainage problem accounts for much of the restricted crop production on the Plain. This is caused in part by poor cultural practice in preparing the land for planting and subsequent furrowing for irrigation. The current practice is to plow the land in a direction parallel to the length of the field without regard to the contour. No form of land leveling is involved in preparing the soil for planting; rather, the seeds are broadcast or placed by hand and covered by a second, light plowing operation. Many surface irregularities result because leveling is not part of the land preparation. Sometimes back furrows are created where the land is not leveled, causing water catchment areas that compound the original drainage problem. In the absence of a farm waste ditch collection system excess surface water is merely transferred to adjacent lands and, as a result, soils remain saturated for an extended period of time. Waterlogged or saturated soils limit root development of winter crops and delay planting of spring crops.

JANOUBI RIVER FLOODING

Flooding of the Janoubi River is also recognized as a serious problem. Flooding restricts crop production on an extended area bordering the Janoubi River from Khirbet Akrad to within approximately two kilometers of the mouth of the river. The floodwater flows northwest through the Ramit Laha swamp before passing into the Mediterranean Sea. In evaluating the frequency of the Janoubi River flooding, it is estimated that damaging floods covering about 850 hectares of irrigable land occur in two out of three years for a 67 percent frequency. It is further estimated that in one year out of ten years a greater flood of much larger flows occurs, covering nearly 1,300 hectares of irrigable land.

SURFACE WATER RESOURCES

The Project Area is transected by the Abrache, Arouse, Kalife, and Abo Falat Rivers, while the Janoubi River forms the southern boundary of the area. Records of river flow are available for varying periods of time for the Abrache, Arouse, Kalife, and Janoubi Rivers. Typical hydrographs are shown on Figure II-4. The hydrographs

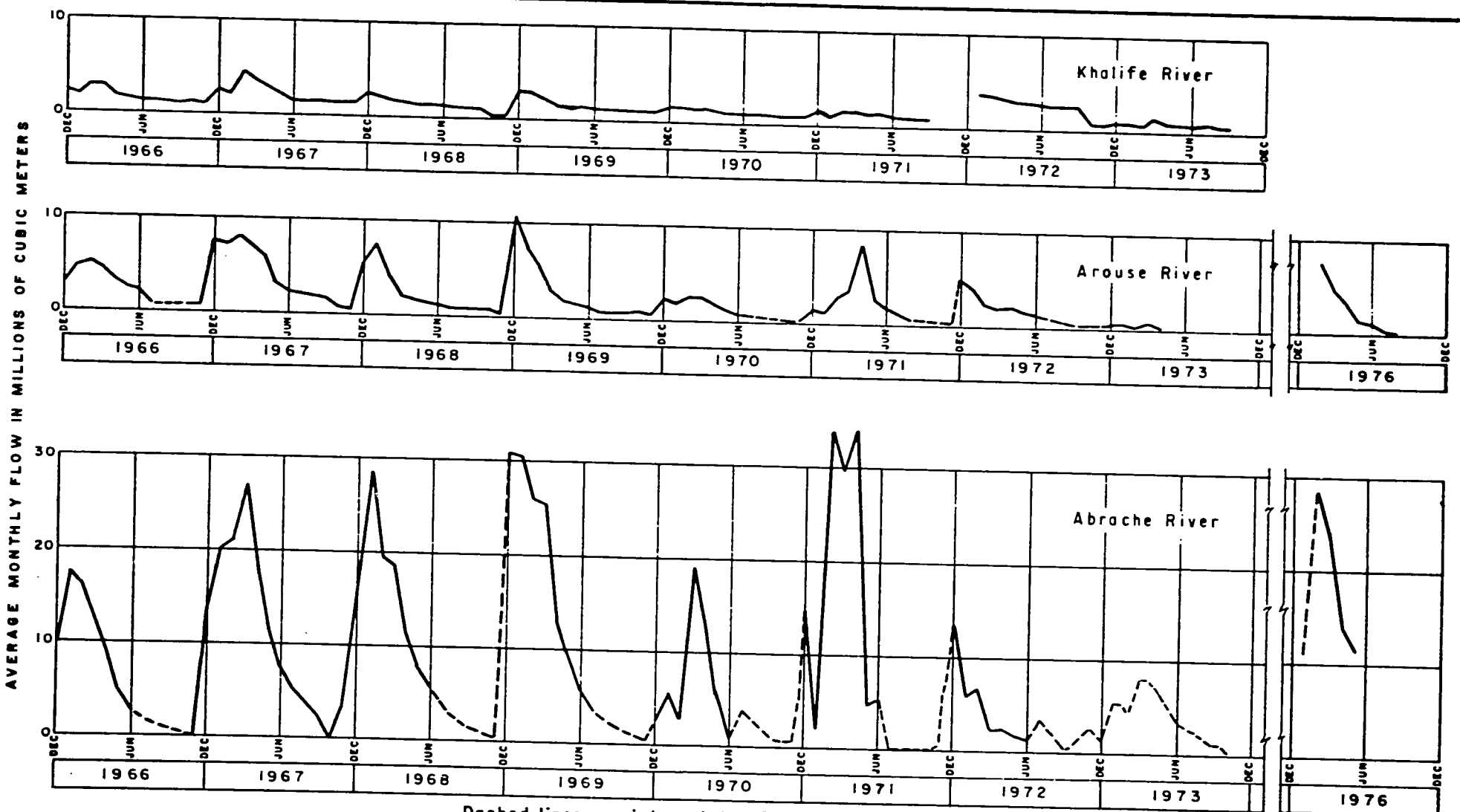
indicate that storage of the annual winter runoff would be required to support an irrigation project throughout the dry season. The Janoubi, Abrache, and Arouse Rivers have volumes of flow which are enough to justify regulating structures. The Janoubi River, however, being an international border, has been eliminated from consideration until an international agreement can be reached for use of its waters.

Flow records are available for the Arouse and Abrache Rivers for the years 1966 to 1977, except the 1974-1975 data are missing on the Abrache and 1974 is missing on the Arouse. The runoff of the Abrache and Arouse Rivers in the years 1970, 1972, and 1973, as shown in the mass flow curves (Figure II-5), was well below the average for other years of record, which indicates that to fully utilize the surface water resource of these rivers holdover storage from years of high runoff to years of subnormal runoff is required.

Present Surface Water Use

Although large-scale use of the area's surface water resources requires holdover storage, some irrigation is practiced through use of low diversion weirs on the rivers, as shown in Figure II-6. All diversions for existing systems are handmade weirs of cobblestones and earth, of cobblestone masonry, or are concrete weirs in very poor condition. Diversion structures are uncontrolled to the canals and, during the months of heavy runoff, no diversion is accomplished. As flood flows diminish, the earth and rock diversions are repaired or replaced and the canal headings are cleaned by hand. In the masonry diversions, flash boards or earth are used to close the sluice openings in the weirs, forcing flow into the canals.

Canals are in earth, are well maintained, and all grass lined; rock masonry lining is placed where necessary on curves and on steep side slopes. All turnouts and canal diversion points are constructed in earth and controlled by a few large stones and earth when not in use. Some canal division points are constructed as a side spillway of stone masonry or as a concrete weir allowing excess flow in the upper ditch to fall to a lower ditch. Paved roads are crossed by concrete pipe or a box culvert. Many of the canals and diversions were originally constructed to serve grist mills which have since been abandoned.



Dashed lines are interpolated from precipitation records

HYDROGRAPHS OF RIVER FLOW 1966 - 1973

Akkar Plain Project

TIPTON AND KALMBACH-SCHICK INTERNATIONAL

FIGURE II-4

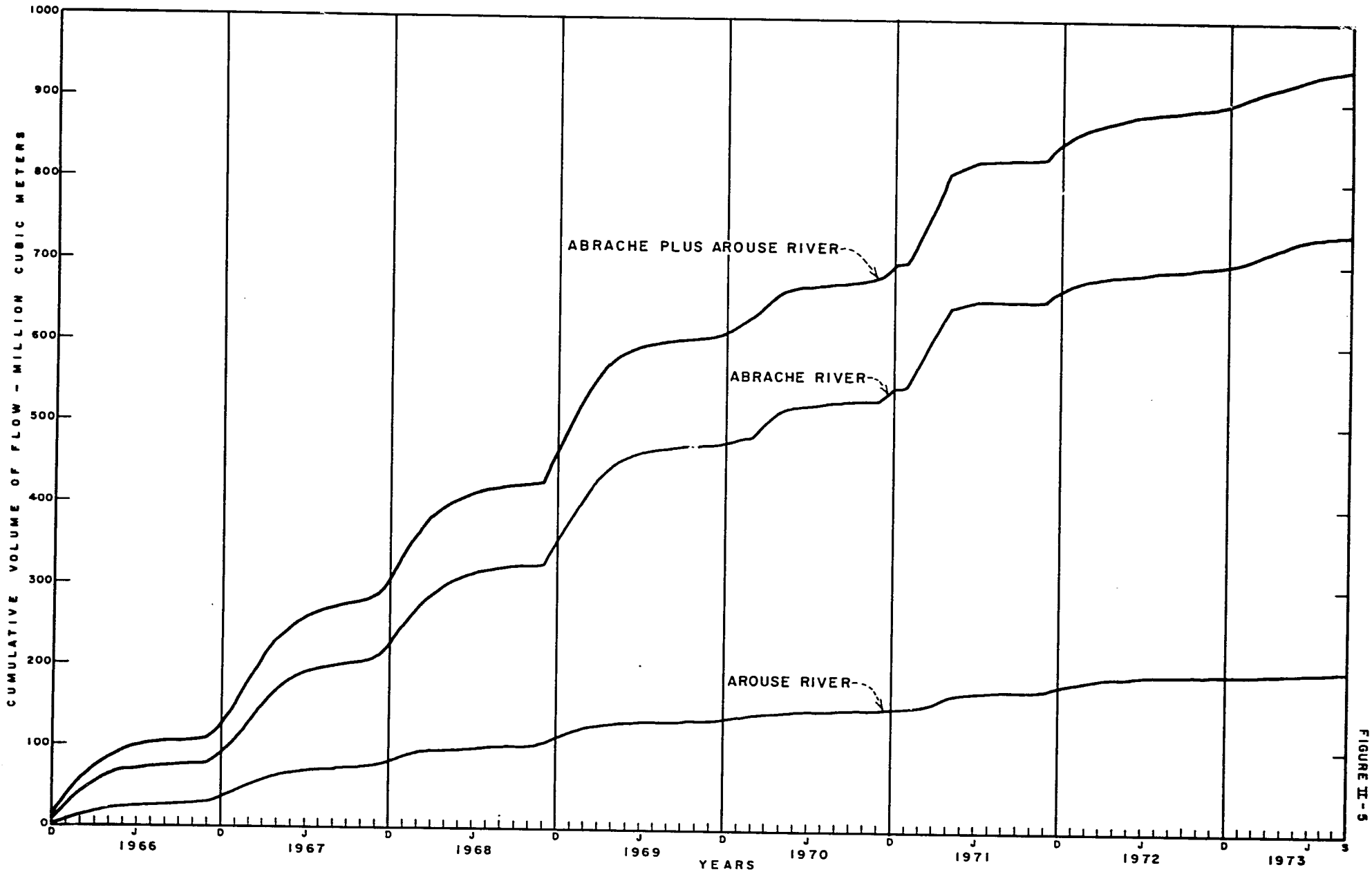
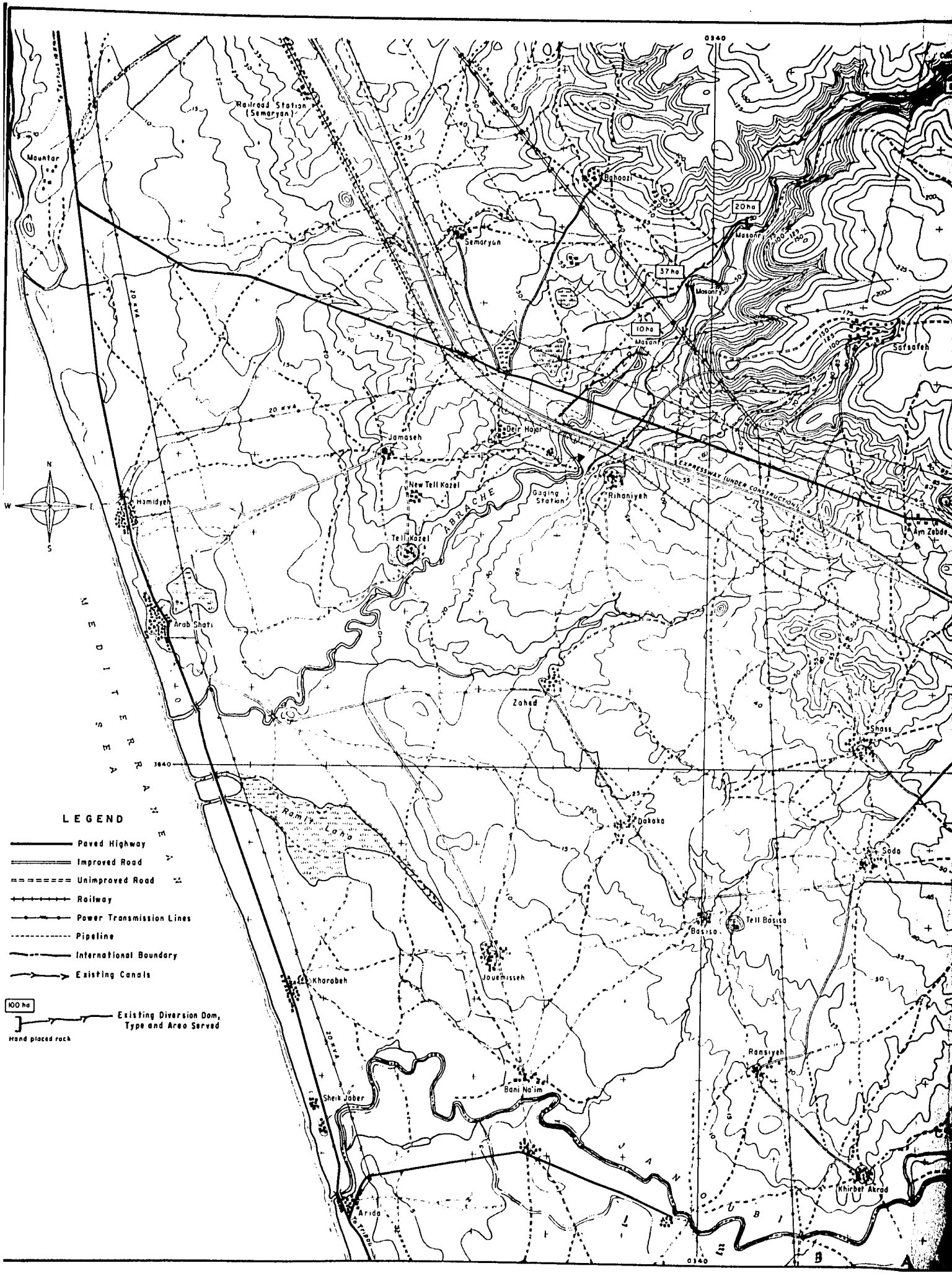


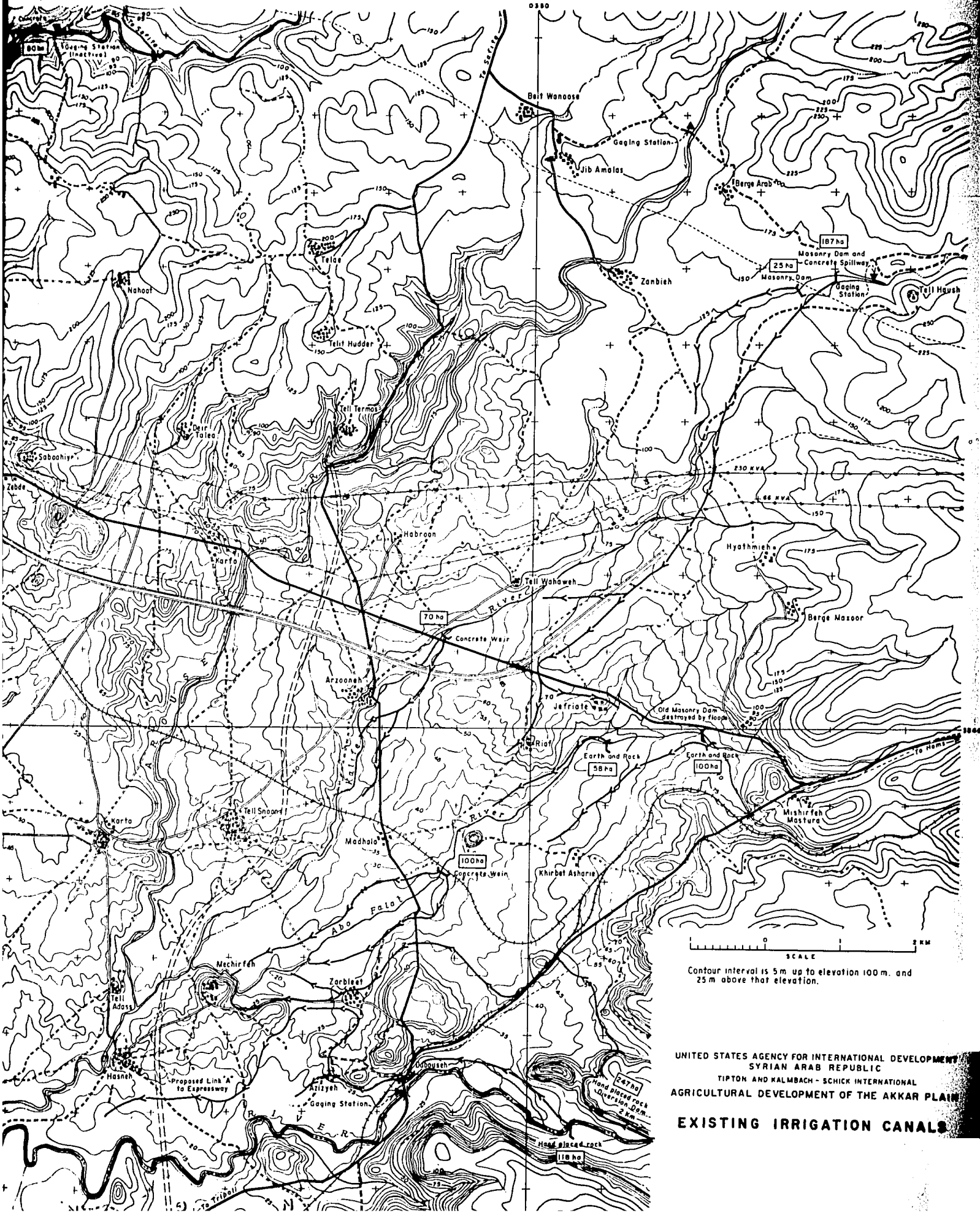
FIGURE II-5

MASS FLOW CURVE
ABRACHE AND AROUSE RIVERS

TIPTON AND KALMBACH - SCHICK INTERNATIONAL


Railroad Station (Semaryun)
Mountar
Semaryun
Bahoozi
20 ha
Masonry
37 ha
Masonry
10 ha
Masonry
Sarsafeh
20 KVA
Jamaseh
Deir Hajar
New Tell Kazel
Gaging Station
Rihaniyeh
EXPRESSWAY (UNDER CONSTRUCTION)
Hamidyeh
Tell Kazel
ABRACHE
Arab Shati
MEDITERRANEAN SEA
Zahed
Shass
Ramiy Lake
Dakaka
Soda
Tell Basisa
Basisa
Jouemisseh
Kharobeh
Ransiyeh
Bani Na'im
Sheik Jaber
JANOUBI
Khirbet Akrad
Arida
to Tripoli
LEGEND
Paved Highway
Improved Road
Unimproved Road
Railway
Power Transmission Lines
Pipeline
International Boundary
Existing Canals
100 ha
Existing Diversion Dam, Type and Area Served
Hand placed rock

FIGURE


Gaging Station (Inactive)
80 ha
To Safita
Beit Wanoose
Gaging Station
Jib Amalas
Berge Arab
187 ha
Masonry Dam and Concrete Spillway
25 ha
Masonry Dam
Gaging Station
Tell Haush
Zanbieh
Telaa
Nahoot
Telat Hudder
Tell Termos
Deir Talea
Saboohiye
Zebde
230 KVA
66 KVA
Habroon
Karta
Hyathmieh
Tell Wahaweh
River
70 ha
Concrete Weir
Berge Mazoor
Arzooneh
Jefriate
Old Masonry Dam destroyed by floods
Riat
Earth and Rock
58 ha
Earth and Rock
100 ha
To Homs
Mishirfeh Mastura
Tell Snoon
Karta
Madhala
100 ha
Concrete Weir
Khirbet Asharie
Abo Falat
Mechirfeh
Zarbleet
Tell Adass
Hasneh
Proposed Link "A" to Expressway
Aizzyeh
Gaging Station
Dubouseh
Hand placed rock Diversion Dam
247 ha
2 Km
Hand placed rock
118 ha
To Tripoli
0
2 KM
SCALE
Contour interval is 5 m up to elevation 100 m. and 25 m above that elevation.
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
EXISTING IRRIGATION CANALS

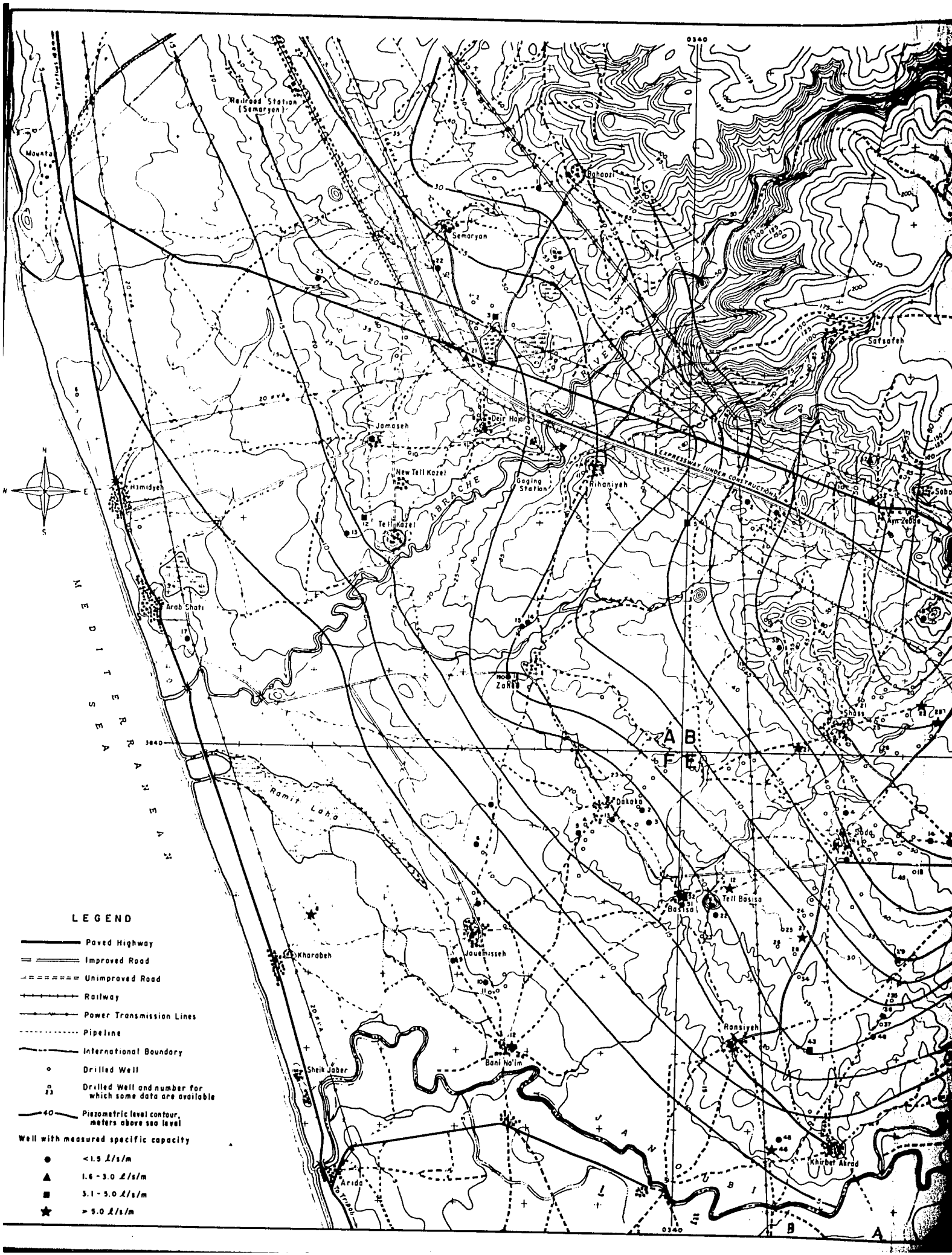
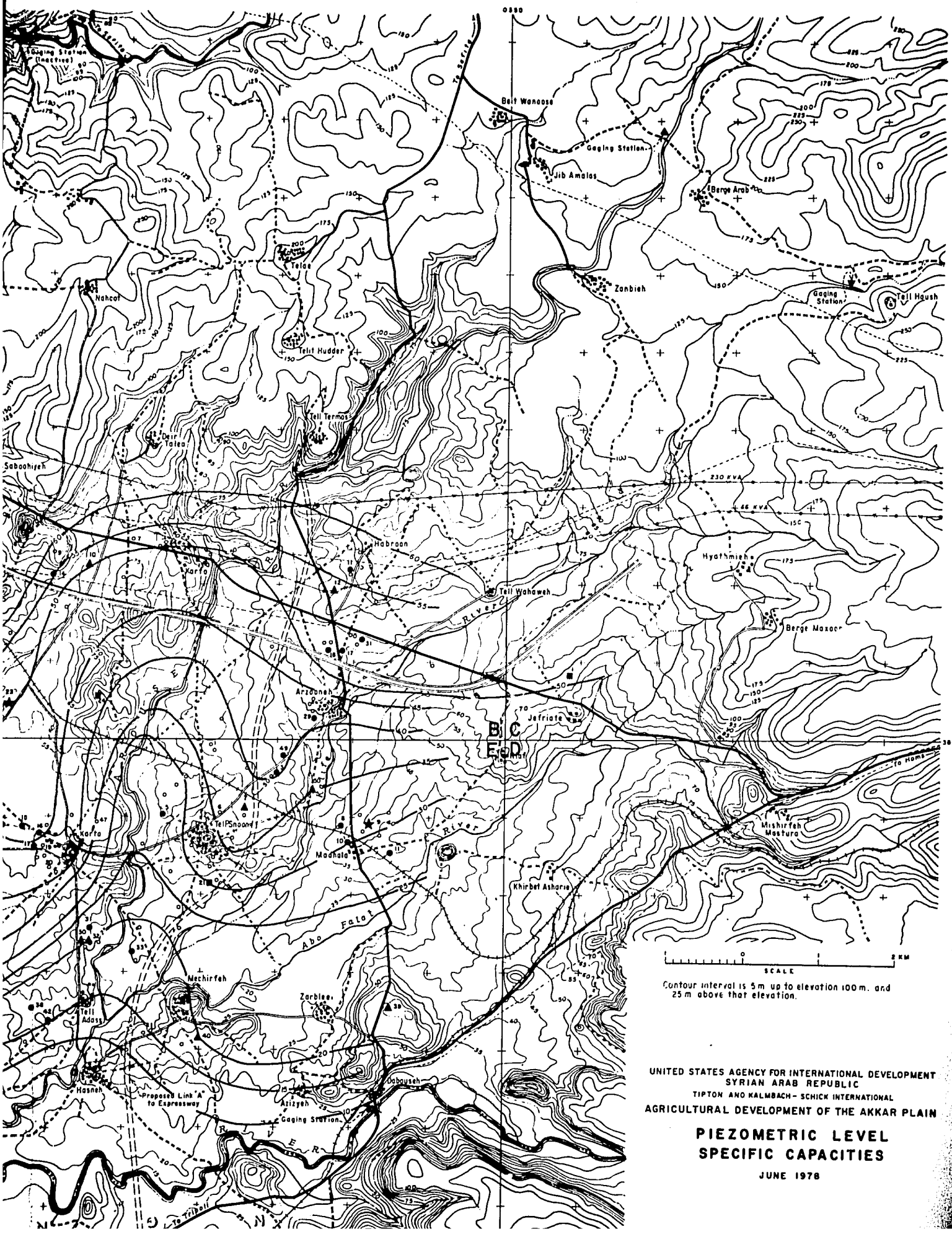

Railroad Station (Semaryan)
Semaryan
Baghaozi
Safsafeh
Jamaseh
Deir Hajar
New Tell Kazel
Tell Kazel
Gaging Station
Rihaniyeh
EXPRESSWAY UNDER CONSTRUCTION
Hamidyeh
Arab Shafi
Zaraa
Ayn Zebde
Shaas
Dakaka
Basisa
Tell Basisa
Ramit Laha
Kharabeh
Jouemisseh
Ransiyeh
Bani Na'im
Sheik Jaber
Arida
To Tripoli
Khirbet Akrad
MEDITERRANEAN SEA
LEGEND
Paved Highway
Improved Road
Unimproved Road
Railway
Power Transmission Lines
Pipeline
International Boundary
Drilled Well
Drilled Well and number for which some data are available
Piezometric level contour, meters above sea level
Well with measured specific capacity
< 1.5 ℓ/s/m
1.6 - 3.0 ℓ/s/m
3.1 - 5.0 ℓ/s/m
> 5.0 ℓ/s/m

FIGURE II-7


Gaging Station (Inactive)
Belt Wanoose
Gaging Station
Jib Amalas
Berge Arab
Telas
Nahcat
Zanbieh
Gaging Station
Tell Haush
Telit Hudder
Tell Termos
Deir Talea
Saboohiyeh
230 KVA
66 KVA
Habroon
Hyathmieh
Karfa
Tell Wahaweh
River
Berge Maxoor
Arzouneh
Jefriate
B C
E D
To Homs
Karfa
Tel Snoon
Madhala
River
Mishirfeh Mastura
Khirbet Asharia
Abo Fatat
Mechirfeh
Zarblaa
Tell Adass
Hasneh
"Proposed Link "A" to Expressway"
Atizyeh
Gaging Station
Dabousieh
R I V E R
To Tripoli
SCALE
0
2 KM
Contour interval is 5 m up to elevation 100 m. and 25 m above that elevation.
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
PIEZOMETRIC LEVEL
SPECIFIC CAPACITIES
JUNE 1978

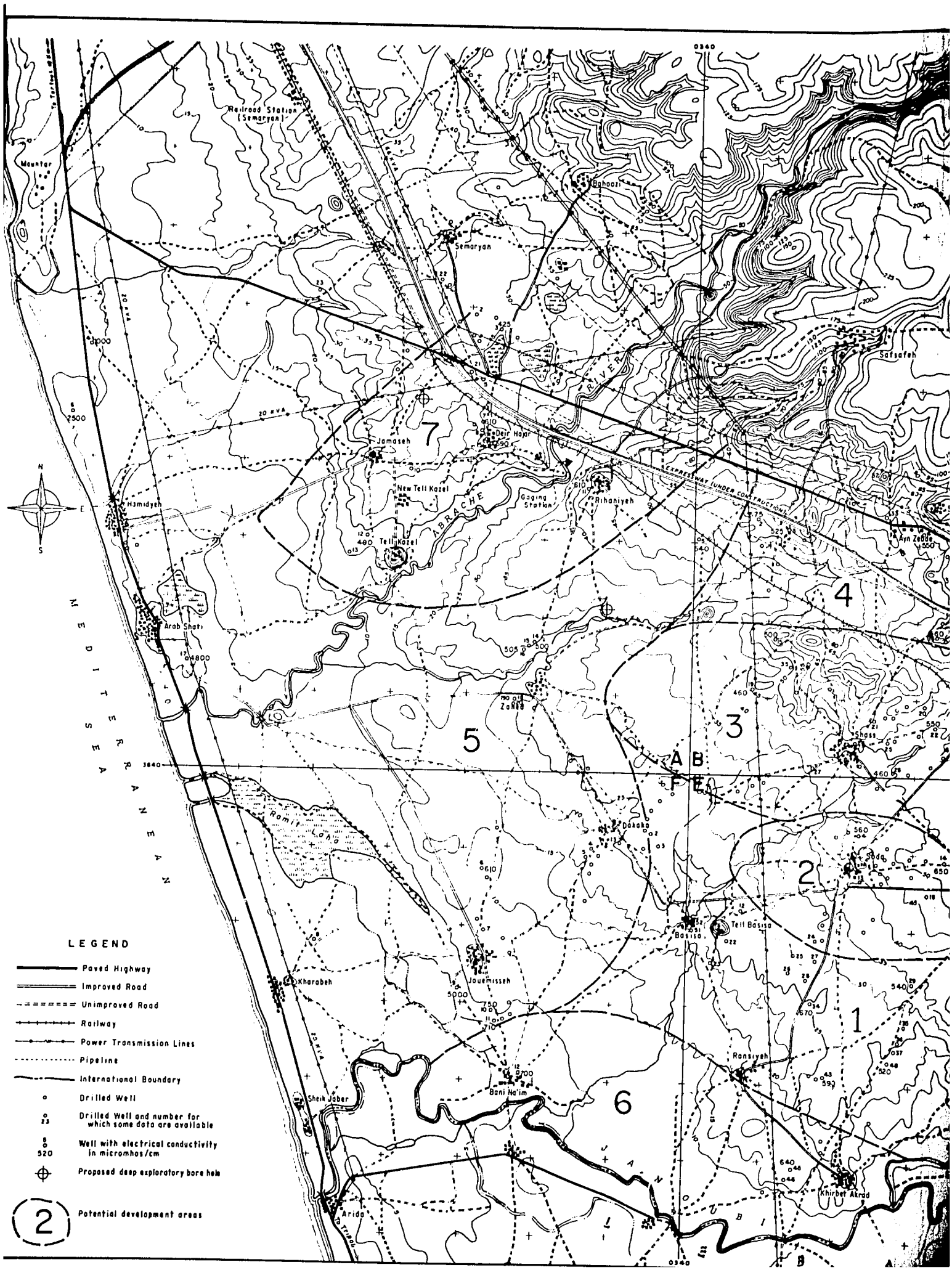
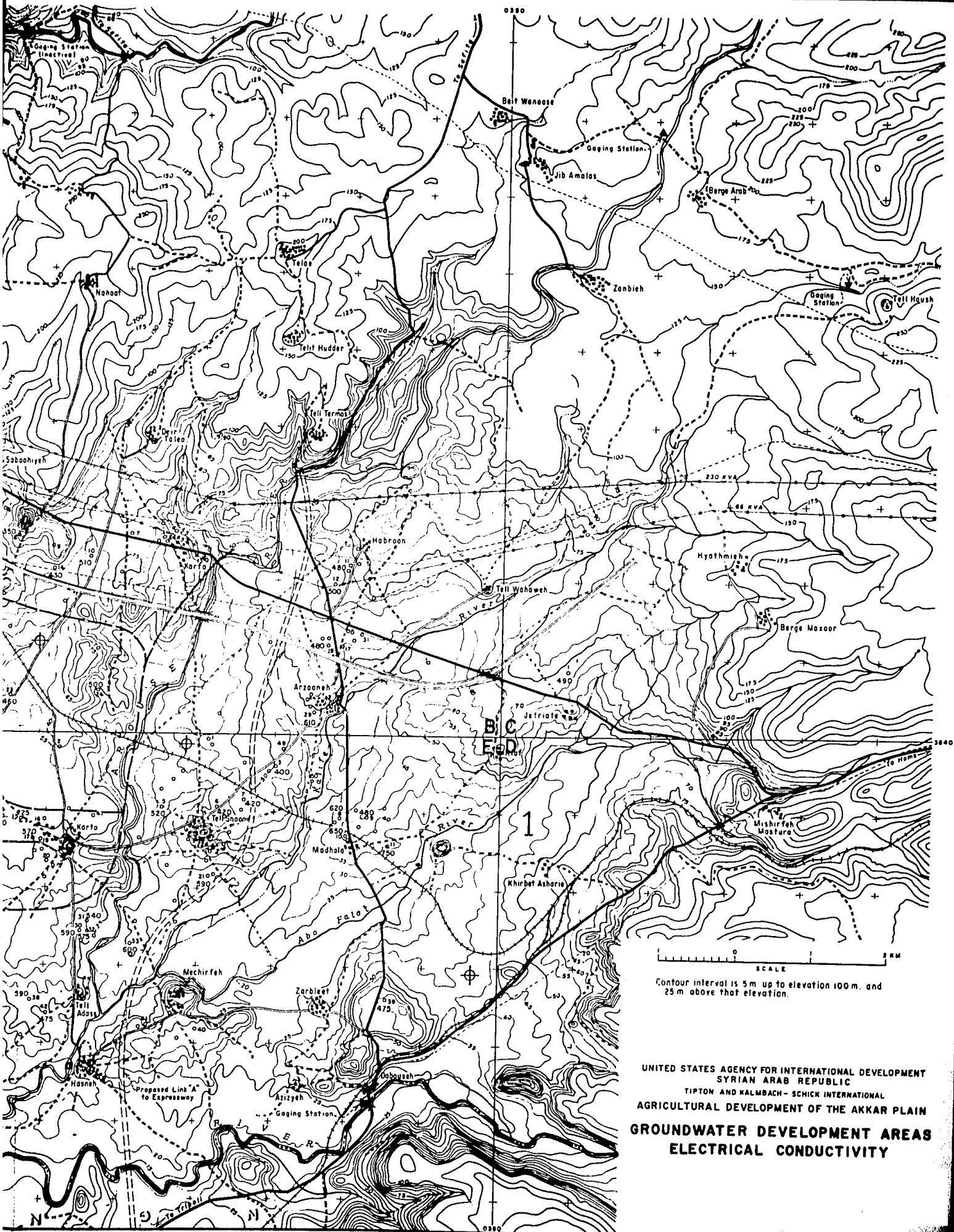

Railroad Station (Semaryan)
Mountar
Bahoozi
Semaryan
Safsafeh
Jamaseh
Deir Hajar
New Tell Kozel
Gaging Station
Rihaniyeh
Tell Kozel
ABRACHE
RIVER
EXPRESSWAY (UNDER CONSTRUCTION)
Hamidyeh
Ayn Zebde
Arab Shati
MEDITERRANEAN SEA
Zarab
Shass
Ramla Lake
Dakaka
Tell Basisa
Basisa
Kharabeh
Jouemisseh
Ransiyeh
Bani Na'im
Sheik Jaber
Arida
Khirbet Akrad
JORDAN RIVER
To Tripoli
N
S
E
1
2
3
4
5
6
7
LEGEND
Paved Highway
Improved Road
Unimproved Road
Railway
Power Transmission Lines
Pipeline
International Boundary
Drilled Well
Drilled Well and number for which some data are available
Well with electrical conductivity in micromhos/cm
Proposed deep exploratory bore hole
Potential development areas

FIGURE II-8



UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN

GROUNDWATER DEVELOPMENT AREAS
ELECTRICAL CONDUCTIVITY

As no control is possible at the diversions, canals sometimes flow during periods of high river flows causing flooding and inundation of fields in the lower part of the systems. Canals are also used as drains for the higher lands making late planting necessary on the lower fields. A full supply of water is not available every season on the existing canals because of the low river stage.

Approximately 365 hectares are irrigated from two diversions on the Janoubi, 280 hectares from three points on the Kalife, and 260 hectares from three diversions on the Abo Falat. The Abrache River presently has four diversions irrigating about 150 hectares. No water is presently diverted out of the Arouse River because of the steep banks and the ephemeral nature of the stream.

GROUNDWATER

It was believed at the outset of this study that a detailed investigation of the geohydrology of the Akkar Plain had already been completed. The present investigation was intended to be an interpretation of the earlier study, combined with an investigation of existing wells, so that a groundwater irrigation system in those areas which could not be served by a canal system could be formulated. It was found, however, that the previous study was only a part of a reconnaissance of all of Syria and the data generated on the Akkar Plain were too scanty to be of use. Consequently, the material contained in this report was gathered from observations on farmers' wells and discussions with drillers and farmers. The field work was carried out in November 1977 and May-June 1978. During the first period, irrigation had ceased, all installations were closed down and only nonpumping water levels could be measured. The May-June period, however, was more productive since dynamic features could be measured.

In May 1978, the records of the Public Works Department indicated a total of about 800 wells in the Project Area, of which about 540 were drilled and 260 hand dug. These figures are believed to be inflated, however. About 300 drilled wells, which are estimated to represent at least 75 percent of the total, were visited. If this estimate is accurate, there are presently about 400 drilled wells in the Project Area. Public Works records show about 260 dug wells, and no attempt was made to

verify this number; however, it is considered to be high. Installation of both type of wells continues at a fast pace--several per week.

The Aquifers

The Plain is underlain by Cretaceous limestone at depth over most of the area and at the surface in the northwest, northeast, and perhaps in the valley of the Arouse. Unconformably overlying the Cretaceous is a series of Tertiary deposits of extrusives and various facies of marine limestones, limey sandstones, and marls. Essentially the entire Plain area east of the Arouse River has basalt at the surface and no wells visited were reported to have penetrated into limestone. West of the Abrache River most of the area has marine calcareous sediments at the surface, but basalt layers have been found at depth. Between the Abrache and Arouse, alternating limestones and basalts predominate, with the surficial rocks being largely basalt in the north and limestone in the south.

Productive wells have been found in nearly all types of formations, but no measured data are available to determine the horizons from which wells produce. Since the local farmers are primarily interested in producing only the amount of water required for an individual farm, drilling is generally stopped when sufficient water is obtained. Therefore, it can be assumed in most cases that the water is derived from a relatively thin zone near the bottom of the well.

Subsurface information was obtained through conversations with drillers and well owners. Since the information recorded was usually a translation of a layman's recollection of what was encountered in drilling, little confidence can be placed in the details of the logs. Although recognizing that the data are suspect, it is concluded that the subsurface geology is complex, with both vertical and lateral facies changes, unconformable contacts, and faulting.

Most of the drilled wells and some of the dug wells penetrate confined aquifers. It is believed that permeability is primarily in individual but discontinuous layers or beds with restricted and/or discontinuous vertical permeability. Permeability in the limestones probably is due largely to solution channels and fractures. In the basalts it is believed that permeability derives from cooling joints and from old

weathered surfaces. "Red" zones commonly yielding water are probably surfaces which were weathered between periods of lava flow.

No reasonable lateral correlation of aquifers can be made over more than limited distances with the subsurface data at hand. Whether this difficulty stems from erroneous logs or complicated geology is unclear; probably both contribute.

Piezometric Levels

Nonpumping water levels were measured in about 75 drilled wells at the end of the 1977 dry season and in about 65 wells at the end of the 1977-78 wet season. The piezometric level generally ranges from about 30 meters below the surface to flowing at the surface, depending upon both topography and the aquifer tapped. The piezometric surface is shown on Figure II-7. Surface elevations were picked from the topographic map with a 5-meter contour interval. In the area west of the Kalife River, only one to two meters difference in piezometric level was found between the spring and fall periods in which measurements were taken. While few observations were made east of the Kalife, it is reported that seasonal fluctuations in the water levels in that area range up to six meters, indicating the local recharge and subsequent discharge to the streams during the dry period.

Existing Wells

As stated above, it is estimated that about 400 drilled wells and perhaps 150-200 shallow wells, usually hand dug, exist on the Plain. Most of the wells are privately owned and supply irrigation water to the land of the well owner. Water is also sometimes supplied commercially to neighboring farms. A few towns have domestic water systems supplied by wells.

Wells are drilled using percussion drilling rigs. Normally a 12- to 14-inch (30 cm$^{\pm}$) hole is drilled to whatever depth is necessary to encounter the required amount of water. Wells may or may not be cased throughout their length depending upon the character of the section drilled. In cased wells, locally rolled steel pipe is used and torch slotted where necessary. The average depth of a drilled well is about 65 meters, with the median depth about 55 meters. Of the 86 wells for which

the owner was able to give the depth, only 10 were deeper than 100 meters and 28 were less than 40 meters.

The vertical turbine pumps used in the Akkar Plain are manufactured in Syria. So far as could be determined, all pumps installed are of 7½-inch bowl diameter (8-inch nominal diameter pumps). These pumps are referred to as 3-inch, 4-inch, or 5-inch depending upon the size of column pipe to which they are coupled. In the initial "acceptance test" carried out by the driller, no drawdown measurements are taken and no attempt is made to assess the specific capacity of the well for various pumping rates. The test is merely designed to prove that the well produces sufficient water so that the Agricultural Credit Bank will make a loan to purchase a pump which will be adequate to supply the farmer's own needs. Little thought is given to the possibility of purchasing a pump to supply several farmers; rather, availability of the pump in the market place is the criterion. The result of this practice is that many good wells are fitted with pumps of inadequate capacities and, therefore, only a fraction of the potential discharge of the well is developed.

Drivers used are usually diesel engines which drive the pump through a flat belt. The engines are imported. Normally, no structure houses the pumping unit; both engines and pump heads are enclosed in plastic to protect them from the weather in the rainy season.

Discharge from the drilled wells ranges from less than one liter per second to about 20 liters per second. The average is about 6 liters per second. The potential discharge is considerably greater, however, as few pumps are sized to produce the optimum capacity of the well.

The pumps commonly discharge directly to the field through a plastic hose, either 3-, 4-, or 5-inch depending on the discharge of the pump. Less commonly, a discharge box or stilling basin is used, from which the water flows directly into the farm ditch.

Costs of drilling in the Akkar Plain by local contractors are exceptionally low, being typically SP 40 per meter in easy drilling and SP 100 per meter in hard rock. Typical well depths are about 60 meters, making the drilling cost of an average well about SP 4500. A typical well may require 20 meters of casing at

SP 110 per meter and, in addition, the cost of pump and engine is about SP 18,000. The total cost of a typical production well having a depth of 60 meters is on the order of SP 25,000-30,000.

Deeper drilling may be expected to be much more expensive, costs of SP 850-1000 per meter for rotary drilling having been quoted by the government contractor in Homs. The cost for a 300-meter well may therefore be about SP 300,000 plus a pumping unit installation cost of about SP 50,000.

Open wells are most common in a band about four kilometers wide along the coast, where the groundwater level is only a few meters below the surface. The wells range in depth up to about eight meters and are from two to five meters on a side. Usually no lining is used. Most of the open wells have been hand dug, but recently back hoes have been used.

The quantity of water discharged from shallow, open wells is quite variable because of location of the well and season of the year. In many installations the small diesel-driven centrifugal pump is operated from two to four hours, then turned off for about the same length of time to allow the well to recover. The average discharge probably does not exceed 1.5 liters per second.

Geohydrology

The investigation of aquifer characteristics was carried out by abbreviated pumping tests using existing installations. The data obtained are necessarily approximations since the conditions under which the tests were made were not ideal. It was necessary to coordinate testing with the irrigators' schedules, discharge could not be held constant, and the return flow was commonly large when the pump was turned off. Pumping drawdown tests were carried out only for one to three hours; recovery tests were commonly made after up to six hours or more antecedent pumping. Nevertheless, information was gathered which, while it must be used with discretion, is of value.

Pumping or recovery tests were carried out on 25 wells, from which data the transmissivity (T) of the aquifer was derived. Transmissivity is expressed in terms of cubic meters per day per meter (m^2/day) and is defined as the rate of flow in cubic

meters per day through a one-meter wide prism of the saturated thickness of the aquifer under a unit hydraulic gradient at the prevailing temperature. As would be expected, transmissivity values were obtained which vary greatly--from only a few square meters per day to over 2400 square meters per day. In one well, E-46, recovery was so rapid that T could not be calculated.

On only one test were conditions such that the coefficient of storage (S) could be derived. The coefficient of storage is defined as the volume of water released from storage per unit area per unit decline in head. The value of the coefficient of storage for a given aquifer is not a constant and will vary according to the conditions of occurrence of groundwater. In a deep or semi-confined aquifer, the water released is obtained by elastic compression of the aquifer structure or expansion of the water; and under these conditions, the coefficient of storage is a small decimal fraction. In a water table, or unconfined aquifer, the water is released from storage by gravity drainage and the coefficient of storage under these conditions is equal to the specific yield which commonly ranges from 0.10 to 0.25. After a recovery test on A-14, well A-15 was pumped and observations continued on A-14. The interference of A-15 on A-14 indicated a coefficient of storage of 0.001 which is reasonable for the aquifers involved.

Specific capacity determinations were carried out on 44 wells in addition to those on which drawdown or recovery measurements were made. Specific capacity is defined as the pumping rate (liters per second) divided by the drawdown (meters) expressed in liters per second per meter of drawdown. Again, a great range was found, from less than 1 liter per second per meter to 53 liters per second per meter in E-46, the average being slightly over 2 liters per second per meter if E-46 is not considered. Over two-thirds of the wells on which data are available have a specific capacity of less than 2 liters per second per meter, however. The relationship between transmissivity and specific capacity is affected by such parameters as well efficiency, coefficient of storage, partial penetration, and geohydrologic boundaries. Because of the necessarily short duration and the uncontrolled discharge during the tests, more confidence is placed on the specific capacity figures as an indication of aquifer characteristics than on the calculated transmissivity. Figure II-7 shows the range and distribution of specific capacities.

From inspection of specific capacity and discharge, it is apparent that many of the existing wells could produce more water than they presently do; however, it is not possible to accurately predict the drawdown in the well at a much higher discharge by using the specific capacity at low pumping rates. Specific capacity and transmissivity are directly related for small pumping rates, but the relationship becomes invalid as the pumping rate becomes larger and well losses at the seepage face become a major factor in specific capacity, but do not change the transmissivity of the formation. In aquifers where flow is through fissures, high pumping rates may induce turbulent flow whereby the increase in friction losses is not proportional to the increase in flow. Also, in most cases the producing horizon is not known and if, by increasing discharge, the pumping level is drawn down below the producing horizon, no further increase in flow could be produced. Notwithstanding the limitations of extending specific capacity to higher pumping rates, it can be stated that few, if any, wells with a specific capacity of 2 liters per second per meter or more are pumping to capacity.

Comparison of the piezometric surface and the specific capacities on Figure II-7 suggests that the slope of the piezometric surface may give an indication of more favorable drilling areas. Groundwater flow can be described by the Darcy's Law equation:

$$Q = T\,W\,\frac{dh}{dL} \quad \text{and} \quad \frac{dh}{dL} = \frac{Q}{T\,W}$$

in which:

Q = Discharge from a section of aquifer, expressed in cubic meters per day;

T = Transmissivity of aquifer, expressed in square meters per day;

W = Width of the aquifer section, expressed in meters;

$\frac{dh}{dL}$ = Slope of the piezometric surface, expressed in meters/meter.

It is seen that for a unit width, W, the slope of the piezometric surface is directly proportional to Q and inversely proportional to T. When the piezometric surface is flat, it is an indication that either the transmissivity is high or there is very little groundwater flow. Conversely, when the slope of the surface is steep, the T is low or there is a large groundwater flow. The presence of a relatively steep slope to the

piezometric surface and the poor wells in the Soda-Karto area therefore seem to indicate an area of low T, and the flat piezometric surface in the area of high specific capacity wells east of Shass indicates an area of high T. A similar correlation also seems to be present east and southeast of Tell Basisa. Therefore, areas where the piezometric surface is relatively flat should be the more favorable areas for groundwater development.

The piezometric level map must be viewed with caution because it represents a composite of heads from various horizons. If there is insufficient areal vertical interconnection between aquifers to integrate the heads, the piezometric level in an individual well may not depict the general aquifer characteristics. However, only two wells near Semaryan have significantly anomolous heads when compared to the areal head distribution.

Figure II-7 indicates that both the Abrache and Arouse act as drains, the Arouse in its entire reach to the Janoubi and the Abrache as far as Tell Kazel. From Tell Kazel to the sea the Abrache is gaining. Between the two rivers, the mountains are drained largely in the subsurface as indicated by the "nose" in the contours south of Saboohiyeh.

Quality of Water

Over most of the area, the quality of groundwater is excellent. While no chemical analyses are available, electrical conductivity, which is an indication of dissolved salt content, ranges from 350 micromhos per centimeter to about 600 micromhos per centimeter over most of the Plain, indicating about 300 parts per million total dissolved solids. (See Figure II-8.) Toward the coast the conductivity rises into the 700 micromhos per centimeter range and, within one kilometer of the coast, up to 4800 micromhos per centimeter were observed. Well F-9, 2.5 kilometers from the coast, is anomalous, having an EC of 5000 micromhos per centimeter. No difference which could be related to aquifer lithology was seen in the conductivity. It is possible that chemical analyses would make such a differentiation.

The generally high quality of water and the high winter rainfall combine to avoid salt buildup in the soils as a result of use of groundwater.

Temperature

The temperature of the groundwater ranges from 19°C in the large spring upstream of the gaging station on the Kalife River to 23°C in two wells near Tell Snoon and Madhala. Most temperatures measured range between 21.5°C and 22.5°C. No temperature pattern is evident.

Present Groundwater Abstraction

The mean discharge of the 100 wells whose discharges were measured is 6.3 liters per second. It is estimated that an average farmer pumps eight hours per day from mid-April through September. At that rate, the annual withdrawal from the groundwater reservoir by the estimated 400 wells is 12 million cubic meters per year.

The well-irrigated area on the Plain has been estimated at 2500 hectares using several different criteria. The irrigation water requirement for two vegetable crops is about 0.7 meter with optimum management practice. Under present conditions it is doubtful that an average of over 0.5 meter is applied, requiring a yearly groundwater withdrawal of 12.5 million cubic meters. Perhaps an additional 1.0 to 1.5 million cubic meters are withdrawn from dug wells.

Recharge

Replenishment of the groundwater reservoir comes from three sources, direct infiltration of rainfall, infiltration from stream beds, and underflow originating in the mountains to the north.

Average annual precipitation on the Plain is 860 millimeters. Of this, it is estimated that about 44 percent of the winter precipitation, or 380 millimeters, runs off in rivers, streams, and drains. With full agricultural development, about 285 millimeters of the rainfall will be consumptively used, leaving about 195 millimeters for groundwater recharge from direct infiltration of rainfall. Over 22,000 hectares, this would yield 43 million cubic meters to groundwater storage from precipitation on the Plain alone. By introducing the average slope of the piezometric surface and the width of the aquifer section into the Darcy's Law equation, it was determined that an average transmissivity of about 850 square meters per day is required

to drain that quantity of groundwater flow from the Project Area. From the data obtained in the pumping tests performed, that transmissivity appears reasonable.

Lying inland from the Plain is an area in the mountains of about 600 square kilometers, from which the groundwater probably drains southwestward under the Plain to the sea. Rainfall in the area averages 1000 millimeters annually, of which about 55 percent is drained by the rivers. Consumptive use of precipitation in the mountains is probably the same as on the Plain owing to higher rainfall in the growing season and because of terracing. If this is true, about 90 million cubic meters of water would be found as annual underflow from the mountains to the sea.

Potential Development Areas

On the basis of the above considerations, the Project Area has been divided, for ease of description, into seven areas within which wells appear to derive water from the same or similar aquifers as shown on Figure II-8.

Area 1 includes all of the eastern and the south central parts of the Plain. It is underlain by extrusives. Most wells in this area were completed at between 30 and 50 meters in depth; only one well reached the underlying limestone. Permeability is probably largely controlled by jointing and the degree of weathering, and therefore varies greatly within a small area.

Area 2 is a small area in the center of the Plain around Soda and Karto. A surface layer of basalt has a thickness of between 15 and 40 meters and is underlain by limestone. The area is characterized by all of its wells being very poor. The underlying limestone has not been adequately explored.

Area 3 is also an area of basalt underlain by limestone, but all the wells visited in Area 3 had excellent specific capacity and yield characteristics. It is not clear whether the aquifer is basalt or limestone. As some of the good wells do not penetrate to the limestone, it seems likely that fractured basalt is the aquifer for all of the wells, perhaps being recharged by leakage from the limestone below.

Area 4 is a rather indistinct area against the northern hills in the central strip of the Project Area. As in Areas 2 and 3, it is predominately basalt underlain by limestone, but is an area of rather poor wells.

Area 5 covers most of the western part of the Akkar Plain. It has a mixed lithology, being typically alternations of so-called "blue clay", which appears to be marl, with thin horizons of basalt. The wells found in this area all have low specific capacities, although many have flowing artesian water.

Area 6 includes a strip of land along the northern bank of the Janoubi River between Bani Na'im and Khirbet Akrad. The aquifer is limestone which is similar to the Cretaceous limestone seen to the north of the Project Area. Wells are either very good or very poor.

Area 7 abuts the hills in the northwest of the Plain. Most wells are fairly deep penetrating into limestone which is probably Cretaceous. Well performances are generally moderately good, although two deep wells were failures. The piezometric map indicates that wells in the area west of Semaryan may intersect significant subsurface drainage.

CHAPTER III

PRESENT STATE OF DEVELOPMENT

The type of farming does not vary significantly on the Akkar Plain. The better irrigable land is used to produce a variety of vegetable crops. The average farmer has a small farm with little equipment; plowing is usually done by custom-hired tractor at least once a year and draft animals are still sometimes used. Planting is done by hand, except in the case of groundnuts which are sometimes planted by machine. Much labor goes into the cultivation of vegetable crops, especially tomatoes, cabbage, and eggplant. Vegetable seeds are planted in small plastic-covered hotbeds located close to the farmhouse and then seedlings are transplanted into the field. All weeding is done by hand, mostly by the women family members. As vegetables ripen, they are picked by hand.

Olives are an important crop to the economy of Syria. They are usually grown on lands unsuitable for field crops. After initial planting and cultivation, the olive tree requires periodic pruning until it is brought into full production in five to eight years. The crop is harvested by hand and used mostly for oil. Some of the crop is crushed in small, locally owned presses. The olive grower may interplant a crop between his trees, but after the trees are in full production this practice is discontinued. Most growers also raise a few vegetables and some grain to supplement their income.

Citrus production is limited on the Akkar Plain, although greater production is being encouraged by the Government. Those areas that now grow citrus are well drained and protected by windbreaks. Strong winds, either from the sea or from the mountains, make most areas of the Plain unsuitable for citrus unless protected by a windbreak. In addition, successful citrus production requires careful management and cultural practices.

The dry land crops utilize the residual soil moisture from winter and spring rains. Winter wheat crops are planted to make use of residual moisture, but the yields are low owing to poor root development caused by heavy winter rain. Sorghum is also planted in the spring in the heavy bottom lands.

LAND USE

The lands in the Project Area are presently used for agriculture, with a total of about 17,000 hectares under cultivation. Of this total, approximately 3,550 hectares are irrigated. Olive groves and hillside pasture occupy 2,300 hectares, mostly on Class 6 land. A very small percentage of the region which consists of roadsides, steep hillsides, and other areas not suited for agriculture is used for grazing.

The wet season crops include wheat, barley, lentils, chick peas, and beans. These crops, with the exception of the grains, are planted in early spring and use the residual moisture from winter and early spring rains.

The crops presently grown under irrigation are located close to dug wells, drilled wells, streams, and rivers. The area under irrigation is currently limited by the availability of water and the small pumping capacity at each water source. Vegetables are the main irrigated crops, with tomatoes, cucumbers, squash, and eggplant being the most prominent and profitable. Other small vegetables that are grown include onions, both green and dry, green beans, and peppers. Groundnuts are generally used as a second crop where possible, and maize is grown mainly as a windbreak for vegetables; both of these crops are planted in late spring.

The nonirrigated land is used to grow grain sorghum or is left idle after the harvesting of the winter crop. Vetch is also planted to make use of winter moisture, but only in selected areas.

LAND OWNERSHIP AND TENURE

The land area in the Akkar Plain is classified into four main areas or categories of ownership: private, reformed, cooperative, and government. Of the cultivated

land, 67 percent is owned privately, 30 percent is reformed land being purchased by the farmers, 2 percent is government land rented to the farmer, and 1 percent is owned by the cooperatives. Land owned by a cooperative is operated by farmers on a share crop basis, or farmers can receive a salary plus a share of profits at year's end.

The government-sponsored redistribution program, Agrarian Reform, was initiated in 1958. The program distributed land from large-scale farmers to the small operators. This land is being paid for at a nominal rate over a 20-year period. Most of the farmers received some land as a result of the Agrarian Reform program. The land was allocated to landless peasants and small-scale operators according to shares with the shares being based on family size. The average farm operator has 8.4 hectares, including land rented for his own use.

FARMING CULTURAL PRACTICE

Because of the small size of the farms, most farmers cannot afford to own tractors and essential farm implements. Approximately two-thirds of the farmers hire their plowing done and do some harvesting by machine. The remainder of the land is plowed by animals and harvested by hand. There is a lack of adequate tractors and farm implements in the Project Area which makes it difficult to till and harvest the crops at the optimum times.

Adequate equipment is not available to properly prepare the seedbed and cultivate the crops. Farm tillage operations are limited to tractor-plowing one or two times using either a moldboard or disk plow before seeding. Small grains are hand broadcast on the plowed surface then covered by a shallow plowing, resulting in poor germination of seed. No other tillage is performed on the small grains before harvesting. Vegetable crops are usually transplanted from farm hotbeds into the seedbed prepared in the same way as for a grain crop. Lack of surface finishing complicates the limited irrigation on the vegetable crops. Weeds are removed from row crops by hand.

Fertilizers and insecticides are commonly used on vegetable crops; nitrogen, phosphate and potash are the only fertilizers used. Micronutrients required have not

been made available to farmers. Farm operators often exceed the proper application rates for agro-chemicals, which increases the unit cost and has damaged crops in many cases. Agro-chemicals are seldom used on general field crops owing to the higher total cost for larger areas. Fertilizers and other chemicals are available through the cooperatives.

Harvesting of small grains is generally completed using large combines with straw accumulators on the discharge tunnels. Some grain is still cut with a binder then threshed in the field with a small stationary machine. Vegetables, including potatoes, are hand harvested. Groundnuts are tediously hand harvested from the heavy clay soils, leaving much of the crop in the ground.

Present Irrigation Practice

Most of the farm operators practice limited irrigation. There are four small diversions from the Abrache River which serve 147 hectares, but the Abrache becomes essentially dry during late spring and summer. There are several hundred drilled and dug wells in the Project Area and one hundred or more pumps on the Janoubi and Abrache Rivers. Pumps range from a few liters per second to 25 liters per second. Discharge lines are usually flexible polyethylene pipe which is lightweight and can be changed easily from one area or row to another.

CROPPING PATTERN

The present cropping pattern on the Akkar Plain shown on Table III-1 was determined from on-farm interviews and observations made during the growing season. Crops presently grown reflect both the capability of the soil and the demand for the product. Some crops, such as groundnuts, are not suited to the heavy clay soils, but farmers continue to produce the crop because of the strong demand in the market place and for family use as a source of protein. Other crops, such as wheat and barley, do not have a strong demand but do provide a return to the farmer under present nonirrigated conditions.

Sorghum is planted on the heavy, poorly drained land on areas subject to flooding. Maize is frequently produced on the same heavy soils as sorghum, but is also grown in the more arid uplands.

Table III-1
Present Cropping Pattern

Crop	Percent
Irrigated (some rainfed)	
Groundnuts	39.2
Tomatoes	14.0
Cucumbers	21.8
Green Beans	1.2
Squash	0.5
Melons	12.3
Eggplant	8.3
Potatoes	2.7
TOTAL	100.0
Nonirrigated	
Grains (wheat, barley, oats)	64.2
Beans	3.0
Chick Peas	4.7
Maize	1.2
Sorghum	26.7
Cabbage	0.2
TOTAL	100.0

Vegetables are produced where irrigation water is available, which includes some clay soils. Maize is often interplanted as a windbreak for vegetables. Availability of water is the main constraint in vegetable production. The crops grown around the wells and river diversions represent most vegetables that are in demand in Syria.

INFRASTRUCTURE AND MARKETING

Over fifty villages are presently within or adjacent to the Akkar Plain Project. The population of the villages ranges from less than 50 to approximately 2,000 at Safsafeh. In general, present infrastructure in the villages is inadequate to meet the needs of the people. Both farmers and nonfarmers living on the Akkar Plain must go to Tartous, Homs, or other major cities to obtain many services.

Marketing

Agricultural products produced on the Akkar Plain are marketed throughout Syria and any surpluses are exported. The Government has plans underway to control both export and import of agricultural products.

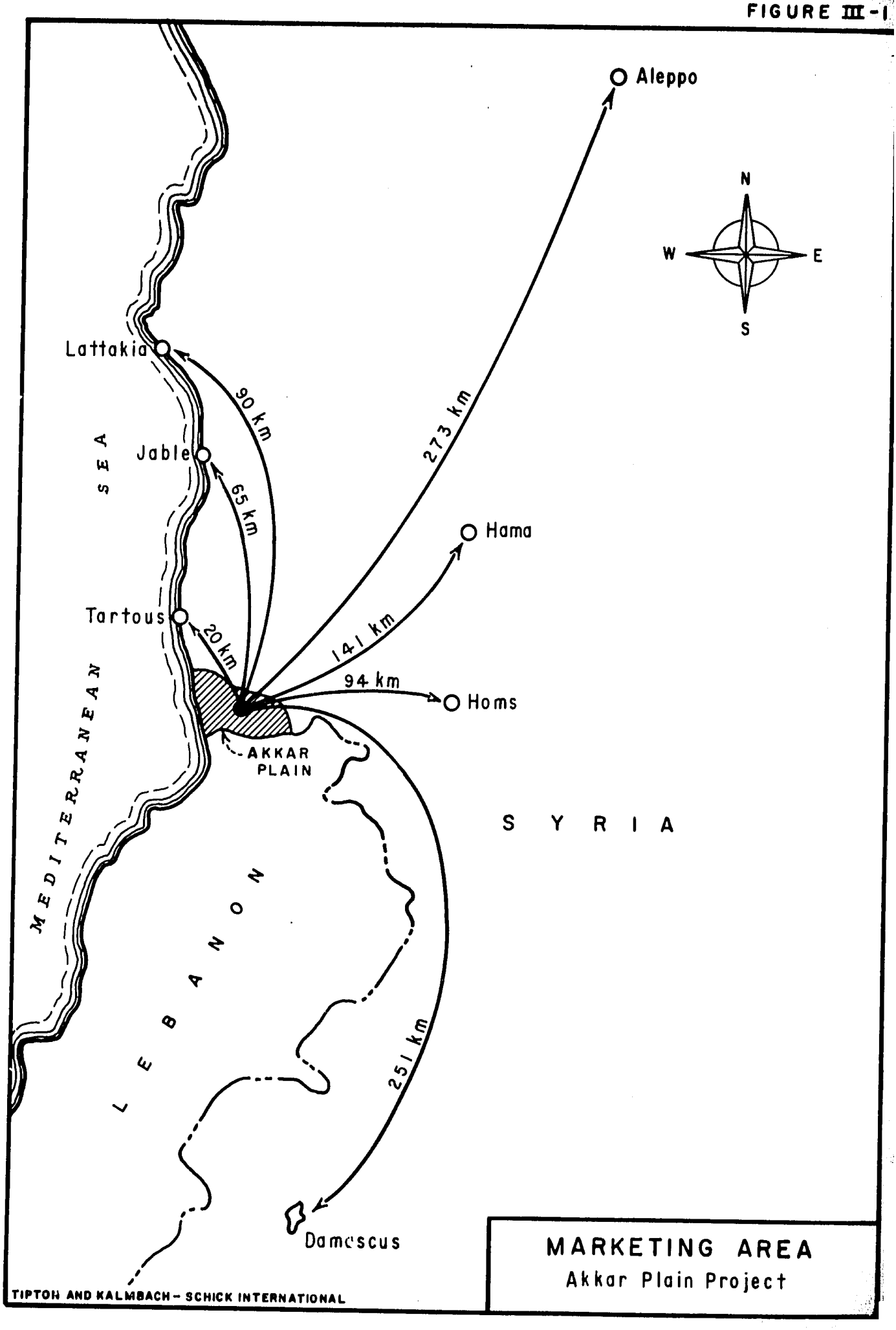
Because of the favorable climate and lower elevation, crops mature earlier on the Akkar Plain than near Homs, Hama, Alleppo, Damascus, and other inland market centers shown on Figure III-1, and thus bring higher early season prices. Farm products are commonly sold at Tartous and from small stands along the main highways. Products marketed in Tartous are sold mainly to the central cooperative market which consists of covered produce stalls rented to the wholesalers. The cooperative is administered by the Mohafaza. Marketing channels for farm products are illustrated in Figure III-2. Farm products are bought and sold daily as there is no storage or holdover capacity. Grading of agricultural products is done by the buyer and seller, so quality varies widely within each price range. Prices of basic products are controlled by the Government.

A new marketing facility is being constructed in Tartous by the Mohafaza. When completed, stalls or space in the facility will be rented to individuals or farmer-operated cooperatives to enable farmers to sell directly to consumers. The present system of wholesalers will be phased out over a few years. Each Mohafaza will set and control prices under direction from the Ministry of Agriculture in Damascus.

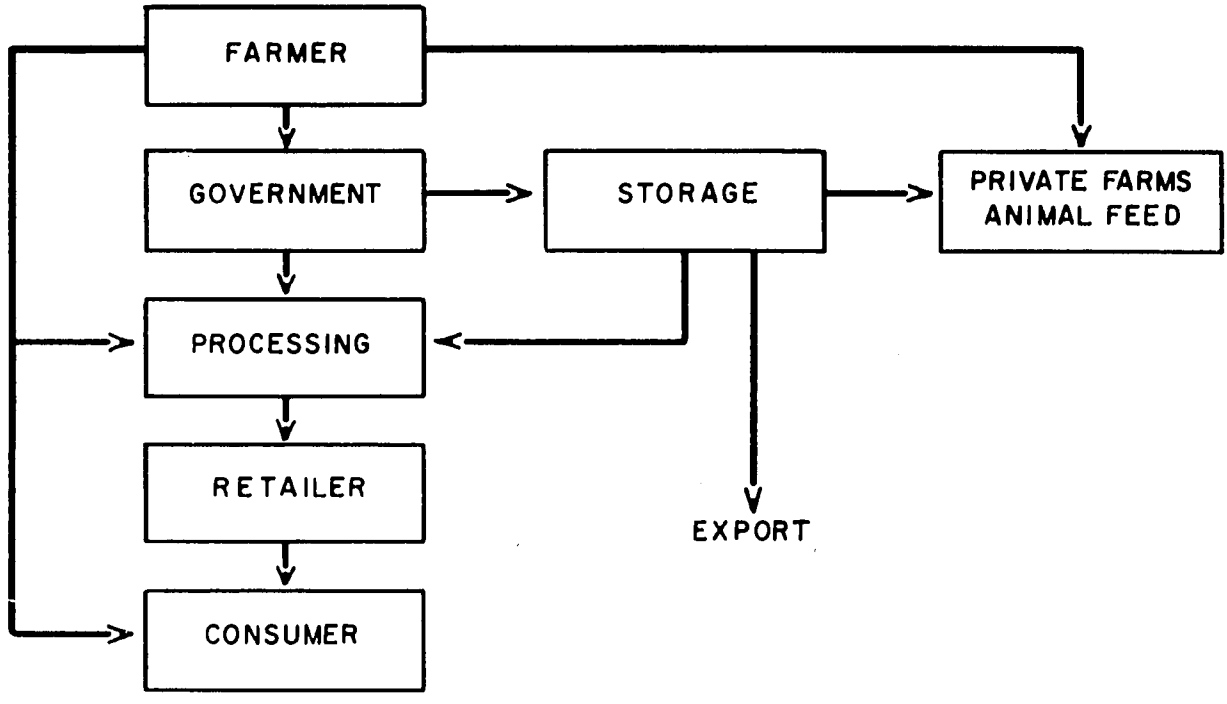
Storage Facilities

A cold storage warehouse (capacity 5,000 cubic meters) has been constructed by the Government at the Tartous port to handle vegetables, meat, and other perishables. This facility handles products being imported and exported, but additional capacity is available for rent to farmers and wholesalers. Grain silos are also under construction at the port. The first grain storage unit of 25,000 tons was completed in 1978. Three additional units of the same capacity will follow, making a total storage capacity of 100,000 tons within the next three to five years.

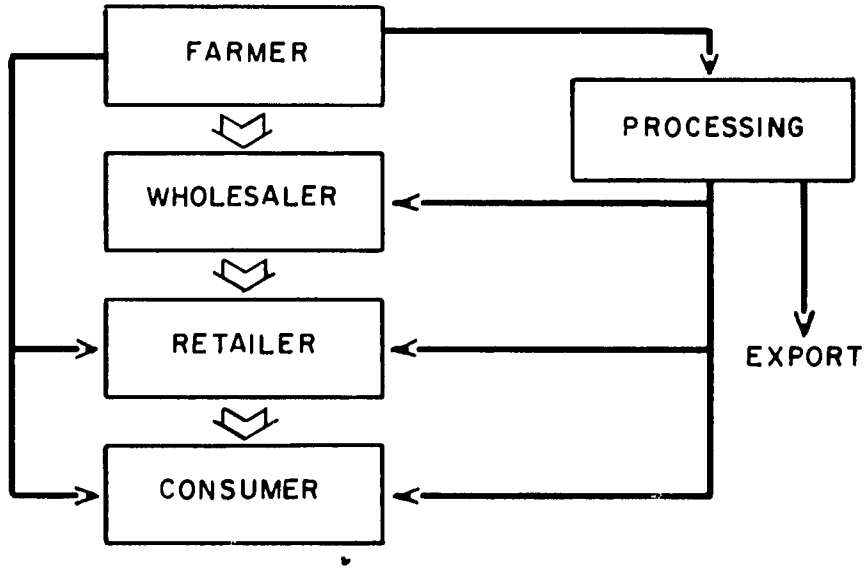
FIGURE III-1



MARKETING AREA
Akkar Plain Project



CEREAL CROPS



VEGETABLE CROPS

FARM PRODUCE MARKETING CHANNELS

Akkar Plain Project

TIPTON AND KALMBACH - SCHICK INTERNATIONAL

At the present time approximately 40 percent of the wheat, maize, and other small grains is used by the farm families. Essentially all of the grain is stored on the farm. The storage facilities vary widely in construction and losses from rodents and spoilage during the wet season are high.

Fruit and Vegetable Processing

There are no food processing or canning facilities in Tartous or near the vicinity of the project, except for groundnuts and olives. The neaest canning and processing plants are located at Jable and Lattakia, some 65 to 90 kilometers north of Tartous. Products canned at these facilities include tomatoes, beans, fruits, fresh jam, and apricot, orange, and tomato juices. Dairy and vegetable processing plants are located at Homs.

Animal Processing Facilities

The principal meat products, beef and mutton, are imported from Australia and Argentina. Minor amounts of pork, ham, and bacon are imported from European countries. There are several small slaughter houses in Tartous, but the nearest slaughtering and processing plant of commercial size and acceptable standards is located at Homs. The Government operates a poultry processing plant near Tartous.

Dairy Industry

Consumption of fresh milk is low in the Project Area and Syria in general. This is attributed to lack of refrigeration and dairy cows. However, consumption of cheese, yogurt, and other milk products is increasing. These products are imported from other areas of Syria and from foreign countries. There are only three small dairies with a total of less than forty cows in the vicinity of Tartous. Presently, milk production per cow is low compared with major dairy production countries. Production conditions and sanitation are substandard.

Farm-to-Market Roads

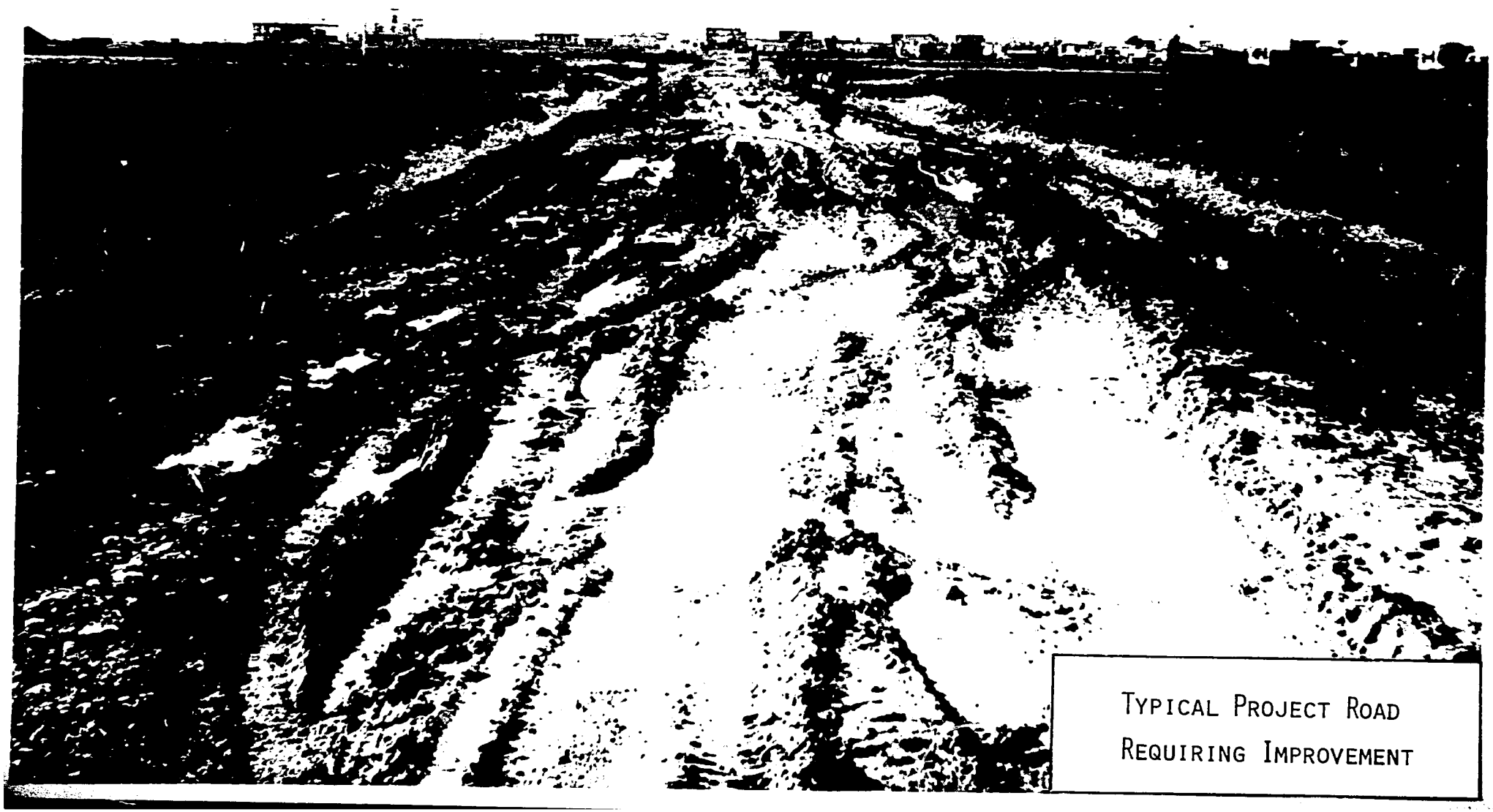
Construction and maintenance of roads and highways are the responsibility of the Transportation Department at Tartous. Two-lane asphalt-surfaced highways connect the Akkar Plain with Tartous, Homs, and cities in Lebanon. Truck transportation of exports and imports to and from the ports at Tartous and Lattakia have overtaxed the present highways causing high maintenance cost and creating hazardous conditions. A new four-lane expressway from Homs to Lattakia is presently under construction with completion scheduled for 1980. A network of graded roads, some with gravel surfacing only and some with gravel surfacing with an asphalt binder or tack coat, serves major villages on the Akkar Plain. These roads are narrow and are considered single lane under present standards; most roads in the area break up badly during the winter season. Villages served by unsurfaced roads are, in general, accessible only by tractors, burros, and foot travel during the wet season.

Farmer Cooperatives

Essentially all of the farmers are members of cooperative organizations, whether in their own village or a nearby village. Leaders of the cooperatives are usually appointed by the Government. The cooperative provides vital services to the farmers which include: obtaining and distributing fertilizer, seeds, and insecticides; arranging with the Agricultural Bank for credit for the purchase of seed, fertilizer, and machinery; and serving as a meeting place and limited retail outlet.

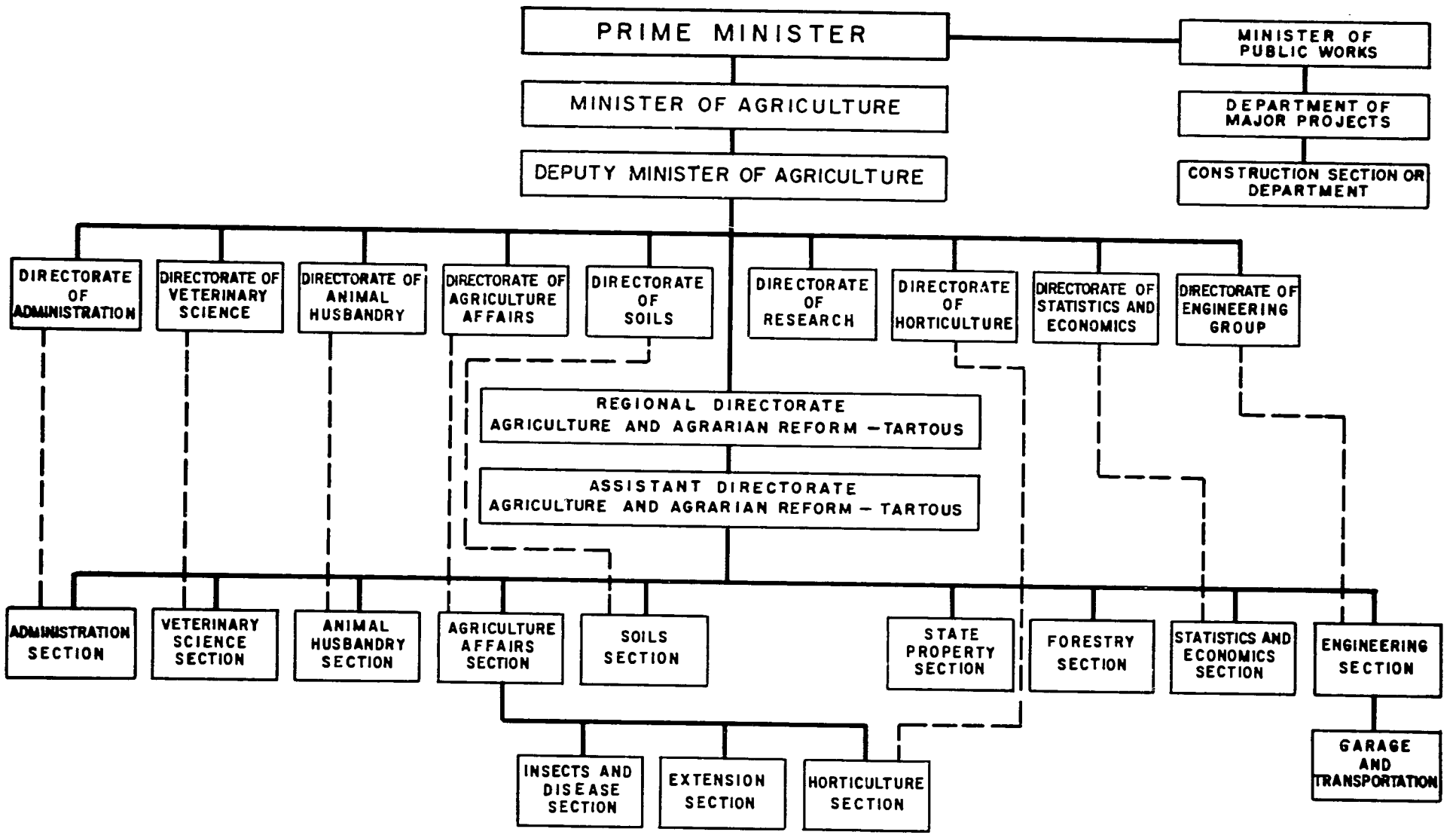
Agricultural Research Services

The Department of Agriculture and Agrarian Reform of the Ministry of Agriculture, with a regional office at Tartous, furnishes agricultural research services to the farmers on the Akkar Plain; the organization chart of the Department is shown on Figure III-3. Under the regional office there is an office in each Mantika which is staffed with an agricultural engineer and an assistant. The regional office conducts a two-phase program which consists of demonstrations of experiments which include the introduction of new fruits and vegetables in experimental or demonstration tracts



TYPICAL PROJECT ROAD
REQUIRING IMPROVEMENT

MINISTRY OF AGRICULTURE ORGANIZATION CHART



TIPTON AND KALMBACH - SCHICK INTERNATIONAL

FIGURE III-3

and holding meetings with village leaders and farm cooperatives to disseminate information and data useful to farmers.

Two research stations are located in Tartous, the Tartous Nursery and the Amrit Nursery. The Tartous Nursery is concerned with citrus and is primarily engaged in providing grafted trees and ungrafted seedlings to local citrus growers. Various kinds of other fruit trees and evergreen trees are also being grown at Amrit. Neither of these stations conducts research on vegetables or field crops; the nearest research station doing limited work on these crops is at Jable. The regional office has plans to set up a full-scale demonstration farm on the Akkar Plain, with construction of a research building or office at either Safsafeh or Hamidyeh. However, lack of funds has curtailed both that program and the regular research and development program.

Educational Facilities

The Government has placed a high priority on advancement of education since 1967 and has made education free and compulsory through the primary grades. The universities are supported by the Government and are also tuition free. This has caused a renewed interest in education, resulting in enrollment reaching 1,800,000 students at all levels. As a result, the Government has been unable to expand public school facilities at a rate sufficient to meet the demand.

The public school system in Syria is divided into six years of primary school (ages 6 to 12); three years of intermediate school (ages 12 to 15); and three years of secondary school (ages 15 to 18) to prepare students for university entrance. Universities are located at Lattakia, Alleppo, and Damascus.

Educational facilities available in the project area villages include a primary school in most villages; intermediate schools at Arzooneh, Hamidyeh, and Safsafeh; and secondary schools at Safsafeh and Karto. Vocational schools are available at Tartous and are attended by some students from the Project Area. School facilities available in the Project Area are inadequate under present conditions and, unless improved, would become more so under full project development.

School buildings are, in general, undersized and have poor lighting, heating and ventilation. Classrooms are overcrowded and must accommodate several grades. The number of students per teacher is high, school supplies are inadequate, sanitary facilities are poor, and playground or physical development facilities are essentially nonexistent, especially in primary schools. Students attending intermediate and secondary schools walk long distances owing to lack of transportation.

Health Facilities

There are one government-owned and one private hospital at Tartous. These hospitals are staffed and equipped to handle general medicine and emergencies. A new 500-bed hospital is planned at Tartous, but has not yet been funded. Dental offices are also located at Tartous.

The major health problem is the low ratio of doctors and dentists to the population, about 1:4,000 persons. A secondary problem is the lack of transportation to the villages. To alleviate these conditions, health care centers have been established at Hamidyeh and Safsafeh and are staffed with one doctor and two nurses, one of whom is a midwife. Each of the villages has a midwife. One of the most important health needs at the villages is proper postnatal care for both mother and child.

Doctors and/or nurses visit the schools periodically to inoculate the children, but there is a lack of transportation for timely medical aid to reach the villages in case of epidemics or other emergencies. Cholera and tuberculosis are common in the area; the most common health problems in the villages result from untreated culinary water and lack of personal sanitation.

Domestic Water

At the present time, a well and elevated storage tank located at Deir Hajar provides culinary water to six villages in the vicinity. The Department of Public Works is presently constructing a domestic water system at Karto. The system, which consists of two wells at Karto with elevated storage tanks at Karto and Tell Snoon, was completed during 1978 and will serve eleven villages in the area. The

Department plans to start work in the near future on the construction of wells and storage tanks between Zahed and Dakaka which would supply culinary water to nine villages in that area. Villages served or which will be served under each of these systems are shown on Figure III-4.

The systems supply water to standpipes and faucets in each village. Property owners are responsible for piping the water to their residences. In general, the water is handcarried from the central hydrants to the residences. The cost of extending service lines to each residence is probably the deterring factor. Water is tested periodically but is not chlorinated or otherwise treated unless the tests indicate the necessity. Other villages in the area obtain domestic water from shallow wells with hand pumps, irrigation wells, springs, and streams. The water is handcarried from these sources to the residences.

Telephone Service

At the present only four project villages have telephone service: Safsafeh, Hamidyeh, Arab Shati, and Karto; see Figure III-5. Hamidyeh and Arab Shati are served by a 10-line circuit from Tartous, and Karto is served by a branch line from Safsafeh. Only one telephone is located in Arab Shati and Karto. There are no plans at the present time for extension of telephone service to other project villages.

Electrical Service

Tartous is presently served by a 66 KVA transmission line from Homs plus a diesel electric plant. A second 230 KVA transmission line from Homs to Lattakia is under construction. These transmission lines cross the northwest side of the Project Area. An intertie line, which traverses the project north to south near the center, will connect the 230 KVA line to transmission facilities in Lebanon. A secondary transmission line (20 KVA) serves the villages of Hamidyeh and Arab Shati. The Government plans to extend electric service to Kharabeh, Deir Hajar, and Karto by 1980; see Figure III-6.

PRESENT YIELDS AND VALUES

The present yields for crops on the Akkar Plain as shown on Table III-2 were determined through farm interviews at each village on the Plain. All yields are very low compared to yields in the United States, showing the adverse effects of poor drainage, lack of adequate irrigation water, and the other constraints existing on the Akkar Plain. The present situation is improving with the use of improved seeds and the application of commercial fertilizers, but physical constraints still limit the amount of production.

Table III-2
Present Crop Yields

Crop	Average Yield Per Hectare
Wheat	0.9 tons
Tomatoes	10.5 tons
Sorghum	0.8 tons
Pasture	2.5 animal unit months
Forage	0.6 tons
Citrus	Not established
Maize - grain	1.5 tons
Dry Beans	1.0 tons
Chick Peas	0.8 tons
Potatoes	12.3 tons
Cabbage	7.6 tons
Melons	7.7 tons
Cucumbers	10.1 tons
Peanuts	1.6 tons

Value of Production

The present production of the Akkar Plain was determined by multiplying the yields shown in Table III-2 by the area of each crop planted. The value of production was then determined by multiplying the total production of each crop, expressed in tons, by the farm gate prices of agricultural products in the Akkar Plain. The value of farm product shown in Table III-3 is largely derived from world market prices except for a few items such as peanuts, forage and beans, which are based on actual farm gate prices in the Project Area.

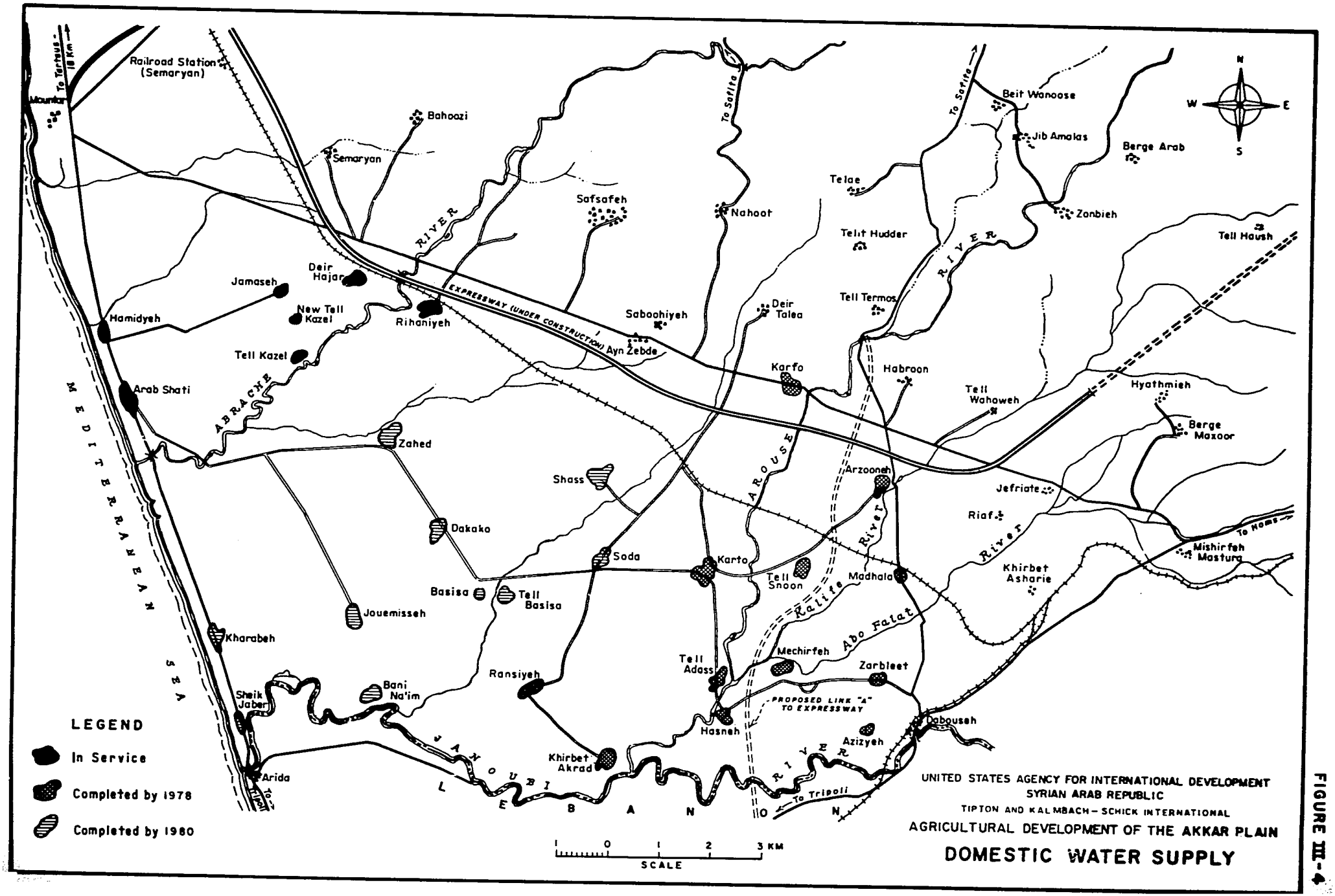

Railroad Station (Semaryan)
To Tartous 18 Km
Mountar
Bahoozi
Semaryan
Safsafeh
Nahoot
To Safita
Telae
Telit Hudder
Tell Termos
Beit Wanoose
Jib Amalas
Berge Arab
Zonbieh
Tell Haush
Deir Hajar
Jamaseh
New Tell Kazel
Rihaniyeh
Hamidyeh
Tell Kazel
Arab Shati
ABRACHE RIVER
EXPRESSWAY (UNDER CONSTRUCTION)
Saboohiyeh
Ayn Zebde
Deir Talea
Karfo
Habroon
Tell Wahaweh
Hyathmieh
Berge Mazoor
Zahed
Shass
Arzooneh
AROUSE RIVER
Jefriate
Riaf
Dakako
Soda
Karto
Tell Snoon
Madhala
Khirbet Asharie
Mishirfeh Mastura
To Homs
Basisa
Tell Basisa
Jouemisseh
Kharabeh
Kalife River
Abo Fatat River
Mechirfeh
Zarbleet
Tell Adass
Ransiyeh
Bani Na'im
Sheik Jaber
PROPOSED LINK "A" TO EXPRESSWAY
Hasneh
Dabouseh
Azizyeh
Khirbet Akrad
Arida
To Tripoli
JAOUBI RIVER
LEBANON
MEDITERRANEAN SEA
LEGEND
In Service
Completed by 1978
Completed by 1980
SCALE
1 0 1 2 3 KM
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
DOMESTIC WATER SUPPLY

FIGURE III-4

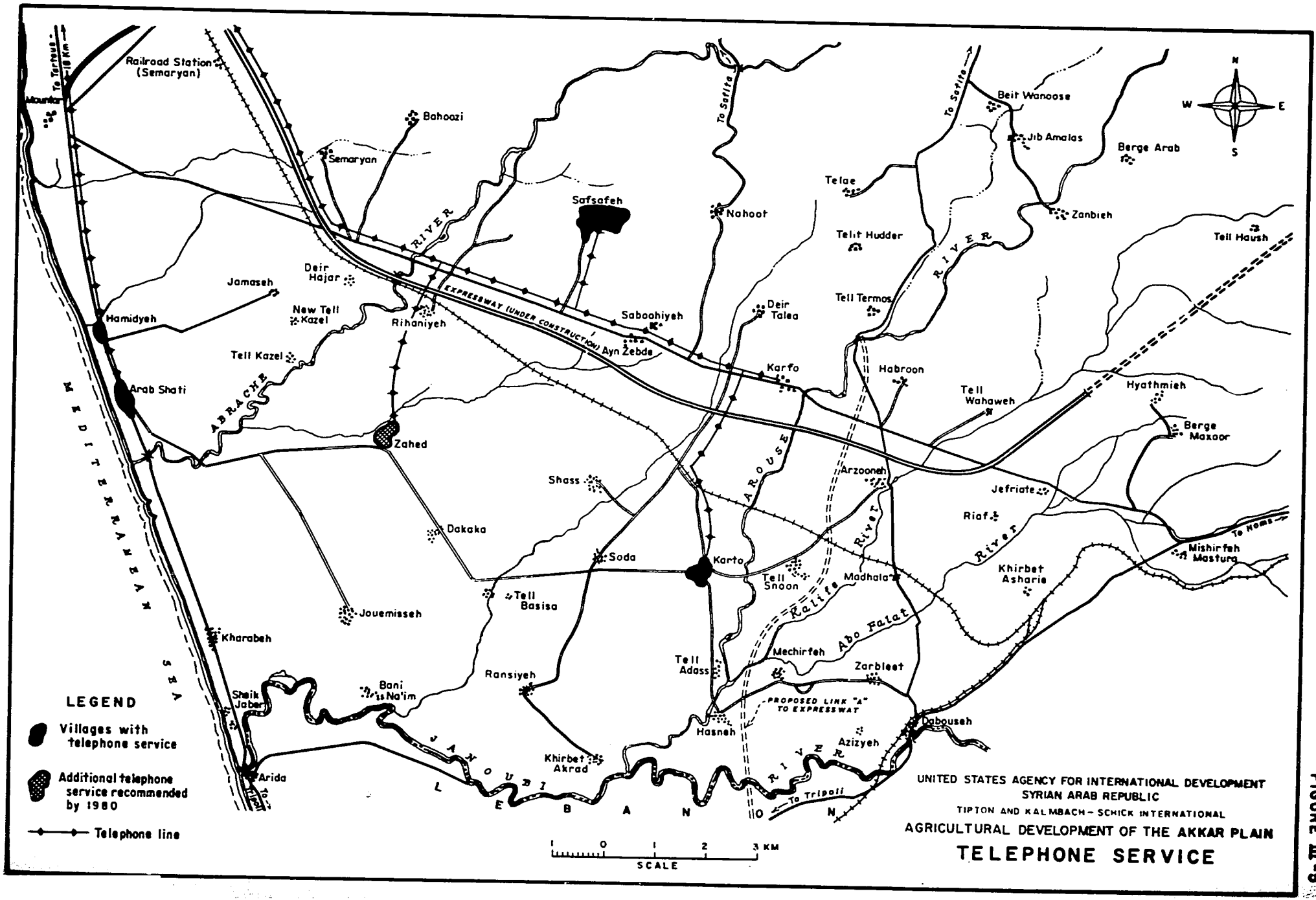

Railroad Station (Semaryan)
To Tartous 18 Km
Mountar
Bahoozi
Semaryan
Safsafeh
Nahoot
To Safita
Telae
Telit Hudder
Tell Termos
Beit Wanoose
Jib Amalas
Berge Arab
Zanbieh
Tell Haush
Hyathmieh
Berge Maxoor
Jefriate
Riaf
Mishirfeh Mastura
To Homs
Khirbet Asharie
Madhala
Tell Snoon
Habroon
Tell Wahaweh
Arzooneh
Karfo
Deir Talea
Saboohiyeh
Ayn Zebde
EXPRESSWAY (UNDER CONSTRUCTION)
RIVER
Deir Hajar
Jamaseh
New Tell Kazel
Rihaniyeh
Hamidyeh
Tell Kazel
Arab Shati
ABRACHE
Zahed
Shass
Dakaka
Soda
Karto
Tell Basisa
Jouemisseh
Kharabeh
Sheik Jaber
Bani Na'im
Ransiyeh
Khirbet Akrad
Arida
To Tripoli
Tell Adass
Hasneh
Mechirfeh
Zarbleet
Azizyeh
Dabouseh
PROPOSED LINK "A" TO EXPRESSWAY
Ratifa
Abo Fatat
AROUSE
River
MEDITERRANEAN SEA
LEBANON
N
S
E
W
LEGEND
Villages with telephone service
Additional telephone service recommended by 1980
Telephone line
0 1 2 3 KM
SCALE
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
TELEPHONE SERVICE

FIGURE III-6

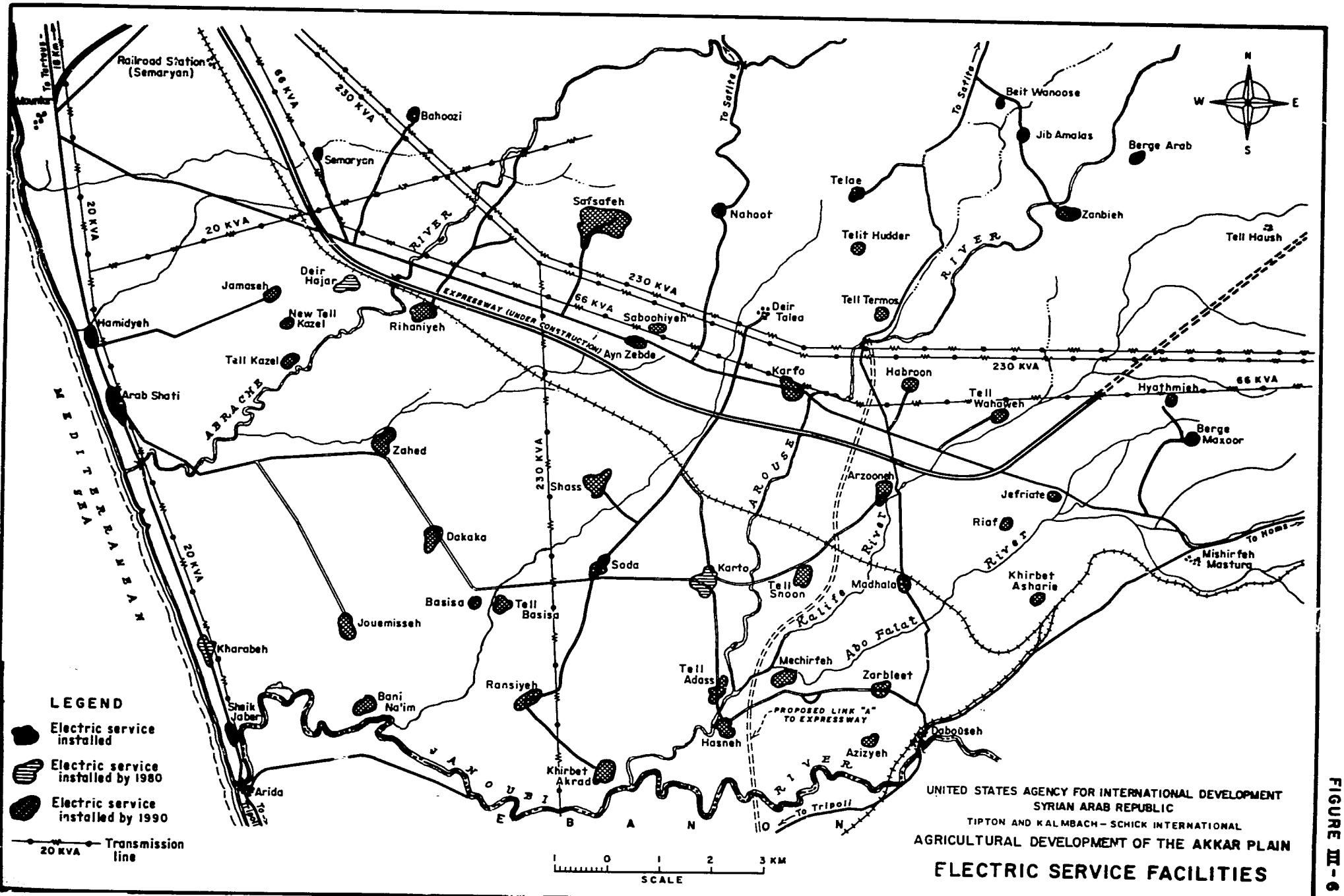

Railroad Station (Semaryan)
To Tartous 18 Km
66 KVA
230 KVA
20 KVA
Bahoozi
Semaryan
Safsafeh
Nahoot
To Safita
Telae
Telit Hudder
Tell Termos
Beit Wanoose
Jib Amalas
Berge Arab
Zanbieh
Tell Haush
Deir Hajar
Jamaseh
New Tell Kazel
Hamidyeh
Rihaniyeh
Saboohiyeh
Ayn Zebde
Deir Talea
Karfo
Habroon
Tell Wahaweh
Hyathmish
Berge Maxoor
Tell Kazel
Arab Shati
ABRACHE
MEDITERRANEAN SEA
Zahed
Shass
Arzooneh
Jefriate
Riaf
Dakaka
Soda
Karto
Tell Shoon
Madhala
Mishirfeh Masturq
Khirbet Asharie
To Homs
Basisa
Tell Basisa
Jouemisseh
Kharabeh
Mechirfeh
Abo Falat
Zarbleet
Tell Adass
Ransiyeh
Bani Na'im
Sheik Jaber
PROPOSED LINK "A" TO EXPRESSWAY
Hasneh
Dabooseh
Azizyeh
Khirbet Akrad
Arida
To Tripoli
ARUSS
Kalife River
Abo Falat River
ORONTES RIVER
LEBANON
LEGEND
Electric service installed
Electric service installed by 1980
Electric service installed by 1990
20 KVA Transmission line
SCALE
1 0 1 2 3 KM
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
ELECTRIC SERVICE FACILITIES

FIGURE III-6

Table III-3
Summary of Farm Prices

Crop	Farm Gate Price (U.S. $/ton)	(SP/ton)
Wheat	155.76	607.46
Sorghum	123.11	480.13
Tomatoes(1)	105.13	410.01
Peanuts	400.00	1,560.00
Maize (table)	177.00	690.30
Maize (grain)	125.41	489.10
Forage	44.00	171.60
Beans (dry)	194.87	759.99
Citrus	263.00	1,025.70

(1) Represents price used for all vegetables

The estimated present production and value of production of the Akkar Plain is shown in Table III-4. The present value of production is estimated to be SP 44,279,000.

Table III-4
Present Production and Value of Production
(17,179 ha)

Crop	Production (tons)	Unit Price (U.S. $/ton)	Total Value (U.S. $)
Feed Grains			
Wheat	6,480	155.76	1,009,325
Sorghum	1,958	123.11	241,049
Subtotal - Feed Grains	8,438		1,250,374
Groundnuts			
Peanuts	4,398	400.00	1,759,200
Vegetables(1)	21,646	105.13	2,275,644
Cucumbers	36,076	105.13	3,792,670
Melons	21,646	105.13	2,275,644
Total	92,204		11,353,532
			SP 44,279,000

(1) Represents all vegetables

CONSTRAINTS TO IMPROVED AGRICULTURE

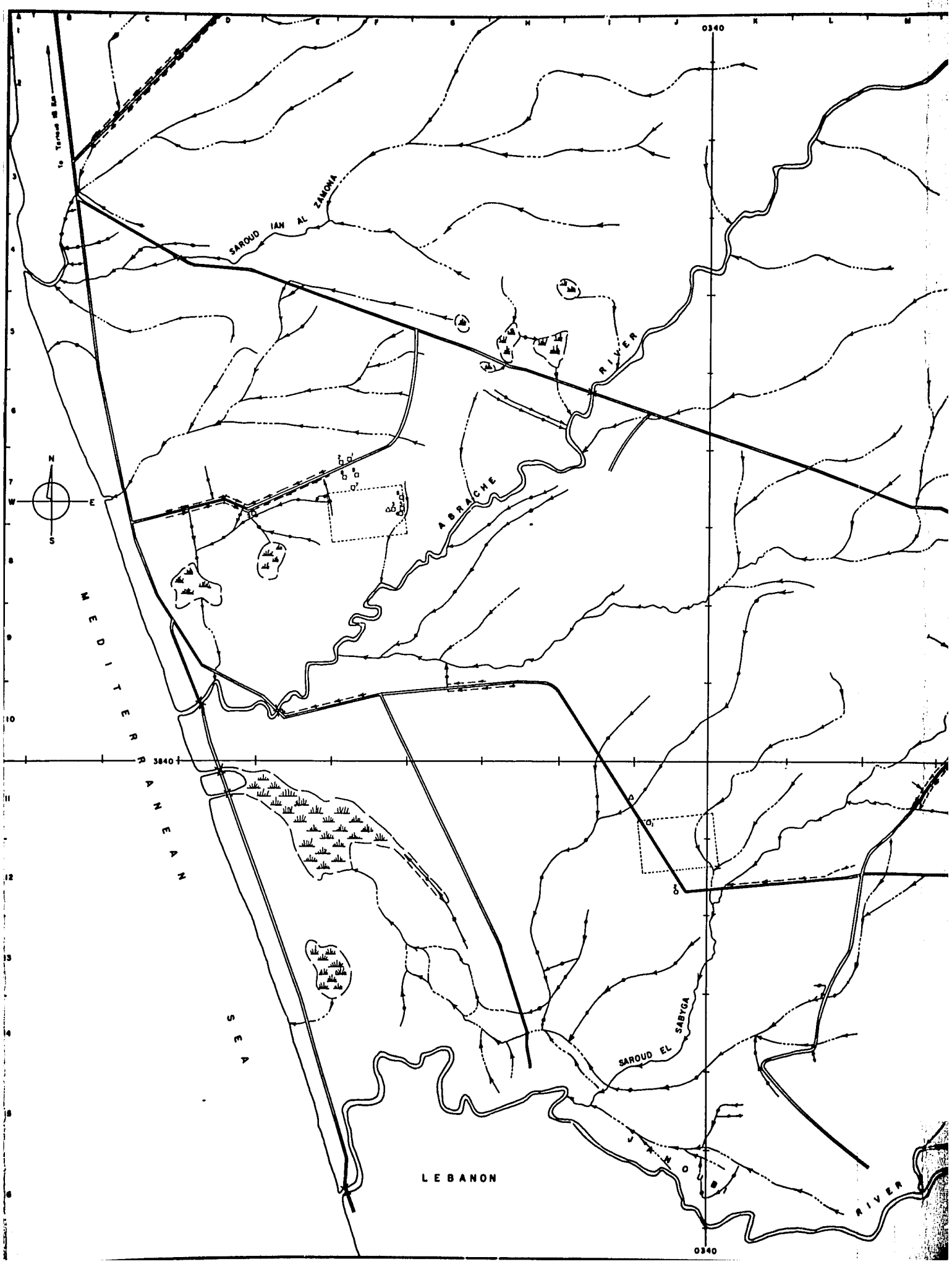
There are many factors that adversely affect the productivity on the Plain. Heavy seasonal rains and ponding of water make cultivation impossible in early spring and cause damage to crops planted in the fall. The lack of moisture in the summer makes the growing of any crop difficult without irrigation. Those crops which are irrigated obtain water from drilled or dug wells by low volume pumps designed to supply only one or two hectares.

Drainage

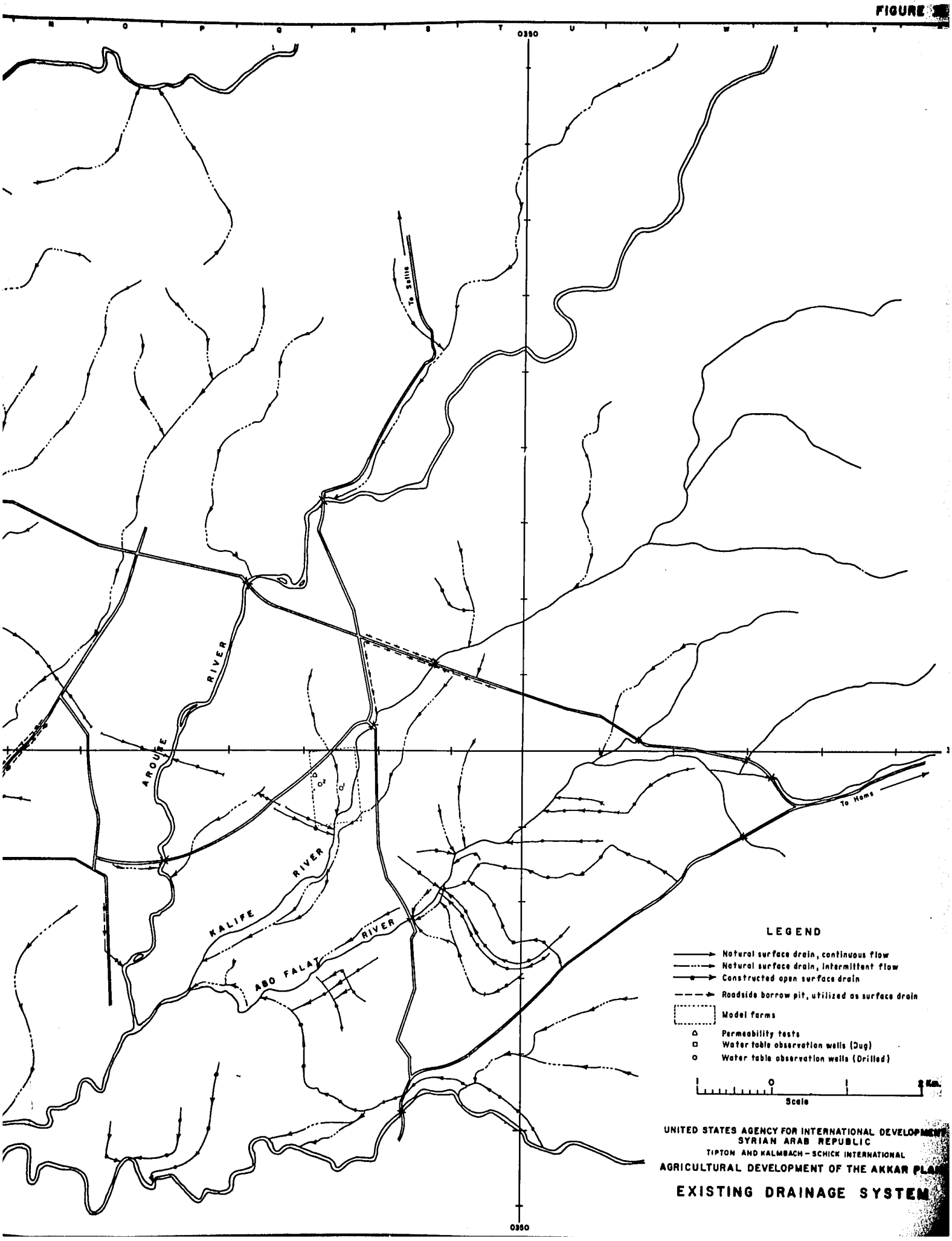
The inadequacy of surface drainage on the Plain is a definite constraint to improved agriculture. Because of inadequate drainage, the lands are subject to various degrees of temporary inundation. As a result, the soil remains saturated for an extended period of time, which limits the root development of winter crops and delays planting of spring crops. However, the existing drainage system which serves the Plain is quite extensive throughout the total area. These drains, shown on Figure III-7, are adequate on most of the higher lands, but are not adequate on the lower lands. The total length of the existing drainage system is 120 kilometers.

River Flooding

Flooding from the Janoubi River during heavy winter storms restricts crop production on an extended area in the southern portion of the Project Area. The floodwaters temporarily inundate about 850 hectares of irrigable lands in about two of every three years and approximately 1,300 hectares once in 10 years. Several periods of flooding may be expected, as in the winter of 1977-78 when three such floods occurred.


SAROUD IAN AL ZAMONA
RIVER
ABRACHE
MEDITERRANEAN SEA
LEBANON
SAROUD EL SABYGA
JANOUB
RIVER
0340
3840
0340
N
S
E
W

FIGURE


0350
To Salia
To Homs
AROUSE RIVER
KALIFE RIVER
ABO FALAJ RIVER
LEGEND
Natural surface drain, continuous flow
Natural surface drain, intermittent flow
Constructed open surface drain
Roadside borrow pit, utilized as surface drain
Model farms
Permeability tests
Water table observation wells (Dug)
Water table observation wells (Drilled)
0
Km.
Scale
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TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLA
EXISTING DRAINAGE SYSTEM

CHAPTER IV

POTENTIAL DEVELOPMENT AND CRITERIA

The Akkar Plain in its present state has all of the components required to develop an intensive irrigated agricultural economy except one. It has good soils, favorable climate, industrious and intelligent farmers, a ready market, and only an ensured water supply during the growing seasons is lacking. While some water development can and is being carried out through private efforts in the form of wells, small pumps in the rivers, and crude river diversions, project-type works are required to fully correct major problems and to maximize the use of the water resources of the region. These integrated project works are: flood control and drainage works; one or more major storage reservoirs to capture winter runoff to serve a comprehensive irrigation system; and infrastructure improvements. In addition to these works, a study is required to explore and to evaluate the feasibility of fuller development of the groundwater resources. In this chapter, the present constraints of agriculture in the wet and dry seasons and potential development are discussed.

FLOOD CONTROL

Some 800 to 1,300 hectares of land are affected by flooding from the Janoubi River, resulting not only in damage to lands and roads but in loss of crop yields because of the late planting. Some of the best lands in the area are flooded each rainy season, including part of the potentially productive citrus land.

Based on visual evidence and many interviews with local farmers, some degree of flooding over the river bank occurs along approximately a 10-kilometer reach of the river extending downstream from the vicinity of Khirbet Akrad. The flooding is most severe in the upper and central reaches where the channel is smallest and is restricted by heavy brush growth. Under existing conditions, the minimum degree of flooding is experienced on the lower river reaches. This is because most of the

surplus flow spills from the river channel in the upper reaches and there is comparatively little tributary inflow below those points. To achieve full development, all of the flows should be contained within the river channel.

During the study period, major storms which produced flooding of the Janoubi River occurred on December 17, 1977 and on January 17, 1978. The maximum flood discharges during these storms in the Ramit Laha outlets were estimated to be approximately 66 cubic meters per second. It was estimated that 16 cubic meters per second of this flood flow was contributed as direct runoff from the Akkar Plain, with the remaining 50 cubic meters per second resulting from Janoubi River water overflowing the river bank below Khirbet Akrad.

During the June 1978 field review of engineering surveys of the Janoubi River channel, it was estimated that about one-third of the total floodwaters overtopping the river banks flowed to the south, or over the Lebanon bank of the river. Based on this estimate, the excess flood flows during the winter storms of 1977-78 which could not be contained by the Janoubi River channel below Khirbet Akrad were approximately 75 cubic meters per second, with about 25 cubic meters per second flooding to the south side along a noncontiguous river reach of about 7.0 kilometers. From inspection of available maps, it appears that most of this flood flow on the south side returns to the Janoubi River approximately 0.5 kilometer above its mouth.

SURFACE DRAINAGE

If the Janoubi River were completely controlled, there would still be loss to the agricultural production of the Plain because of waterlogging, ponding, and erosion by runoff from precipitation. Because of the relatively impermeable soil and flat topography, the heavy winter rains cannot be drained expeditiously by existing drainageways. This delay in drainage causes some areas to be planted months after the ideal time. The surface drainageways which exist are totally inadequate.

The existing drains which require improvement total 120.5 kilometers in length and are concentrated on the western portion of the Akkar Plain. They consist of the following drain categories and accumulated lengths:

Natural Drains (intermittent flow)	57.2 km
Natural Drains (perennial flow)	11.4 km
Roadside Borrow Pits	13.4 km
Constructed Surface Drains	38.5 km

Natural drains with intermittent flow represent about one-half of the total existing drains which require improvement. These drains flow only during the rainy season and have an estimated average capacity of approximately 50 percent of the required capacity. One of the significant problems relating to the inadequacy of the drains is the undersized road culverts which create excessive flooding of the related roads and adjacent land areas. Each of the natural drains with intermittent flow, including its culverts, would be enlarged to carry the estimated 5-year frequency storm.

The natural surface drains with perennial flow have an accumulated length of 11.4 kilometers and include three large channels. Each of these channels is spring fed with decreased flows in summer and has only about 55 percent of the capacity required to adequately control heavy storm runoff. Each channel is presently covered with brush because of the constantly available moisture.

The roadside borrow pits utilized for drainage purposes have an accumulated length of 13.4 kilometers. The borrow pits are inadequately sized to accommodate storm drainage, have many man-made restrictions, and appear to have no maintenance. It is estimated that under existing conditions the average channel section has only about 60 percent of the total required capacity.

The constructed drains which need improvement have an accumulated length of 38.5 kilometers. Most of these drains probably originated as natural drains; but because of their insufficient capacity, local farmer groups have enlarged them to provide some of the needed control of the drainage water. However, it is evident that the size of these channels is insufficient to control storm runoff. On the average, these channels are estimated to be only 50 percent of the required size.

A subsurface drainage deficiency exists on a long, narrow strip of land lying at the base of a major topographic break located approximately 3.5 kilometers east

of and parallel to the Mediterranean seacoast. This drainage deficiency is a result of high water table conditions caused partially by artesian pressure resulting from an abrupt drop in the land surface and because the drainage capacity of the permeabl subsurface material is exceeded.

Alleviation of surface and subsurface drainage problems in the Project Area would benefit the entire area by allowing timely planting, easier communication, and less damage to various facilities. Further, immediate benefits would accrue both directly to agriculture and to the other facets of development on the Plain.

IRRIGATION

Intensive agriculture on the Plain is not possible without irrigation. Dry land cropping produces only a single grain crop per year and by itself is not capable of supporting the cultivator. Irrigation during the dry season has been carried out for years in some small areas along the rivers and at locations where shallow wells supply water for a few hectares of summer crops. More recently, drilled wells have been constructed and now serve about 2,500 hectares and undoubtedly have the capability to serve twice that area. In addition, there is much more irrigable land, which can only be irrigated by a system of storage reservoirs and conveyance canals.

As shown in Chapter II, there is a sufficient volume of water available to the Project Area to irrigate a large portion of the Plain. However, the seasonal distribution of precipitation and river flow is such that little use can be made of this resource unless reservoirs are provided to capture the excess stream flow in the rainy season for subsequent release during the summer months. The requirement for storage is paramount. Without it, no significant development of the surface water resource is possible.

Development of a storage site, or sites, to regulate the area's surface water resources was not part of the work included in the terms of reference for this Report. That study was done by Sofrelec of Paris, and it was determined that storage on the Arouse is not possible and that the feasibility of a reservoir on the Abrache is questionable. Since those conclusions were not known until the present study was

well under way, the assumption is made in this Report that further investigations will determine the locations of viable storage sites of adequate capacity to supply the canal system serving the Akkar Plain Project.

The private sector has made a good effort in exploiting groundwater for irrigation. With a canal system, there still will exist the need for wells since only part of the available land can be served from canals. Further, during periods of drought, groundwater will be invaluable as a supplementary source. It is probable that deep drilling would demonstrate a much larger groundwater reservoir than is now known, exploitation of which might markedly increase the area of double-cropping.

Potential for Surface Water Development

Surface water is presently used to irrigate only a small fraction of the land on the Akkar Plain--about 1,000 hectares by gravity diversion and a smaller area by pumping from rivers and drains. Given the seasonal pattern of flow of the rivers, no significant expansion of the surface irrigated area could be made without storage of winter flow. With storage, however, the area which could be double-cropped through irrigation could be greatly increased.

The average annual combined flow of the Abrache and Arouse Rivers, virtually all of which is unused, was over 110 million cubic meters during the period 1965 to 1972. If it were possible to store all unused flow for distribution in the growing season, that average flow would provide water for over 10,000 hectares of double-cropped land. A system of canals would be required to convey the water to the fields, but no difficulty is foreseen in constructing such a system. Thus, the key for achieving the full potential of agricultural development of the Plain is to provide storage.

Sofrelec examined several sites on the Arouse River and concluded that no reservoir was feasible along that river due to excessive permeability of the bedrock. In the Abrache Basin, a topographically favorable dam and reservoir site was found near Yazdieh (Figure IV-1). The bedrock, consisting of karstic limestone, in the reservoir area at Yazdieh, however, is also quite permeable. It was concluded that a grout curtain could probably be constructed which would control the leakage

sufficiently to affect storage. A scheme was conceived by which the Arouse would be diverted by a low weir near Berge Arab and conveyed to the Abrache Basin via a canal so both rivers could be controlled in one reservoir. The optimum height of the dam was determined to have a full reservoir level of elevation 120 meters and would produce an annual yield of 77 million cubic meters to 98 million cubic meters, depending upon whether the Abrache alone or the Abrache plus Arouse are regulated.

Because of the questions regarding the permeability of the basin and the indeterminate extent and cost of grouting which may be required to control leakage, Sofrelec suggested that the site be developed in stages, the first stage being 40 meters high, to elevation 100 meters. A reservoir of that size would yield from 55 million cubic meters per year to 71 million cubic meters per year depending upon whether one or both rivers are controlled.

It was concluded that no reasonable amount of further investigations could determine the magnitude of grouting which would be needed to ensure the integrity of the reservoir. Sofrelec, therefore, suggested that the 40-meter high dam be built as an experiment and the grouting program be staged to determine the requirements. The cost of the dam was estimated to range from about U.S. $20 million to U.S. $100 million depending upon the grouting required.

Because of the risk of excessive leakage and high cost involved with the Yazdieh site, a field reconnaissance was made to ascertain if alternative sites for storage exist. This reconnaissance supported Sofrelec's conslusions: that there is no suitable storage site on the Arouse and that the hazard of excessive leakage at Yazdieh on the Abrache is great. There is, however, a possible alternative site on the Abrache River downstream of Yazdieh, near the town of Rihaniyeh, as shown on Figure IV-1.

Topographically, the Rihaniyeh site is not as favorable for construction as is the Yazdieh site, but the reservoir area appears from the surface to be more impermeable than at the upstream site. While much of the reservoir area is probably underlain by Cretaceous limestone, the rock represents a higher stratigraphic section than that found to be so permeable at Yazdieh. In addition, several dry holes are

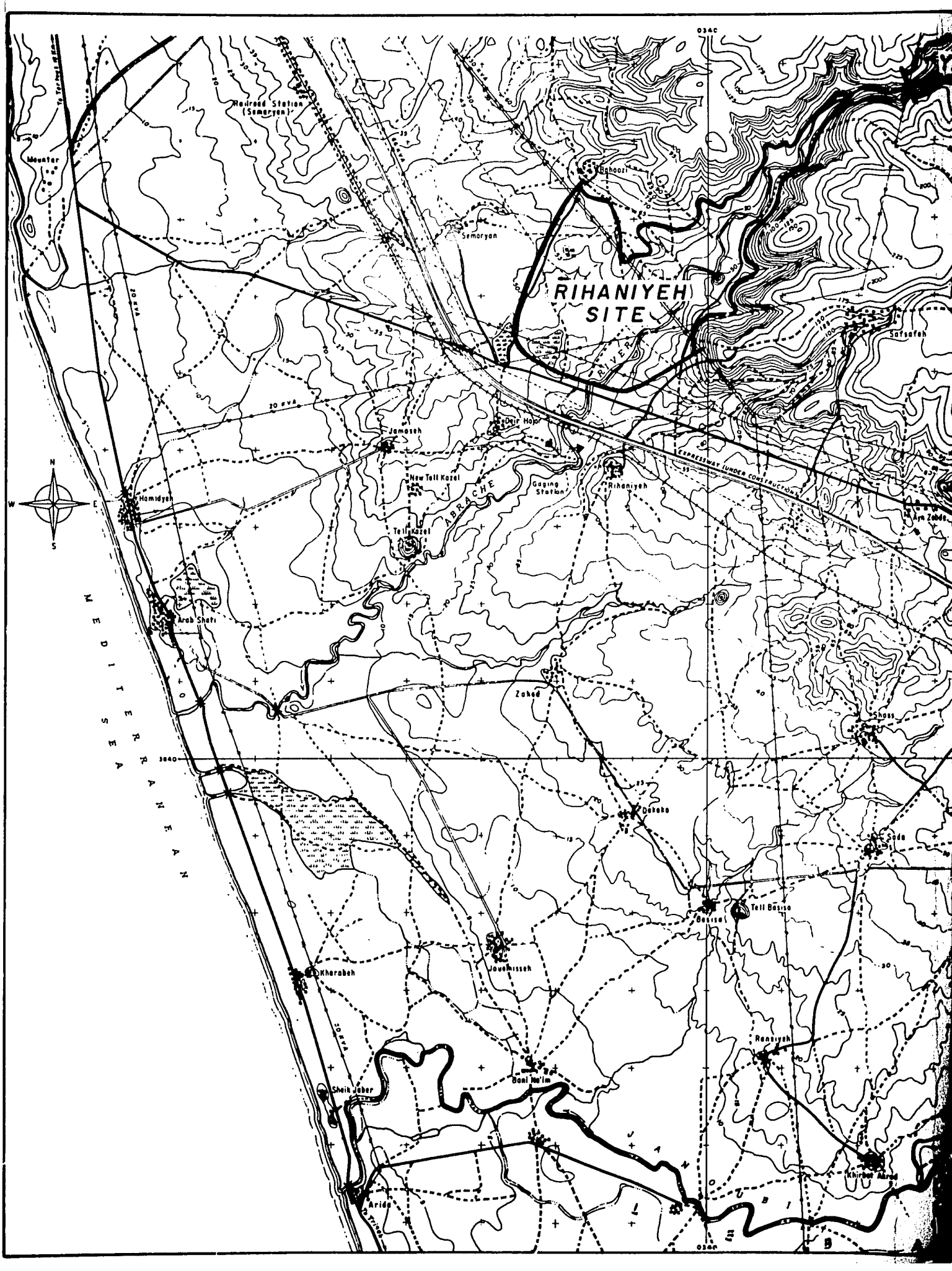
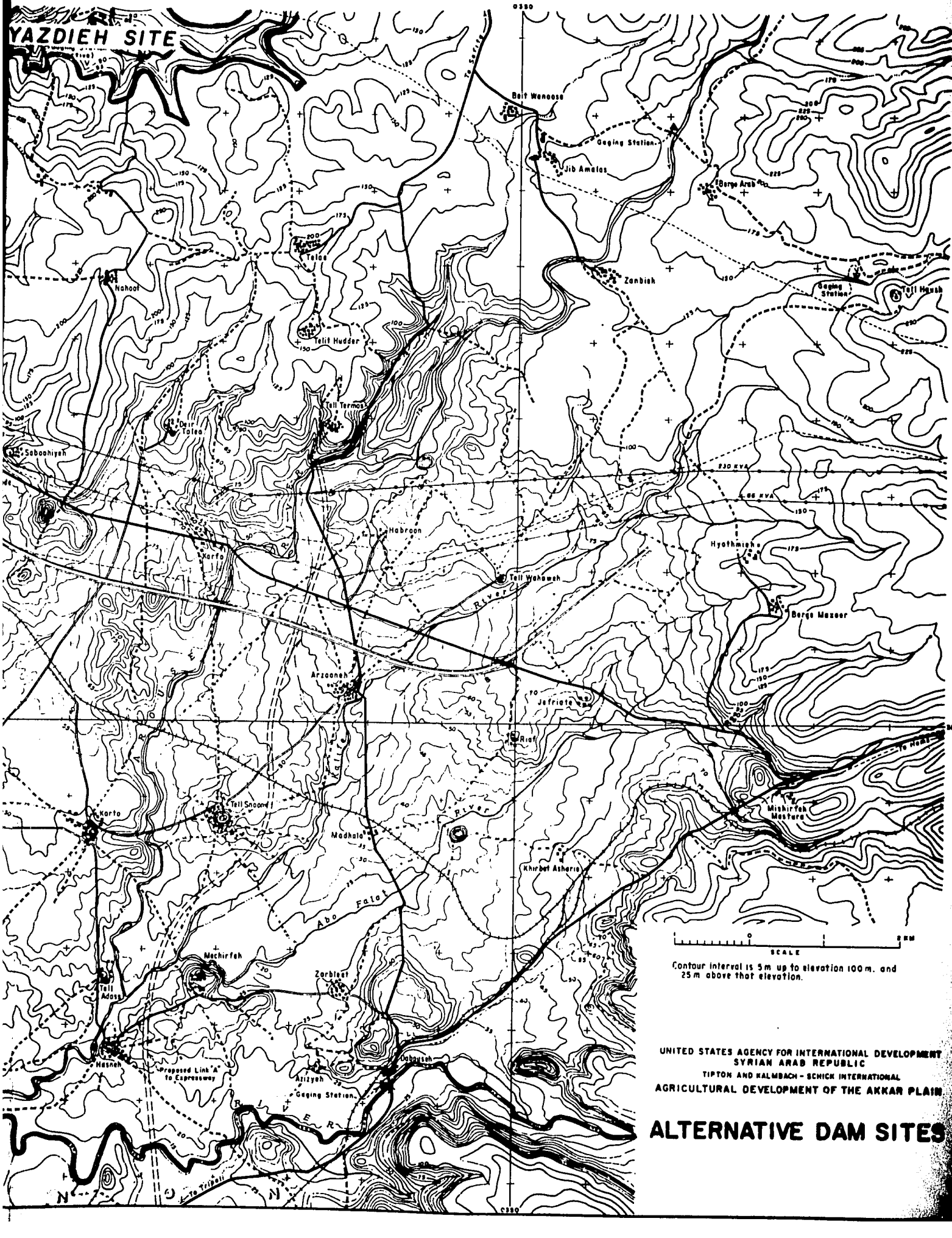

RIHANIYEH SITE
Railroad Station (Semaryan)
Mounter
Semaryan
Bahoozi
Safsafeh
Deir Hajr
Jamoseh
New Tell Kazel
Gaging Station
Rihaniyeh
Tell Kazel
ABRACHE
RIVER
EXPRESSWAY (UNDER CONSTRUCTION)
Hamidyeh
Arab Shafi
Zaheb
Shoss
Dakeka
Tell Basisa
Basisa
Jouhrisseh
Kharabeh
Renaiyeh
Beni Na'im
Sheik Jaber
Arida
Khirbet Akrad
MEDITERRANEAN
SEA
20 KVA
30 KV
N
S
E
W

FIGURE IV-1


YAZDIEH SITE
Beit Wanoose
Gaging Station
Jib Amalas
Berge Arab
Zanbish
Gaging Station
Tell Hush
Nahoot
Telas
Telil Hudder
Tell Termos
Deir Talea
Sabashiyeh
Habroon
Karfa
Tell Wahawah
Hyathmieh
Berge Mazeer
Arzaoneh
Jafriata
Riaf
Tell Snaoni
Karfa
Madhala
Khirbet Asheria
Mishirfeh Mastara
Abo Falat
Mechirfeh
Zarbiaat
Tell Adass
Hasneh
Proposed Link "A" to Expressway
Azizyeh
Gaging Station
Dabayseh
RIVER
Kafra
River
To Tripoli
SCALE
Contour interval is 5 m up to elevation 100 m. and 25 m above that elevation.
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
ALTERNATIVE DAM SITES

reported to have been drilled in the area, and much of the reservoir is underlain by up to 60 meters of "blue clay" which is probably a relatively impermeable marl.

Curves showing the annual water yield of reservoirs of various capacities at the two sites are shown on Figure IV-2. The curves for Yazdieh are taken from the Sofrelec Report. Part of the difference in yield at the two sites is due to the significant differences in the flow measurements used for the Arouse River. During the dry period, 1970-1973, Sofrelec used higher flows in the Arouse than the data furnished for this study indicate. From data used in this study, it appears that the Arouse River will furnish sufficient water to irrigate approximately 1,000 hectares.

The Rihaniyeh site should be explored by detailed mapping and drilling. While the possibility of serious leakage is present and the volume and cost of the dam would be greater than at the upstream site, a small expenditure in exploration would be justified to establish the most feasible storage site of the Abrache River.

POTENTIAL FOR GROUNDWATER DEVELOPMENT

Knowledge of the hydrogeology is not sufficiently advanced to predict the magnitude of the ultimate development of groundwater on the Akkar Plain. It is clear that further development is possible in the shallow aquifer. It is estimated that more than twice the present withdrawals could be made without causing difficulties. Too little information is available on near-coast wells to understand the salt water-fresh water interface, but the magnitude of the recharge and underflow which seems to be present indicates that there is little danger of creating critical intrusion problems. The goal of attaining maximum benefits from the groundwater reservoir can best be attained by two approaches: maximizing yields from existing and new shallow aquifer wells and tapping the deeper aquifers which probably underlie the Plain.

Shallow Aquifers

There is good potential for additional groundwater development in the shallow aquifers in Areas 1, 3, 6, and 7 shown on Figure II-8. Most wells could be expected to yield in excess of the present average of six liters per second, and many could be

expected to yield 20 liters per second and more. Continuing to deepen the well after water is encountered would undoubtedly result in greater yields and higher specific capacities. Pumping tests should be carried out to determine optimum pump design and setting.

Locations which appear promising for shallow wells (<150 meters) are:

1. Along the lines Karfo-Basisa-Bani Na'im,
2. Bani Na'im-Khirbet Akrad, and
3. Shass-Tell Kazel.
4. Northwest of Deir Hajar;
5. West of Semaryan.

As stated previously, the yield and specific capacity are low in the majority of the existing wells, but those which are capable of producing higher yields are not being used to the optimum. An attempt should be made to increase the productivity of the existing wells.

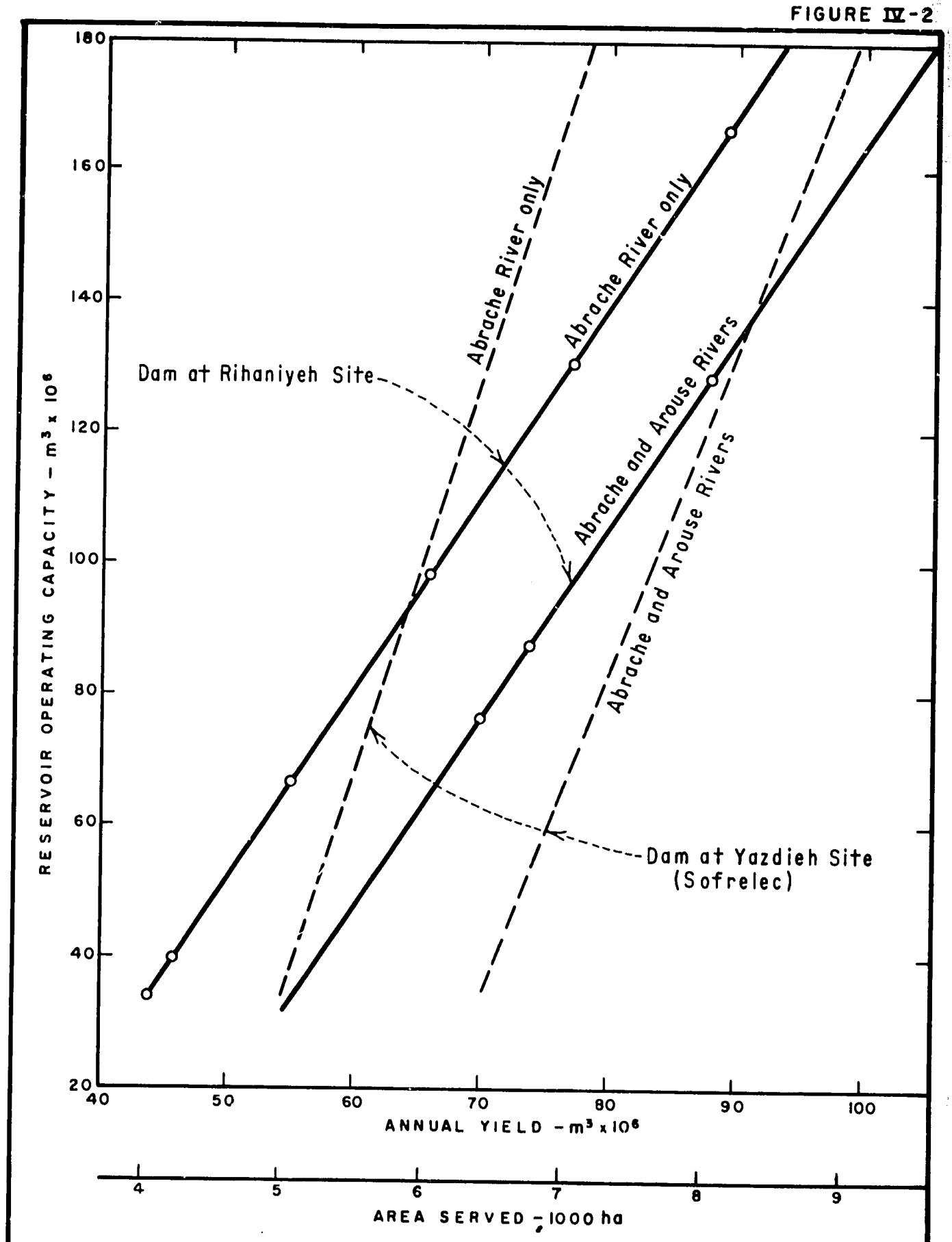
Wells which apparently have relatively high specific capacities and are not being pumped at high rates should be tested with a pump of variable discharge. By so doing, the optimum discharge can be derived for an individual well and proper equipment specified for that discharge. The productivity of the well may then be increased many times at only the cost of the test and a new pumping unit.

Examples of wells on which production can be markedly increased are given below:

Well No.	Specific Capacity l/s/m	Present Yield l/s	Potential Yield l/s
B-22	14.6	6.3	> 80
B-23	8.3	8.5	> 50
B-24	4.3	14	> 30
E-9	8	12	> 50
E-43	3.9	5.5	> 30
E-46	53	11.2	>150
F-12	6.2	7.1	> 40

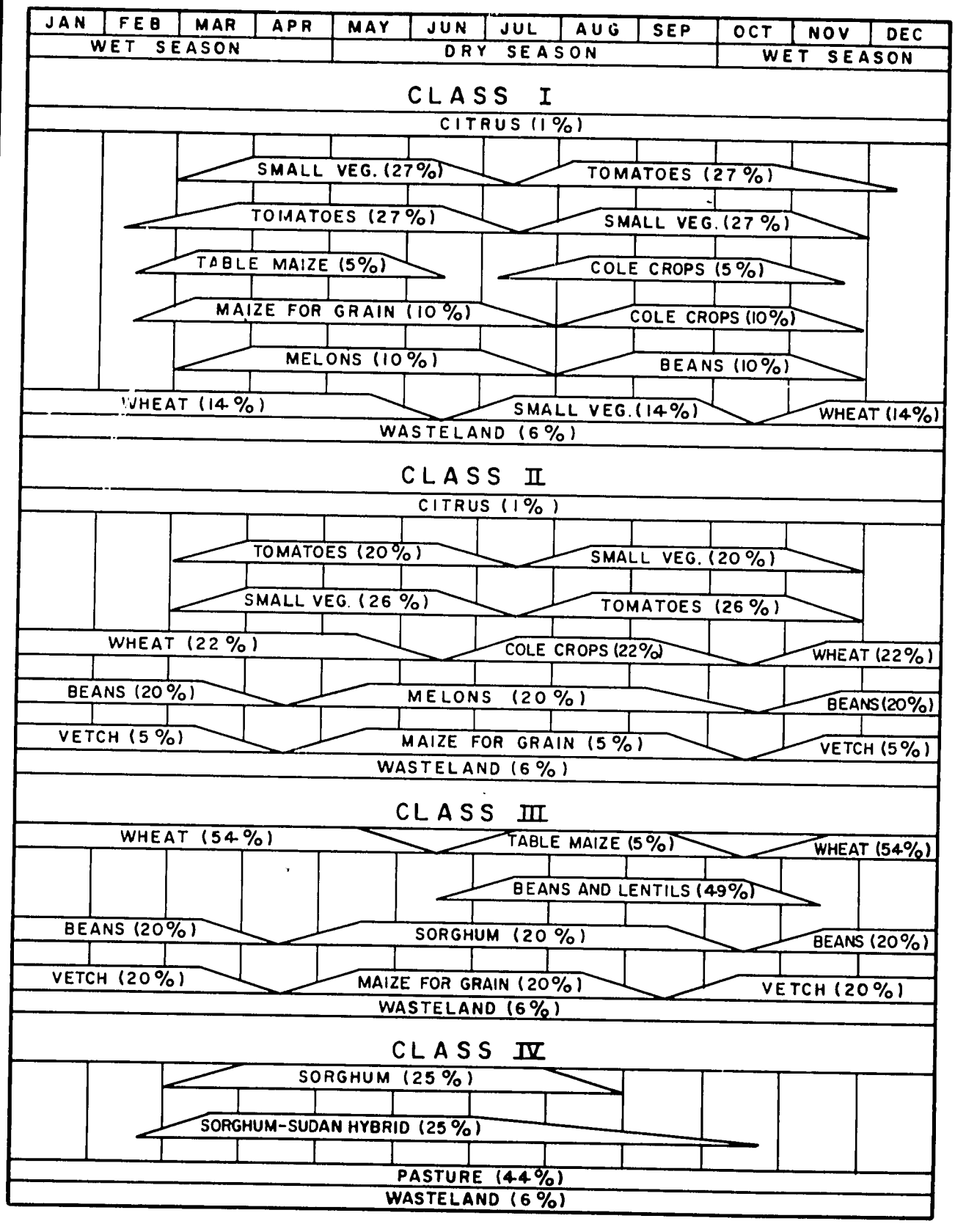
Note that most of the above wells, which are only a few of the under-equipped installations, are outside the area likely to get assured canal supplies.

FIGURE IV-2



CAPACITY VS ANNUAL YIELD
ABRACHE RESERVOIRS
Akkar Plain Project

TIPTON AND KALMBACH – SCHICK INTERNATIONAL



FUTURE CROPPING PATTERN AND LAND USE WITH IRRIGATION BY LAND CAPABILITY CLASS

Akkar Plain Project

TIPTON AND KALMBACH-SCHICK INTERNATIONAL

It is probable that many of the existing wells could be improved by deepening. In a geologic terrain in which permeability is probably limited to joints, solution channels, structural breaks, and weathered unconformable contacts, a few meters in depth could make the difference between a very poor well and a very good one. It is true in such aquifers that the chances of encountering water decrease with depth and there is not the certainty of success in this method of improvement as in merely installing properly sized pumping units. It probably would be worthwhile to consider 75-100 meters as a reasonable cutoff depth for the shallow aquifer. Since the wells generally are cased with 10- to 12-inch casing with open bottoms, deepening could be carried out with ease by use of a cable tool rig.

Deep Aquifers

The Cretaceous limestones which form the mountains to the north dip under the Akkar Plain and are unconformably overlain by the younger, shallow aquifers. It is believed that the Cretaceous limestones carry a large volume of water to the sea. To the north of the Project Area, numerous large springs are known along the coast and on the sea floor. Arwad Island obtains its water supply from a well which penetrates the Cretaceous from 58 meters to 342 meters and encounters flowing artesian zones from 225 meters to total depth. In its study of the Yazdieh dam site, Sofrelec identified two sequences of strongly karstic limestone within the upper Cretaceous. The Abbouli limestone and the Safita limestone contain at least two sections comprising about 100 meters of highly permeable rock, separated by marls and relatively impermeable limestone. Although the configuration of both the geologic structure and the Cretaceous-Tertiary unconformity are not known, it is probable that these limestone aquifers underlie the Plain at a depth of 300 to 500 meters. It is also probable that these formations constitute part of the conduits which drain the mountain area of about 600 square kilometers. In addition to the work to be done on the shallow, better-known aquifer as described above, a deep exploration program should be initiated to test the hypothesis that large quantities of artesian water underflow the Plain. If this proves true, sufficient water may be available to approximately double the area which can be irrigated from surface sources.

The Cretaceous limestone crops out in the Project Area to the northwest of the area in which the highway crosses the Abrache River. The precise contact of the Cretaceous-Tertiary near the highway was not delineated. The Cretaceous also crops out in the valley of the Arouse upstream from Karfo and may be the limestone found along the southern border of the area.

Exploration of a covered formation is difficult as structural features which may indicate preferred well locations are hidden; therefore, drilling must be carried out to understand the subsurface geology. Some features do appear on the surface, however, which may indicate the structural features which could control groundwater flow. The striking difference in topography of the area between the Abrache and Arouse Rivers may indicate that the courses of the two rivers are controlled by structural features. Faulting can be seen in the limestones northeast of Karfo, and unconformable contacts which may be faulting are present along the Abrache west of Rihaniyeh. Landsat imagery reveals a strong lineation along the Abrache. Drilling, however, must be carried out before a proper understanding of the production possibilities of the Cretaceous aquifers are known.

INFRASTRUCTURE DEVELOPMENT

Development of intensive agriculture through irrigation and drainage on the Akkar Plain would provide the incentive for accelerated economic and social growth. The rate of such growth would be in part dependent upon development of adequate infrastructure. As previously noted, existing facilities are inadequate for the present development; however, the necessary elements are present and require only upgrading and supplementing. The social infrastructural facets are already included in long-range government plans but need to be expanded and expedited. Financial facets such as marketing facilities, processing plants, and an active extension service require implementation.

ON-FARM DEVELOPMENT

The people of the Plain are good, industrious, and intelligent farmers; and, with the project, agronomic methods will be changed, and instruction on new

methods and financial assistance in obtaining proper equipment and supplies will be required. As more than the rudiments of farming knowledge are already being practiced, the potential for modern farming on the Plain is great if the basic requirements for intensive agriculture are available. Different methods of irrigation, tillage, land use and management, and pest control will evolve with instruction and demonstration; and it is believed that the farmers will be receptive to new ideas and will carry them out.

Land Preparation

Land leveling is influenced by the depth of soil, slope, climate, crops, method of irrigation, drainage, and the expertise and the desires of the farmer. Land Classes II and III, which comprise 95 percent of the irrigated area, have undulating topography with slopes up to 5 percent. This type of topography, associated with shallow soil profiles which average less than a meter in depth, virtually rules out a land leveling program which would normally be considered essential for intensively cultivated crops, such as vegetables. Some areas are being cultivated which have soil profiles of only 20 to 30 centimeters and, under these conditions, only minor land leveling and smoothing is possible. This treatment would alleviate irrigation problems associated with improper plowing which has left deep dead furrows and the above-average erosion caused by heavy winter precipitation. Initial land smoothing will be planned and accomplished by the Agricultural Services Center. Minor smoothing will be done by the farmer by following proper plowing and tillage practices.

FUTURE CROPPING PATTERN WITH PROJECT

The future with-project cropping pattern was developed to emphasize double-cropping of high value crops. A pattern was developed for each of the four land capability classes using those crops which would be best suited for each class under adequate irrigation. The soil conditions were taken into consideration, along with the climate, the water requirements, the adaptability of the crop, and the potential market or marketability of each crop. Figure IV-3 shows the crops in each land class and the seasons during which each crop would be in the field.

An allowance for wasteland was made. It is estimated that 6 percent of the area would not be used because of headlands, drains, ditches, roads and farmsteads. Care was taken to allocate land so that the least amount possible would be fallow in any one season and production would be maximized on the irrigated lands. Cropping intensity would approach 200 percent on irrigated lands and, when pasture is included, would approach 100 percent on the nonirrigated portion.

IRRIGATION WATER REQUIREMENTS

The irrigation requirements of a crop are made up of the consumptive use requirements of the crop, after accounting for effective precipitation, plus water required for leaching and for land preparation. In the Akkar Plain there is sufficient precipitation to satisfy the leaching requirement and because of the precipitation and double-cropping pattern, it was assumed that there is no land preparation requirement. The irrigation requirements of a crop were therefore determined by calculating the consumptive use requirements and subtracting the effective precipitation.

Consumptive Use Requirements

The consumptive use requirement of a crop is the total amount of water required for plant transpiration and concomitant soil evaporation. This requirement is determined primarily by the genetic characteristics of the plant, the length of the growing season and the evaporative potential. The evaporative potential, in turn, is determined by a number of variables, mainly climatic, operating singly or in combination. Most important among these factors are temperature, daylight hours and humidity.

It should be noted that the rate of use of water by a plant or crop is determined largely by its stage of growth--use generally is a minimum through the seeding state, increases rapidly to flowering or maximum vegetative cover state, and decreases sharply during and after crop maturation. Information on peak-use rates is necessary for the design of canal and distribution systems, and seasonal and monthly requirements are needed for hydrologic studies and cost estimates of energy for pumping.

A number of methods have been developed for predicting monthly and seasonal crop water requirements. These methods differ in convenience, in accuracy, and particularly in the climatic data required for their application. As reliable climatic data for the Akkar Plain are available only for temperature and precipitation, a method that relates consumptive use to these parameters is necessary. The Blaney-Criddle empirical equation fulfills this requirement and has been used in estimating the consumptive use requirements of the crops grown in the region.

Disregarding relatively minor factors, Blaney and Criddle have shown that the monthly consumptive use of water by crops varies directly with the product of the monthly mean temperature and the monthly percentage of daylight hours. This may be expressed quantitatively as follows:

$$U = \Sigma u = \Sigma kf = \Sigma k \frac{p(45.7t + 813)}{100}$$

in which:

U = seasonal consumptive use;

u = monthly consumptive use in millimeters;

k = monthly consumptive use coefficient characteristic of each crop;

$f = \frac{p(45.7t + 813)}{100}$, the consumptive use factor in millimeters, in which p = monthly percentage of annual daylight hours, and t = monthly temperature in degrees centigrade (corresponds to $f = \frac{pt}{100}$, expressed in inches when t = degrees Fahrenheit).

For the determination of consumptive use requirement of the Akkar Plain, the monthly consumptive use coefficients (k values) developed by Blaney and Criddle were modified in accordance with criteria developed by the U.S. Department of Agriculture. In this modification, the monthly consumptive use coefficient (k) is expressed as follows:

$$k = k_t k_c$$

in which:

k = monthly consumptive use coefficient characteristic of each crop;

$k_t = 0.0311t + 0.24$, climatic coefficient, in which

t = monthly mean temperature in degrees centigrade (corresponds to $k_t = 0.173t - 0.314$ when t = degrees Fahrenheit);

kc = growth coefficient related to the stage of maturity of the crop; i.e., to the elapsed time after planting, rather than to a calendar period.

Table IV-1 summarizes the monthly and seasonal consumptive use requirements of each of the crops to be grown in the Project Area. Estimates of consumptive use requirements range from 268 millimeters for cole crops grown in the late summer and fall to 1,253 millimeters for pasture grass, which is a perennial crop.

Effective Precipitation

Any precipitation that can be used by the crop, or that in any way reduces the water needed by the crop, is termed effective precipitation and must be subtracted from the consumptive use requirement to obtain the irrigation requirement at the crop. The amount of effective precipitation in the Project Area is determined primarily by the total rainfall, the consumptive use rate and the net irrigation application. The U.S. Department of Agriculture has developed curves and charts which relate these variables on a monthly basis, which were used in the study. The monthly effective precipitation was determined for each crop from the relationship between mean monthly rainfall and the monthly consumptive use, assuming that the net irrigation application is 75 millimeters. It was found that the distribution of rainfall in the Akkar Plain is such that: the effective rainfall in the months of January, February, November and December fully meets the consumptive use requirement; the effective rainfall in the months of March, April, May, September and October partly meets the consumptive use requirement; and in the months of June, July and August there is no effective precipitation. The seasonal effective precipitation for each crop in Land Capability Classes I, II, and III is shown on Table IV-2.

Crop Irrigation Requirements

The crop irrigation requirement for each crop in Land Capability Classes I, II, and III is shown on Table IV-2 and was determined by subtracting the effective

Table IV-1
Consumptive Use Requirements
(Values in mm at the crop)

Crops	% Farm	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Land Capability Class I														
Spring Crops														
Small Vegetables	27			9	83	128	102							322
Tomatoes	27			21	79	161	148							409
Table Maize	5			24	119	167								310
Maize	10			23	89	168	186	53						519
Melons	10			11	67	128	138	42						336
Summer Crops														
Tomatoes	27								49	145	127	13		334
Small Vegetables	27								48	133	105	23		309
Cole Crops	5								53	136	89			278
Cole Crops	10								21	121	111	15		268
Dry Beans	10								33	159	142	13		347
Small Vegetables	14							48	166	131	17			362
Fall Crops														
Wheat	14	40	52	90	130	202						14	30	558
Perennial Crops														
Citrus	1	19	40	60	79	111	132	151	148	116	91	60	43	1050
Land Capability Class II														
Spring Crops														
Tomatoes	20			10	65	161	175							411
Small Vegetables	26			9	80	128	95							312
Melons	20					37	124	171	160	32				524
Maize	5					39	161	225	197					622
Summer Crops														
Small Vegetables	20								48	133	105	23		309
Tomatoes	26								49	145	127	13		334
Cole Crops	22							52	172	123				347
Fall Crops														
Wheat	22	40	52	90	130	202						14	30	558
Beans	20	67	62	67								27	60	283
Vetch	5	33	36	67							50	57	37	280
Perennial Crops														
Citrus	1	19	40	60	79	111	132	151	148	116	91	60	43	1050
Land Capability Class III														
Spring Crops														
Sorghum	20					30	150	225	185	108				698
Maize	20					39	161	225	197					622
Summer Crops														
Table Maize	5							45	178	135				358
Dry Beans & Lentils	49							64	210	183	105			562
Fall Crops														
Wheat	54	40	52	90	130	202						14	30	558
Beans	20	67	62	67								27	60	283
Vetch	20	33	36	67							50	57	37	280
Land Capability Class IV														
Spring Crops														
Sorghum	25			7	67	160	182	159	31					606
Sorghum-Sudan Hybrid	25			16	86	168	173	156	41					640
Perennial Crops														
Pasture	44	14	34	66	96	140	167	195	191	146	107	60	37	1253

Table IV-2

Crop Irrigation Requirements

Crop	Seasonal Consumptive Use Requirement (mm at the crop)	Seasonal Effective Precipitation (mm at the crop)	Seasonal Crop Irrigation Requirement (mm at the crop)	Area Cropped(1) (hectares)	Seasonal Crop Irrigation Requirement (m^3 at the crop)
Land Capability Class I					
Spring Crops					
Small Vegetables	322	60	262	108	282,960
Tomatoes	409	73	336	108	362,880
Table Maize	310	79	231	20	46,200
Maize	519	76	443	40	177,200
Melons	386	61	325	40	130,000
Summer Crops					
Tomatoes	334	65	269	108	290,520
Small Vegetables	309	73	236	108	254,880
Cole Crops	278	48	230	20	46,000
Cole Crops	268	65	203	40	81,200
Dry Beans	347	67	280	40	112,000
Small Vegetables	362	30	332	57	189,240
Fall Crops					
Wheat	558	260	298	57	169,860
Perennial Crops					
Citrus	1,050	321	729	5	36,450
			Subtotal	751	2,179,390
Land Capability Class II					
Spring Crops					
Tomatoes	411	61	350	541	1,893,500
Small Vegetables	312	60	252	703	1,771,560
Melons	524	25	499	541	2,699,590
Maize	622	14	608	134	814,720
Summer Crops					
Small Vegetables	309	73	236	541	1,276,760
Tomatoes	334	65	269	703	1,891,070
Cole Crops	347	13	334	594	1,983,960
Fall Crops					
Wheat	558	260	298	594	1,770,120
Beans	283	280	3	541	16,230
Vetch	280	259	21	134	28,140
Perennial Crops					
Citrus	1,050	321	729	25	182,250
			Subtotal	5,051	14,327,900
Land Capability Class III					
Spring Crops					
Sorghum	698	26	672	657	4,415,040
Maize	622	14	608	657	3,994,560
Summer Crops					
Table Maize	358	13	345	163	562,350
Dry Beans and Lentils	562	52	510	1,607	8,195,700
Fall Crops					
Wheat	558	260	298	1,770	5,274,600
Beans	283	280	3	657	19,710
Vetch	280	259	21	657	137,970
			Subtotal	6,168	22,599,930
			Total	11,970	39,107,220

(1) Surface Irrigation System only

Surface System Diversion Requirement @ 60% System Efficiency

$$\frac{39,107,220}{.60} = 65,178,700 \text{ m}^3$$

$$\text{Annual Crop Irrigation Requirement} = \frac{39,107,220}{6,000} = 652 \text{ mm}$$

precipitation from the consumptive use requirement of the crop. Estimates of crop irrigation requirements range from 3 millimeters for a fall crop of beans, in which the consumptive use requirement is almost totally supplied by effective precipitation, to 729 millimeters for the perennial citrus crop.

The area to be irrigated by the surface irrigation system is 6,000 hectares, consisting of 378 hectares of Land Capability Class I; 2,538 hectares of Class II; and 3,084 hectares of Class III. The area of each crop and its seasonal crop water requirement expressed in cubic meters of water are shown in Table IV-2. The annual crop irrigation requirement is 39.1 million cubic meters, which is equivalent to a water depth of 652 millimeters on the 6,000-hectare irrigated area.

The total water requirement for the surface system of the Akkar Plain Project is the annual crop irrigation requirement shown on Table IV-2 plus field losses and conveyance losses. Assuming a system efficiency of 60 percent; i.e., 40 percent of the water diverted results in system losses and 60 percent of the water diverted is consumed by the crops, the total annual water requirement for the surface system is 65.2 million cubic meters.

To properly size an irrigation system, the peak crop irrigation requirements must be determined. For the cropping pattern shown in Figure IV-3 and Table IV-2, August is the month of maximum crop irrigation requirements (which coincides with consumptive use as there is no effective precipitation) and the irrigation system must be designed to meet the deliveries required during that month. The average peak consumptive use rate in August is 5.9 millimeters of water depth per day and a diversion requirement of 9.8 millimeters of water depth per day for a system efficiency of 60 percent. The diversion requirement is equivalent to 1.13 liters per second per hectare of continuous flow.

PROJECTED INCREASE IN PRODUCTION

In the future-without-project condition, it is assumed that with better fertilization and improved cultural practices the yields will increase by 10 percent from present conditions. This increase is without the irrigation program or drainage plan.

The future-with-project yields are estimated on the basis of present United States' yields in areas similar in climate and soil types to the Akkar Plain. The assumption is made that over the fifty-year life of the project, yields will increase to at least the level of current U.S. yields. It is assumed that the with-project condition will have adequate water, advanced mechanization, proper commercial fertilizers, and seed that will produce maximum yields. Table IV-3 compares the yields on each land class for the without- and with-project conditions.

Table IV-3
Crop Yields

Crop	Unit	Future-Without-Project				Future-With-Project			
		Class I	Class II	Class III	Class IV	Class I	Class II	Class III	Class IV
Wheat	t/ha	1.10	1.10	1.00	-	5.94	5.94	5.39	-
Sorghum	t/ha	-	-	0.84	0.80	-	-	2.86	2.75
Pasture	a.u.m.	-	-	-	2.60	-	-	-	22.00
Forage	t/ha	0.68	0.68	0.62	0.59	8.14	8.14	7.37	7.04
Maize									
Field	t/ha	1.80	1.80	1.60	-	6.60	6.60	6.05	-
Table	t/ha	-	-	-	-	10.89	10.89	9.90	-
Tomatoes	t/ha	12.60	12.60	11.50	-	54.34	54.34	54.34	-
Cabbage	t/ha	9.20	9.20	8.40	-	12.65	12.65	11.55	-
Cucumbers	t/ha	12.20	12.20	11.10	-	14.52	14.52	13.20	-
Melons	t/ha	9.30	9.30	8.50	-	15.73	15.73	14.30	-
Dry Beans	t/ha	1.20	1.20	1.00	-	2.75	2.75	2.53	-
Chick Peas	t/ha	1.00	1.00	0.90	-	2.09	2.09	1.87	-

CHAPTER V

THE DEVELOPMENT PLAN

The Development Plan is intended to describe the proposed project works which, when implemented, would assure the maximum integrated development of the water and land resources of the Akkar Plain. The program presented would be realistic of achievement with respect to timing and scheduling of project works, non-project works, corollary developments, and to the availability of the financial, physical, institutional, and human resources. These resources are required to implement the construction program and non-project activities that would be necessary to realize the potential economic benefits of the Development Plan.

PRINCIPAL FEATURES

The principal features recommended for development of the land and water resources of the Akkar Plain are:

1. Improvement of the Janoubi River channel to prevent flooding of croplands in the southwestern section of the Plain;

2. Improve existing surface drains and construct additional drains to control excessive precipitation runoff on the entire 23,000 hectares of the Plain and to reclaim the Ramit Laha swamp for agricultural use;

3. Utilization of the water from the Abrache and Arouse Rivers for irrigation. The Arouse River would be diverted into the Abrache River Basin and a storage dam would be constructed on the Abrache River to regulate the water resources of both rivers. Two damsites would be considered.

4. A canal system designed to convey water to 6,000 to 10,000 hectares of irrigable land on the Akkar Plain;

5. Drilled water wells in both the shallow and deep aquifers at locations on the Plain that have potential groundwater supplies;

6. Future extension of the canal system to transfer surface water replaced by the development of groundwater within the original area served from the Abrache River; and

7. Infrastructure facilities necessary to achieve full economic benefits from development of the water resources.

A plan to bring all seven principal features to completion would involve two phases of work with the second phase divided into two stages. Phasing the construction work would facilitate starting portions of the project which are not dependent upon other portions so that economic benefits would start to flow sooner than may occur if all of the development works were to be initiated together.

Implementation

An Akkar Plain Authority would be established as a separate department under the Ministry of Agriculture to implement the project as planned. The Authority would operate with its own financial budget and staff similar to the relationship between the Minister of Agriculture and the present Department of Soils. After the Akkar Plain Development Plan is fully implemented and the various infrastructure features have accomplished their respective objectives, the Authority would begin phasing-out by turning its responsibilities over to the relevant existing governmental departments. The Authority would be active for probably ten years or more following construction of Phase I and II.

PHASE I

The initial phase of construction consists of approximately 10 kilometers of channel improvement along the lower Janoubi River and surface drainage features for the entire Plain. These works are interrelated since the channel improvement would protect the drainage facilities from flood damage, and the drainage system would increase benefits from the area protected from inundation during peak flows in the river. Elimination of the Ramit Laha swamp would also result from the drainage improvements. Additional irrigation development or improvement of the present infrastructure would not be essential for Phase I. Implementation of an Agricultural

Service Center in Phase I would permit farmers to begin receiving increased technological skills that would be beneficial with the present rainfed cropping conditions and limited irrigation.

Janoubi Channel Improvement

The Janoubi River Channel Improvement would have the first priority for construction in the Phase I development. It is essential that the channel improvement be completed prior to excavation of drainage channels in the Ramit Laha area. The physical construction would require a limited capital investment and could be done by SARG. Benefits from the reduced inundation would be realized in the first rainy season after completion.

Drainage Development

Development of adequate drainage on the entire Akkar Plain could begin concurrently with the Janoubi River Channel Improvement. Existing drains would be improved and additional drains would be constructed to provide outlets for surface water from on-farm drainage facilities. The Agricultural Service Center would be responsible for the construction of small grassed channels to convey surface water from private farmland to the main drainage channel developed under the project.

Deep open surface drains would be constructed to relieve subsurface water as needed while other open drains would be improved or constructed to remove surface water from heavy rainfall. The subsurface drains would empty into a drainage channel near the Homs highway and the Abrache River below the proposed irrigation system.

The improved drainage system would reduce the winter damage to existing roads and would improve crop yields without the further development of irrigation. Drainage must be provided prior to the development of the surface irrigation system or before significant quantities of groundwater are utilized for irrigation as the drains are essential to control the increased application of water that would result from the full development of these water resources. For these reasons the Phase I works have priority over the other development phases.

PHASE II

Development of facilities for intensive surface water and groundwater irrigation would be completed in this phase. Because of the complexity of the water resource development, it has been divided into Stage 1 for surface water and Stage 2 for groundwater development, but the two may proceed concurrently or separately. Since sustained irrigated agriculture of the magnitude that would exist on the Akkar Plain with full development would require supporting infrastructure to ensure full economic benefits, it is assumed that the infrastructure not completed in Phase I would be accomplished concurrently with water resource development.

Stage 1

Surface Irrigation System: The surface irrigation system of Stage 1 would consist of a storage reservoir on the Abrache River with a dam located either near Yazdieh or below the mouth of the canyon near Rihaniyeh. Either would include a diversion structure on the Arouse River and a feeder canal to the Abrache River Basin. A gravity irrigation system would convey all water regulated by the reservoir to farms on the Akkar Plain. Should the dam at Yazdieh be built, a diversion dam would be required on the Abrache River about 2.5 kilometers above its crossing of the Tartous-Homs highway. Either dam location would supply the same gravity distribution system for 6,000 to 10,000 hectares of cropland. Pumps would be required to lift water from the main canal to the distribution system serving some portions of the service area.

Infrastructure: Intensity of the farming operation would be increased significantly; therefore, development of infrastructure facilities including roads, increase in Agricultural Service Center activities, processing and packing plants, and medical facilities should be started concurrently with water development. The Agricultural Service Center would be responsible for preparation of on-farm ditches, the necessary laterals to get water to the farms from the main canal system, and initial land smoothing. Benefits would accrue at an increased rate should the infrastructure be operating at the time when the water resource development is completed.

Stage 2

Stage 2 consists primarily of groundwater development from both the shallow and deep aquifers to irrigate approximately 4,970 hectares. Some existing wells in the shallow aquifer would be improved with higher capacity pumps. This activity could begin prior to Stage 2 if equipment and other resources are readily available as immediate benefits would accrue from rehabilitating existing wells.

Under that part of the program which is intended to make a greater use of the groundwater resources of the area, some of the existing wells to be improved and new wells to be constructed will lie within areas under command of canal irrigation systems and others of both categories will lie in areas above or beyond the command of those systems. It is contemplated that in those canal-commanded areas where significant amounts of additional groundwater can be developed, it will be used directly in lieu of canal supplies with any surplus water pumped into the canals to extend the service area. The surface water that is replaced by groundwater could be used to further extend the canal systems to serve areas beyond those initially included within the project described herein. At the time the canal systems become operational it is assumed that the numerous existing dug wells and small capacity drilled wells, which because of geologic or other constraints present little opportunity of improvement in production, would either be abandoned, retained to augment surface supplies, or converted to domestic or other specialty uses.

On-Farm Development

Lesser irrigation and drainage works required to extend the systems to be constructed by the Government to individual farms and all land smoothing activities are classified as on-farm works. As design and construction of on-farm works would be the responsibility of the Agricultural Service Center as part of the infrastructure, costs for these improvements are included as project costs. On-farm works are recognized as vital factors in the development program and financially accountable features in the economic analysis of the program.

ASSUMPTIONS

The foregoing listing of works embodied in the Development Plan is predicated on the assumption that certain supplemental explorations and investigations that have not yet been undertaken will substantiate the technical and economic feasibility of the several features of the plan. There are two areas in which further field investigations will have to be completed before the definitive plan of development can be finalized. Firstly, it is essential that sufficient mapping and exploratory drilling be undertaken at the Rihaniyeh site on the Abrache River to ascertain if it is technically and economically feasible to construct a major storage reservoir at that site and whether it would be more attractive than to attempt to develop the Yazdieh site which earlier was studied by Sofrelec. Secondly, it will be necessary to construct a number of test wells at various locations on the Plain to better define the extent and characteristics of the underlying shallow and deep aquifers to evaluate their water development potential.

It will be recalled that at the outset of this study it was assumed that investigations which had been carried out earlier would adequately define the best storage site and provide sufficient information to evaluate the potential yield of the groundwater resource. As it developed, this was not the case and further investigations will be necessary to define the best site for reservoir storage and the scope of the groundwater development program. Notwithstanding the uncertainties which cannot be resolved until the completion of the exploration program, to enable completion of this Report the assumption is made that provision of storage as well as the development of additional groundwater supplies to the extent envisaged herein will be found to be feasible.

PROJECT AREA

Drainage System

The drainage system which would be constructed as part of the Phase I development would benefit the entire Project Area. In determining the benefits of

the drainage system, it has been assumed that a gross farm area of 17,179 hectares would be benefited by the construction of the drainage system.

Surface Irrigation System

The surface irrigation system which would be constructed as part of Phase II, Stage 1, would command a gross farm area of 6,380 hectares and supply irrigation water to a net irrigated area of 6,000 hectares. As discussed in Chapter IV and shown on Table IV-2, the total annual water requirement of the surface irrigation system at its point of diversion at the Rihaniyeh Reservoir is 65.2 million cubic meters. This amount is compatible with the estimated annual yield of the reservoir of 68 million cubic meters. It is therefore assumed that the surface irrigation system will furnish a full water supply to the cropped area each year and no shortages are anticipated. All of the lands commanded by the irrigation system are in Land Capability Classes I, II, and III.

Groundwater Irrigation System

The groundwater irrigation system which would be constructed as part of Phase II, Stage 2, would command a gross farm area of 5,290 hectares and a net irrigated area of 4,970 hectares. All of the lands commanded by the irrigation system are in Land Capability Classes I, II, and III. The cropping pattern for the groundwater system is the same as the pattern of the surface irrigation system and therefore has the same annual crop irrigation requirement as the surface system as shown on Table IV-2. Assuming a system efficiency of 60 percent, the annual gross pumping requirement of the system is 54.0 million cubic meters. This requirement is approximately 40 percent of the preliminary estimate of the total groundwater resource including the underflow from the mountainous area.

AGRICULTURAL BENEFITS

The following evaluation of agricultural benefits has two objectives--firstly, to arrive at an estimate of the direct irrigation benefits which can be set against the project costs in the economic analysis of the project described in Chapter VII;

and secondly, to establish a basis for estimating future repayment capacities of the irrigators--these, in turn, will be factors in the financial analysis given in Chapter VIII.

A common basis from which both the irrigation benefits and the repayment capacities can be derived is provided by the net farm income. This is defined as the gross value of agricultural production less the costs of all farm inputs, except the costs of irrigation water and family labor, but inclusive of the costs of on-farm land preparation for irrigation. In this analysis the opportunity cost of the farmer's investment in land, equipment, and operating capital is included in the costs of farm inputs. The farmer's investment is defined as the summation of the value of his land, farm irrigation structures, farm machinery, hand tools and operating capital. The annual opportunity cost is estimated to be 6 percent of the farmer's investment. According to the above definitions, the net farm income under future-without-project condition represents the return to family labor from dry farming or existing irrigation conditions. In the Akkar Plain area dry farming or limited irrigation farming is the only alternative to an irrigation project with regard to family labor, thus the opportunity cost of family labor is equivalent to the net farm income under future-without-project condition.

The net direct farm benefit used in the economic analysis in Chapter VIII is defined as the net farm income with-project development in excess of the net farm income without the project. Accordingly, in determining the irrigation benefit; i.e., the returns to irrigation water, family labor is valued at opportunity cost, and this is reflected by the returns under future-without-project development. The other farm inputs are valued at present costs, and agricultural products are valued at world market prices where applicable.

The payment capacity used in the financial analysis in Chapter VIII is the upper limit of the amount available by the farmer for payment of annual costs and for repayment of capital costs of the irrigation project. In this analysis, the payment capacity is equivalent to the residual farm income, which is defined as the net farm income with project development less a family living allowance deduction. The family living allowance is intended to: compensate the operator and family for

its labor; provide the operator a fee for managing the farm; and reimburse the family for the farm products consumed in the home. In this analysis, the labor is compensated at a rate of SP 25 per man day; the management fee is 1 percent of the gross value of sales and the farm products are reimbursed at market prices. It is recognized that only a portion of the payment capacity can be returned to the project as a portion must be retained by the farmer to provide the necessary incentive for the increased labor and financial risks attendant upon intensive agriculture.

Crop Prices

The crop prices used in determining the net direct farm benefits used in the economic analysis in Chapter VII are the world market prices shown in Table III-3. The crop prices used in determining the payment capacity are the actual farm gate prices in the Project Area and are shown in Table V-1.

Table V-1
Farm Gate Prices - Payment Capacity Analysis

Crop	Farm Gate Price (U.S. $/ton)	Farm Gate Price (SP/ton)
Wheat	169.84	662.38
Sorghum	228.40	890.76
Tomatoes(1)	105.13	410.01
Maize (table)	228.40	890.76
Maize (grain)	228.40	890.76
Forage	44.00	171.60
Beans (dry)	327.96	1,279.04

(1) Represents price used for all vegetables

Cost of Production and Net Farm Income

The cost of production and net farm income were determined by individual farm budgets for the future-without and future-with-project conditions. A composite budget for the four land capability classes was calculated for the future-without-project condition and a separate budget was prepared for each individual land capability class for the future-with-project condition. The budgets were prepared for an 8-hectare farm, which is the average size of farm in the Akkar Plain. It was

further assumed that 6 percent of the farm area is idle land to account for headlands, drains, ditches and roads.

Cost of Production: The cost of production was estimated for the entire farm enterprise by determining the inputs for each crop. Cost items include the following: hired labor including custom hire service for land preparation, spraying and harvesting; seeds and plants; fertilizers; insecticides; herbicides; depreciation and repair; interest cost; and miscellaneous. The depreciation and repair expense was calculated as a straight-line depreciation on all farm machinery and farm irrigation structures at 5 percent per year of the gross value of the equipment. The interest cost to the farmer was computed as 6 percent per year of his farm investment. This cost is not an actual out-of-pocket cost to the farmer, but represents the return he could realize on his investment if it were not committed to his farm enterprise. Miscellaneous includes credit and contingencies. No marketing fee was included as the farm gate price was used on farm commodities, assuming no cost to the farmer to market his products. Not included as costs are cost of water and family labor.

Net Farm Income: The net farm income is obtained by deducting the total costs of production, outlined in the preceding subsection, from the gross returns from agriculture. The gross returns from agriculture are determined by summing the gross return of each crop of the farm enterprise. The gross return of each crop is determined by multiplying the total production, expressed in tons, by the crop farm gate price shown in Table III-3. The net farm income per hectare of the various types of farm enterprises for the present condition, future-without-project and future-with-project is shown in Table V-2. The net farm income per hectare is determined by dividing the net farm income of the farm enterprise by the number of hectares of the farm enterprise including idle land.

Table V-2 shows that the maximum net farm income per hectare of SP 9,769.00 is realized from a vegetable farm enterprise operating on Land Capability Class I land for the future-with-project condition. The net farm income per hectare for a general farm enterprise operating on Land Capability Class "Composite" for future-with-drainage-project is SP 406.00.

Table V-2
Net Farm Income Per Hectare

Farm Type	Condition	Land Capability Class	SP	U.S. $
General	Present	Composite	94.00	24.00
General	Future-Without	Composite	199.00	51.00
Vegetable	Future-With	Class I	9,769.00	2,505.00
Vegetable	Future-With	Class II	8,755.00	2,245.00
General	Future-With	Class III	811.00	208.00
Forage	Future-With	Class IV	316.00	81.00
Citrus	Future-With	Class I & II	8,818.00	2,261.00
General (Drainage)	Future-With	Composite	406.00	104.00

Net Direct Farm Benefits

The net direct farm benefit, defined as the net farm income with project development in excess of the net farm income without the project, was determined for the several phases of the project.

Phase I: The net direct farm benefits of Phase I consist of the benefits of the drainage system and the Janoubi River Channel Improvement. The benefits of the drainage system apply to the full gross farm area of the project and are equal to future-with drainage less future-without-project as shown in Table V-3.

Table V-3
Net Direct Farm Benefits - Drainage

Net Farm Income (Per Hectare)			Area	Net Direct Farm Benefit
Future-with-Drainage (U.S. $) (1)	Future-without-Project (U.S. $) (2)	Net (1)-(2) (U.S. $) (3)	(ha) (4)	(U.S. $) (5)
104.00(1)	51.00(1)	53.00	17,179	910,487
		Use	U.S. $	910,000
			SP	3,549,000

(1) From Table V-2

The net direct farm benefits of the Janoubi River Channel Improvement are expressed as the value of the reduction of crop damage resulting from the construction of the flood control works and were determined to be U.S. $ 102,000 or SP 397,800.

Phase II: The net direct farm benefits of Phase II consist of the benefits of the surface water and groundwater irrigation systems. The benefits apply to the gross farm area under irrigation and are equal to future-with-project less future-with-drainage as the drainage benefits for the entire Project Area are credited to Phase I. The net direct farm benefits are shown in Table V-4.

Table V-4
Net Direct Farm Benefits - Phase II

Land Capability Class	Net Farm Income (Per Hectare)			Area	Net Direct Farm Benefit
	Future-with-Project (U.S. $)	Future-with-Drainage (U.S. $)	Net (2)-(3) (U.S. $)		
(1)	(2)	(3)	(4)	(ha) (5)	(U.S. $) (6)
I	2,505.00(1)	104.00(2)	2,401.00	735	1,764,735
II	2,245.00(1)	104.00(2)	2,141.00	4,937	10,570,117
III	208.00(1)	104.00(2)	104.00	5,998	623,792
			Total	11,670	12,958,644
			Use	U.S.$	12,960,000
				SP	50,544,000

(1) From Table V-2
(2) From Table V-2 for Land Capability Class "Composite"

Payment Capacity

The payment capacity defined as the net farm income with project development less a family living allowance deduction was determined for Phase II of the Development Plan. As shown in the financial analysis in Chapter VIII, payment capacity will only be considered for the cultivators under the surface water and groundwater irrigation systems. The payment capacity of the irrigators of Phase II is shown in Table V-5.

Table V-5
Payment Capacity - Phase II

Land Capability Class	Payment Capacity (Per Hectare)	Area	Total Payment Capacity
	(U.S. $)	(ha)	(U.S. $)
(1)	(2)	(3)	(4)
I	2,160.18	735	1,587,732
II	1,939.49	4,937	9,575,262
III	407.35	5,998	2,443,285
	Total	11,670	13,606,279
		Use U.S. $	13,606,000
		SP	53,063,000

CHAPTER VI

PROJECT WORKS

The various project works embodied in the Development Plan are described in Chapter V. In this chapter, the general conditions and concepts which influence the design of the various works are discussed. This is followed by descriptions of the principal features of the project. The chapter concludes with a discussion of the manner in which the construction of the project works can be carried out and some of the problems associated therewith.

GENERAL CONDITIONS

Depending on the results of the exploration work associated with the investigations for the Rihaniyeh storage site on the Abrache River and for groundwater in some areas, which have yet to be undertaken, no particularly unusual or difficult geologic problems are likely to be encountered at the sites of the various project works. From the standpoint of design and construction, the geologic materials that will be encountered can be grouped into several categories as follows:

> Earth -- Ranging from heavy expansive residual clay in the basalt terrain to silty-clay and sandy-loam soils in other terrains. In some areas, the soils may contain a high proportion of rock fragments. All of these materials can be excavated with scrapers or similar earth-moving equipment. Where clay predominates, careful control of moisture content will be required during construction of embankments.
>
> Rock -- In some areas basalt or limestone may lie at the surface or at shallow depth. Where these rocks are weathered and strongly jointed, they can be excavated with conventional equipment after ripping, but erratic overbreak will probably result in open-cut excavations. In some areas, light blasting may be required to facilitate the excavation of the canal prism or foundations for structures.

CONSTRUCTION MATERIALS

Sand and gravel aggregates are not readily available in the area. There are, however, several sites on the Plain where limestone of acceptable quality could be quarried and processed to produce concrete aggregates, including sand.

Most of the earth materials in the basalt areas are highly plastic and exhibit considerable shrinkage upon drying. Although these are not the most desirable materials for canal embankments and for fill construction, they can be successfully utilized if proper precautions are taken. These measures generally will involve placing the material in embankments at a moisture content somewhat higher than optimum and maintaining it moist until it is covered with other materials or with concrete lining.

Cement, reinforcing steel, structural steel shapes, and fabricated gates in certain sizes can be procured from sources within Syria. The requirements for the project, combined with the demands of other projects, may make it necessary to import some of these materials. This will largely depend upon the production capability of National facilities at the time the construction is undertaken; and in some instances, these materials may be imported at a landed cost less than that of locally produced products. Certain specialty items, such as plywood for concrete formwork, special steel products, well screens, some turbine pumps, electric motors, gate hoists, and flap gates, probably will have to be imported.

PHASE I

The works which would be started immediately because of the urgent need, the absence of long lead-time requirement, and the immediate benefits include flood control and surface drainage features. Some of the groundwater development, although considered in Phase 2, can and should also be initiated early in the schedule.

Flood Control

Flood control measures to be constructed in the first phase of the Akkar Plain development, Figure VI-1, include the Janoubi River channel improvement and associated structures on the north and south sides of the river as follows:

1. Channel improvement of the north, or Syrian, side of the river for a continuous reach of 10 kilometers beginning directly south of the village of Khirbet Akrad and ending about 2 kilometers above the mouth of the river. Improvements include a flap gate structure with a capacity of 2.5 cubic meters per second at the mouth of Sarous El Sabyga to contain the Janoubi River water during flood stages and three spoil bank crossings, one each at the existing farm road river crossings. Each would require a special design with side slopes of 8:1 and armored facing to prevent excessive wearing and erosion of the bank surfaces.

2. Channel improvement of the south or Lebanon side of the Janoubi River for a noncontiguous length of 7.0 kilometers. The difference in length of improvement on the two sides is due to a topographic rise in the landscape at several locations along the south side of the river. Small villages generally occupy these elevated areas as they are free from flooding. No special structures for the south side of the river are deemed necessary.

Janoubi River Peak Flows: Stream flow records consisting primarily of average monthly flows for the Janoubi River at the Debouseh Station for the period 1961-62 through 1972-73 and 1973-74 through 1976-77 were utilized to determine the magnitude and frequency of river flooding. In addition to the monthly discharge, some data were available on daily flows. A correlation was made of average monthly flow with available data on peak daily discharge to develop a 10-year frequency flood discharge of 274 cubic meters per second at the Debouseh Gage. The corresponding peak flow of the Janoubi River below its confluence with the Arouse River is 300 cubic meters per second and was used as the design flow for the channel improvement.

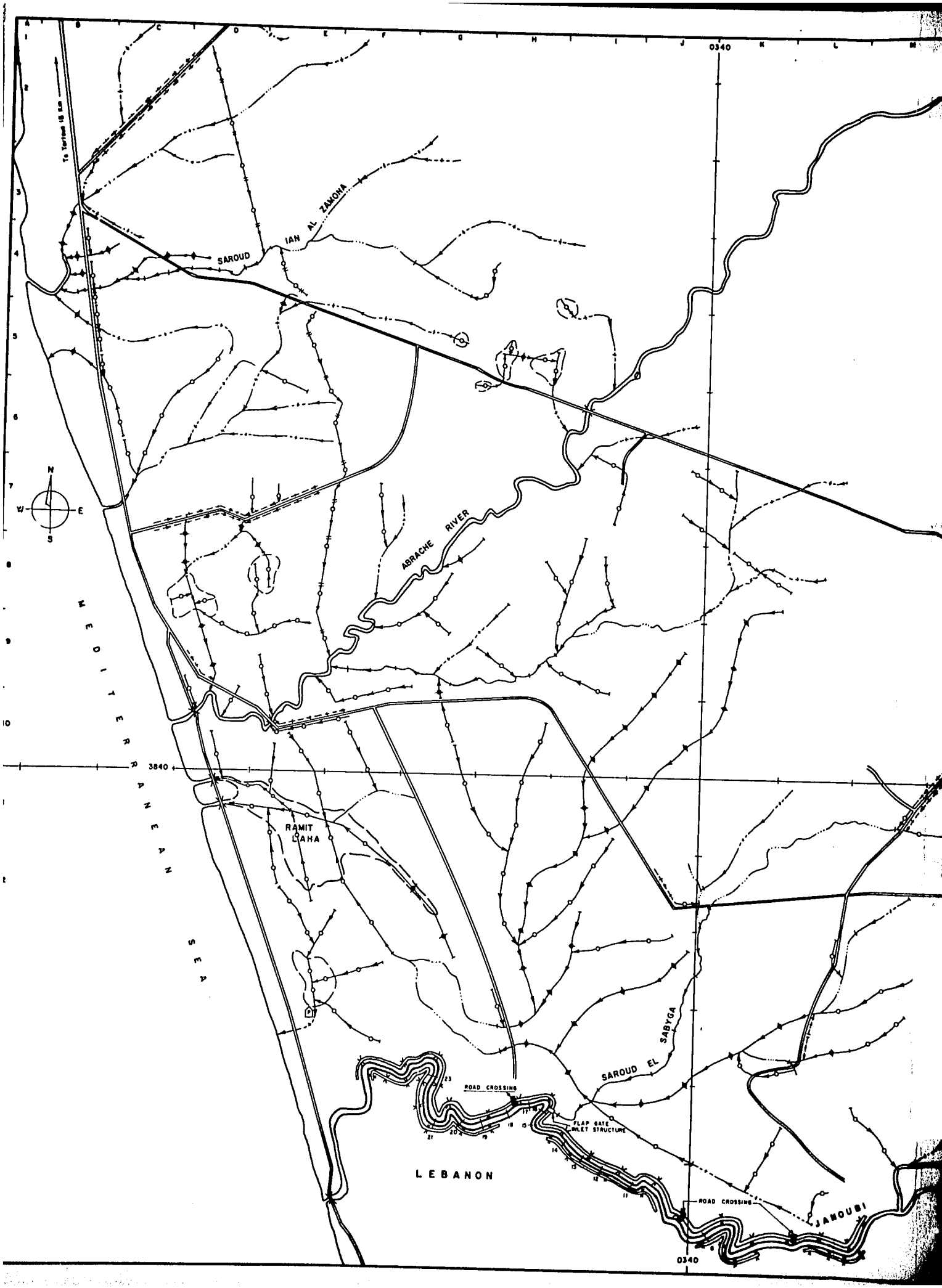
A corresponding peak flow during the 1977-78 period of investigations was determined to be 176 cubic meters per second, which represents about a 5-year flood frequency.

Design of Improved Janoubi River Channel: Thirteen representative sections across the Janoubi River were surveyed to provide engineering information sufficient to permit adequate design of the improved channel for feasibility cost estimates. Surveyed section No. 17, shown on Figure VI-2, most nearly represents the average cross section and was used for estimating purposes. The average height of the spoil bank would be 1.3 meters, which provides for 0.3 meters of freeboard for the 10-year frequency flood. The spoil bank would consist of compacted earthfill with a 3-meter top width and side slopes of 4:1. The material for the fill would be excavated from the river bank. Approximately 20 percent greater volume of excavation than of fill would be required to allow for shrinkage of the compacted material. A berm 3 meters wide would be provided between the edge of the excavated river bank and the inside toe of the spoil bank.

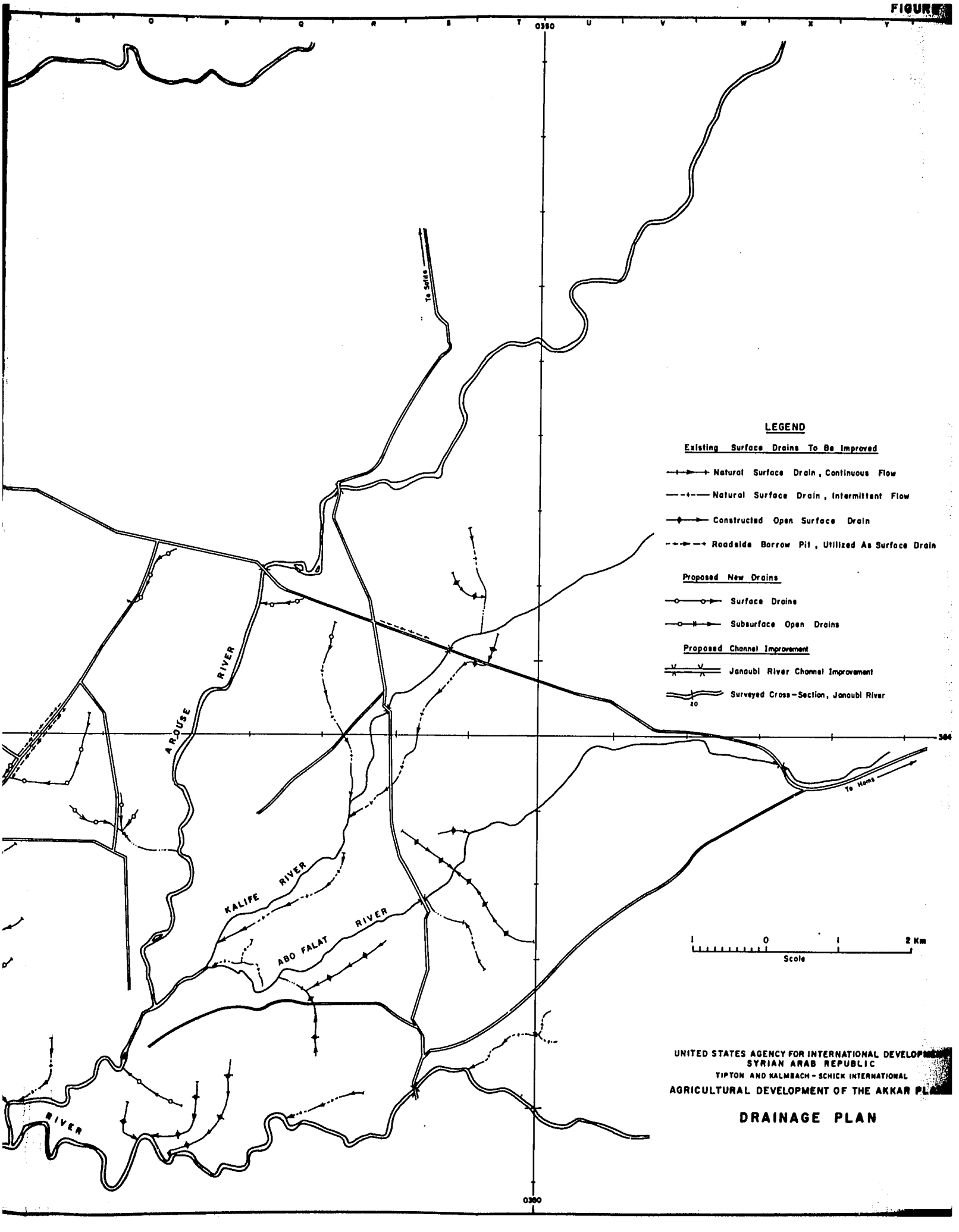
The material to be excavated from the river bank consists of fine-textured alluvial materials of sand, silt and clay and should be ideal for easy compaction by equipment travel without the need of additional moisture. Clearing of numerous trees and brush from the river banks will be required before bank excavation can be properly accomplished.

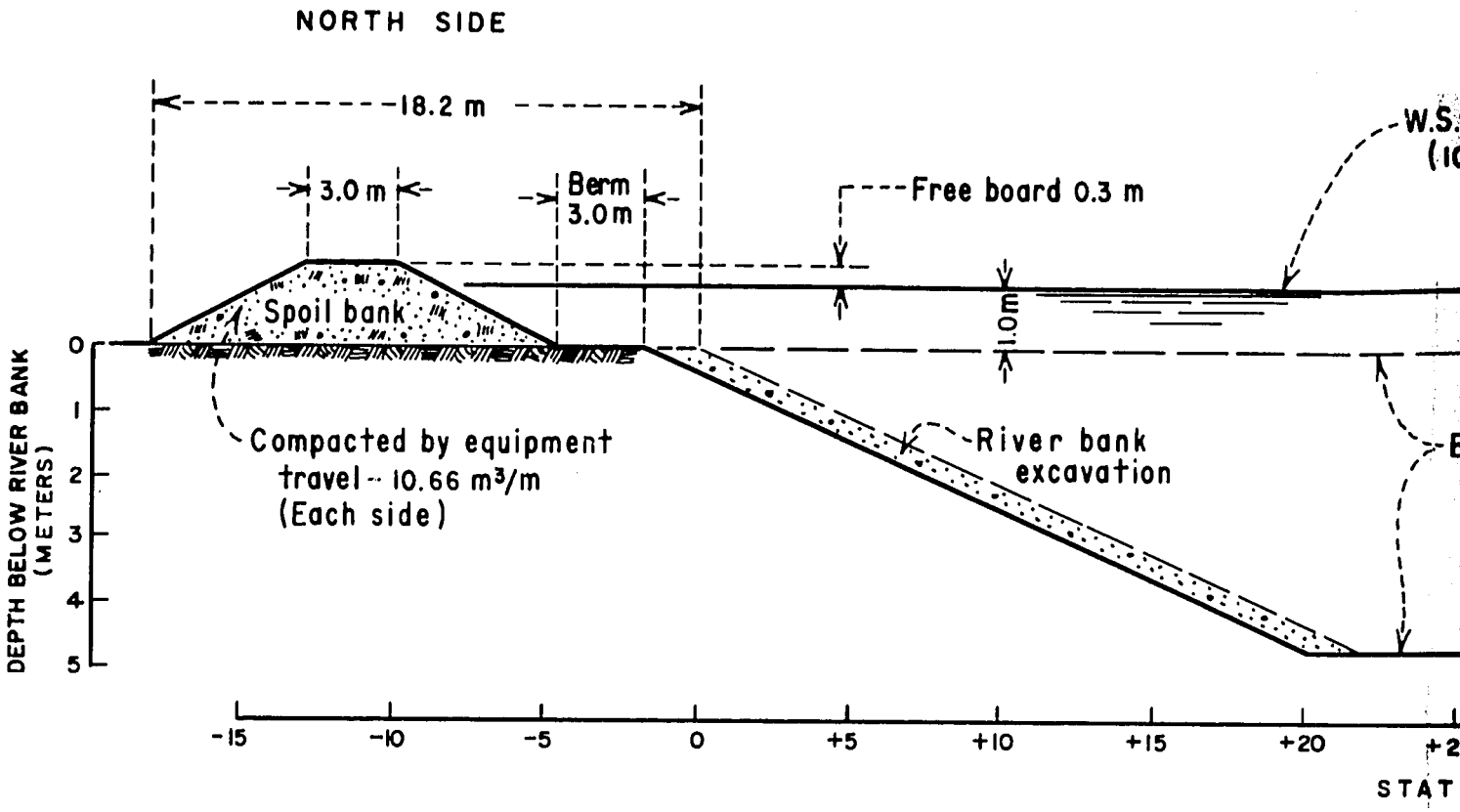
The flat side slopes of 4:1 provided in the design of the spoil bank will accommodate establishment of grass or other vegetative growth for grazing purposes and provide erosion protection. The side slopes of the river bank should be left as smooth as possible to improve stream hydraulics. Re-seeding of the river bank with appropriate grass varieties will also be necessary to control bank erosion.

The principal flood control features and related quantities for the north side and south side of the Janoubi River Channel Improvement are shown below:


To Tartous 18 Km
SAROUD
IAN AL ZAKONA
ABRACHE RIVER
MEDITERRANEAN SEA
RAMIT LAHA
SAROUD EL SABYGA
ROAD CROSSING
FLAP GATE INLET STRUCTURE
LEBANON
ROAD CROSSING
JANOUBI
0340
3840
N
S
E
W

FIGURE


N O P Q R S T U V W X Y
0380
To Safita
LEGEND
Existing Surface Drains To Be Improved
Natural Surface Drain, Continuous Flow
Natural Surface Drain, Intermittent Flow
Constructed Open Surface Drain
Roadside Borrow Pit, Utilized As Surface Drain
Proposed New Drains
Surface Drains
Subsurface Open Drains
Proposed Channel Improvement
Janoubi River Channel Improvement
Surveyed Cross-Section, Janoubi River
20
ARDUSE RIVER
KALIFE RIVER
ABO FALAT RIVER
RIVER
To Homs
384
1 0 1 2 Km
Scale
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
DRAINAGE PLAN



HYDRAULIC PROPERTIES
IMPROVED CHANNEL

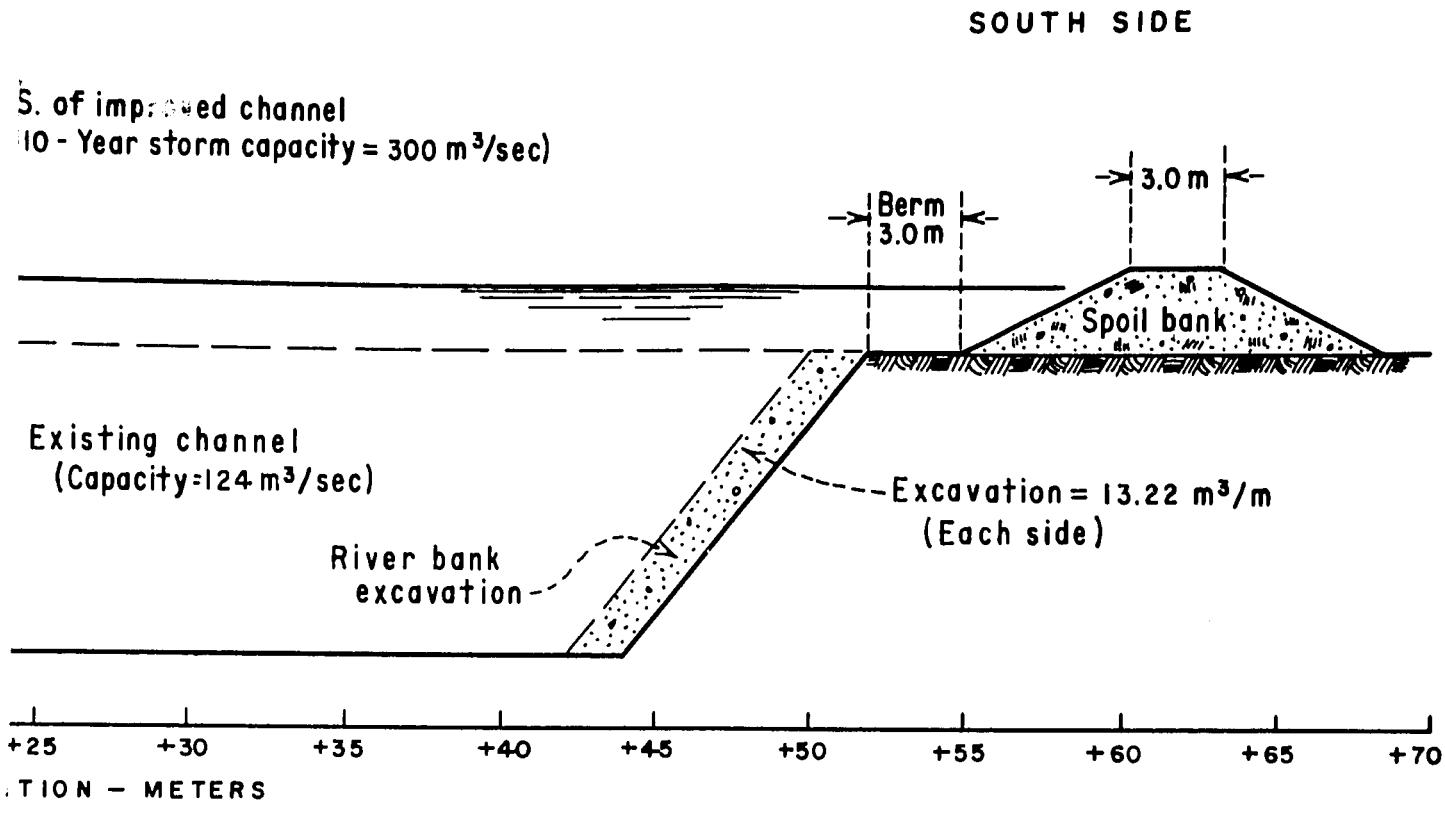
Cross-sectional area	= 256.6 m^2
Wetted perimeter	= 71.0 m
Hydraulic radius	= 3.6 m
S (Slope)	= 0.0005
n (Roughness coef.)	= 0.045
V (Velocity)	= 1.17 m/sec
Q (10 Year storm)	= 300 m^3/sec

MANNINGS FOR

$$V = \frac{r^{2/3}\ s^{1/2}}{n}$$

NOTE

Required river excavation equals compacted spoil bank plus 20% to allow for shrinkage



HYDRAULIC PROPERTIES
EXISTING CHANNEL

ORMULA

1/2

Cross-sectional area	= 158.7 m²
Wetted perimeter	= 52.4 m
Hydraulic radius	= 3.0 m
S (Slope)	= 0.0005
n (Roughness coef.)	= 0.060
V (Velocity)	= 0.78 m/sec
Q (Present capacity)	= 124 m³/sec

JANOUBI RIVER CHANNEL IMPROVEMENT
AT
AVERAGE SECTION – NO. 17
Akkar Plain Project

Item	Unit	Quantity
Syrian Side (10 kilometers)		
Earth excavation	cubic meters	132,200
Spoil bank placement and compaction (by equipment travel)	cubic meters	106,600
River bank clearing (trees and brush)	hectares	15
Flap gate structure (3), 60 centimeters diameter by 45 meters	meter	135
Farm road river bank crossings	each	3
Lebanon Side (7 kilometers)(1)		
Earth excavation	cubic meters	92,500
Spoil bank placement and compaction (by equipment travel)	cubic meters	74,600
River bank clearing (trees and brush)	hectares	10

(1) The cost of channel improvement for the Lebanon side of the Janoubi River was not used in the economic evaluation of the Akkar Plain Project since it only benefits the Lebanon area and is totally unrelated to the Project Area.

Drainage

The drainage features to be constructed are shown in Figure VI-1 and are summarized in the following tabulation:

Item	Range in Capacity (m^3/s)	Total Length (km)	Number of Structures
Improvement of Existing Drains			
Natural surface drains (perennial flow)	2.80- 5.10	11.4	
Natural surface drains (intermittent flow)	.10- 2.80	57.2	
Constructed drains	.15-10.20	38.5	
Roadside borrow pits	.15- 1.40	13.4	
New Surface Drains	.10-16.10	63.3	
Subsurface drains (1.8 meter depth)		8.3	
Special Drainage Structures			
Drainage inlet pipes			
12-inch diameter			80
15-inch diameter			12
Bridge culverts (highway crossings)(1)			5
Flap gates - 15-inch diameter			8
Drainage pump (140 liters per second)			1

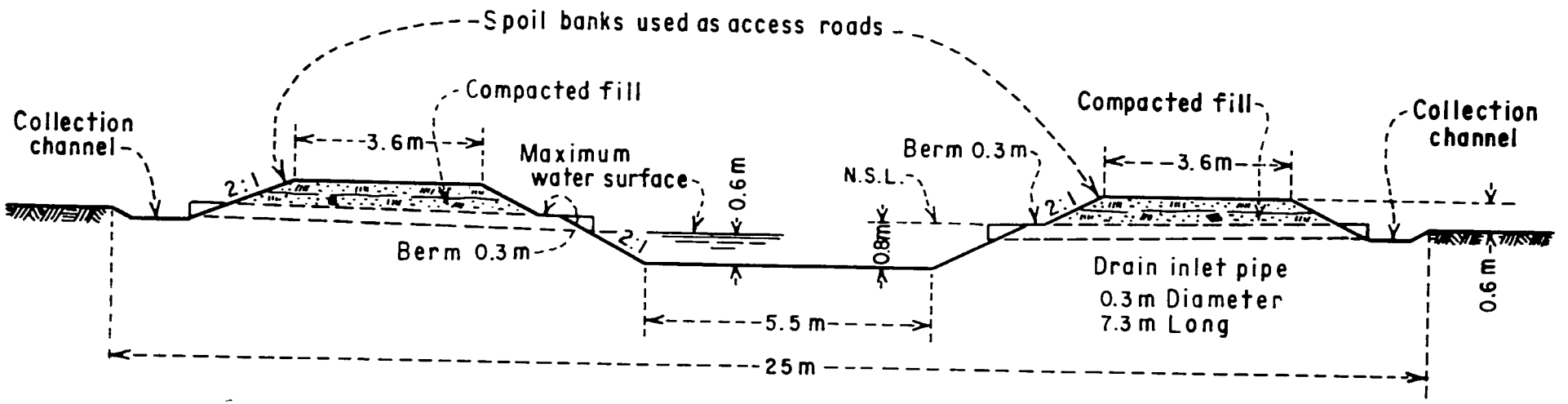
(1) Includes only drainage culverts under major highways. All drainage culverts required for farm roads are included in the infrastructure development.

The surface drainage requirement for the Akkar Plain is based on the 1977-78 winter storm runoff which represents about a 5-year storm frequency.

Surface Drains: The requirement for proposed new surface drains on the Akkar Plain is very significant, a total length of 63.3 kilometers. The largest of these drains would be located in the Ramit Laha area where most of the flooding occurs. In general, the new drains would be positioned between widely spaced existing drains to provide adequate outlet for lands now damaged by sheet flooding. Wherever the situation is technically feasible, drains would be located along existing farm roads to minimize the disturbance of farm tract boundaries.

The Ramit Laha area will require an especially wide but shallow drain to provide the proper hydraulics for delivery of the drainage water into the Mediterranean Sea. During extremely windy conditions, seawater is backed into the Ramit Laha area. This water would be controlled under the Development Plan by providing high banks with flap gates on the drainage inlet structures to control the seawater, yet allowing surface water runoff to enter the outlet drain as soon as the heavy winds subside. Generally, the winds precede the rainfall and therefore runoff from precipitation would not immediately flow through the drainage inlet structures because of flap gate closure imposed by wind-blown seawater. As the seawater drains out, the precipitation drainage will be outleted through the opened gates.

General Design of Surface Drains: The design of the individual surface drain is dependent upon the maximum flow. Table VI-1 shows the accumulated drain length and representative capacities in each of the drain categories. Typical designs for selected drains with representative capacities are shown in Figures VI-3 and VI-4. The hydraulic properties for each of the drain designs are based on the application of Manning's formula for open channels. The applicable coefficient of roughness, "n", selected for the drains is 0.030. It is anticipated that the channels will be smooth with short vegetative growth during the wet season period of maximum flow. This conforms to the short vegetative condition of the existing channels which is maintained by grazing of sheep and livestock. One exception is the perennial flow channels where brush will need to be controlled by spraying as well as by grazing to maintain good channel hydraulics.



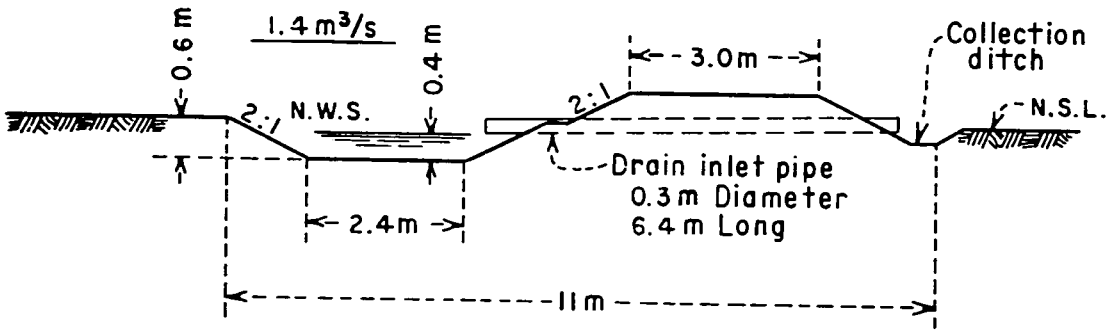
HYDRAULIC PROPERTIES

Maximum Q	= 2.8 m^3/sec
Max. water depth	= 0.6 m
Drain Depth	= 0.8 m
Bottom width	= 5.5 m
Side slopes	= 2:1
n (Coef.)	= 0.030
S (Slope)	= 0.001
V (Velocity)	= 0.67 m/sec

TIPTON AND KALMBACH - SCHICK INTERNATIONAL

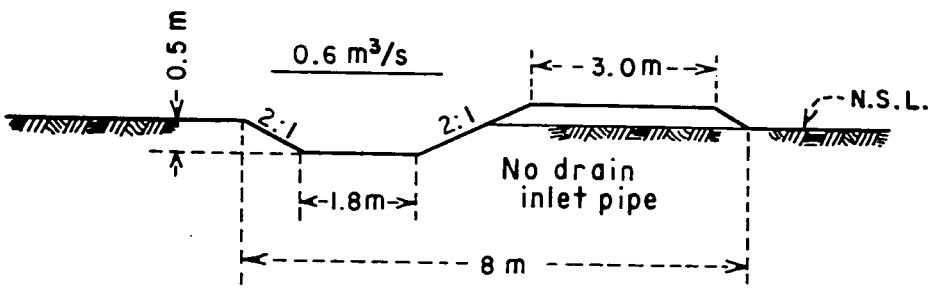
DRAIN SECTION
(2.8 m/sec. Capacity)
Akkar Plain Project

FIGURE VI-3

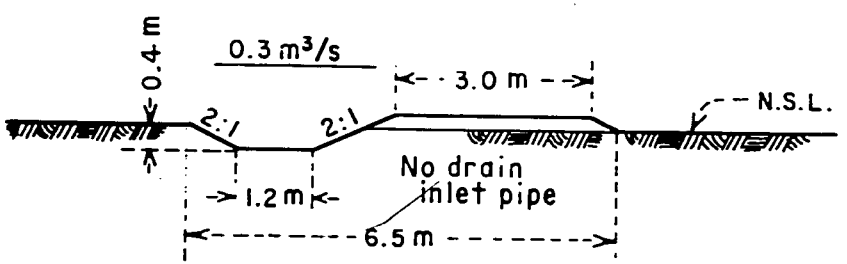


HYDRAULIC PROPERTIES

Maximum Q	= 1.4 m³/sec
Max. water depth	= 0.4 m
Drain depth	= 0.6 m
Bottom width	= 2.4 m
Side slopes	= 2:1
n (Coef.)	= 0.030
S (Slope)	= 0.006
V (Velocity)	= 1.1 m/sec
Height of spoil bank	= 0.5 m



Maximum Q	= 0.6 m³/sec
Max. water depth	= 0.4 m
Drain depth	= 0.5 m
Bottom width	= 1.8 m
Side slopes	= 2:1
n (Coef.)	= 0.030
S (Slope)	= 0.002
V (Velocity)	= 0.63 m/sec
Height of spoil bank	= 0.35 m



Maximum Q	= 0.3 m³/sec
Max. water depth	= 0.24 m
Drain depth	= 0.4 m
Bottom width	= 1.2 m
Side slopes	= 2.1
n (Coef.)	= 0.030
S (Slope)	= 0.004
V (Velocity)	= 0.67 m/sec
Height of spoil bank	= 0.25 m

TYPICAL DRAIN SECTIONS

Akkar Plain Project

FIGURE VI-4

TIPTON AND KALMBACH - SCHICK INTERNATIONAL

Table VI-1
Summary of Project Surface Drains by Drain Capacity

Drain Capacity (m^3/sec)	Existing Drains to be Improved (km)				Proposed New Drains (km)	Total (km)	Percent of Total Length (%)	
	Nat. Surface Drains Intermittent Flow	Nat. Surface Drains Perennial Flow	Roadside Borrows	Constructed Surface Drains				
.10	2.3				5.6	7.9	4.3	
.15	6.7		2.7	7.0	23.9	40.3	21.9	
.20	1.5					1.5	0.8	
.25					1.2	1.2	0.7	(0.10-0.40m^3)
.30	13.5		3.7	4.9	11.9	34.0	18.5	50.6
.40	2.7		1.4	2.3	1.7	8.1	4.4	
.60	8.5		1.8	3.5	11.1	24.9	13.5	
.90	8.9			1.5	2.3	12.7	6.9	
1.10	8.9		1.9	0.2	1.3	12.3	6.7	
1.40	2.7		1.9	4.6		9.2	5.0	(0.60-2.00m^3/s)
1.70	1.0			5.4		6.4	3.5	36.0
2.00				0.7		0.7	0.4	
2.80	0.5	6.5			0.9	7.9	4.3	
3.40				5.8		5.8	3.1	
4.20		0.9				0.9	0.5	
4.40				0.9		0.9	0.5	(2.80-4.80m^3/s)
4.70				0.4		0.4	0.2	9.0
4.80		0.7				0.7	0.4	
5.10		3.3				3.3	1.8	
10.20				1.3		1.3	0.7	
13.00					0.7	0.7	0.4	(5.10-16.10m^3/s)
14.90					2.0	2.0	1.1	4.4
16.10					0.7	0.7	0.4	
TOTAL	57.2	11.4	13.4	38.5	63.3	183.8	100.0	

The drains are designed with a 2:1 side slope with most of the spoil material being placed on the bank to construct an access road. The design provides for corrugated metal pipe surface water inlets on a spacing of approximately 300 meters for most drains with a capacity larger than 0.9 cubic meters per second. Quantities of excavation required for all existing and new drains are summarized in Table VI-2.

A sump pump would be required to remove the ponded water from a depression below sea level near Kharabeh. The pump capacity would by 140 liters per second, and it would be required to operate at full capacity for a total of 37 days during stormy periods each winter season.

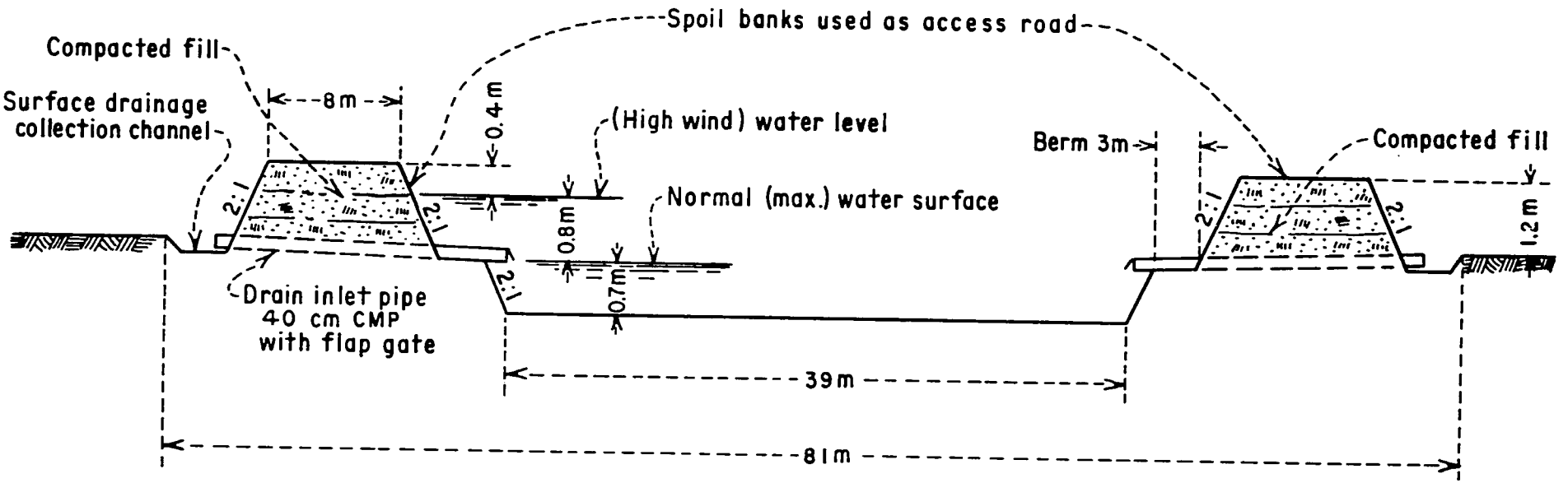
Ramit Laha Drain: The Ramit Laha Drain, with a maximum capacity of 16 cubic meters per second is the largest and most complex drain proposed for the Akkar Plain. The drain has two outlets to the sea, consisting of the north and south channels. With future control of the Janoubi River floodwater, the two channels under the coast road bridges will have more than adequate capacity for the anticipated drainage water.

The very flat gradient of the Ramit Laha area, coupled with the adverse wind conditions, imposes design limitations on the proposed Ramit Laha Drain. The limitations include:

1. A maximum channel depth of 0.7 meter,
2. High spoil banks of about 1.2 meters to contain wind-driven seawater, and
3. Surface water inlet pipes with flap gate closures to prevent the wind-driven seawater from overflowing onto cultivated land.

A typical section of the Ramit Laha Drain including its hydraulic properties is shown in Figure VI-5.

Subsurface Drainage: The extent of the area adversely affected by the subsurface drainage deficiency is approximately 8 kilometers long and 400 meters wide. A deep subsurface interceptor drain located at the base of the topographic break should adequately control the high water table to permit early spring cultivation, planting and unrestricted plant growth for improved agricultural production.



HYDRAULIC PROPERTIES

Bottom width	= 39 m
Water depth	= 0.7 m
Side slopes	= 2:1
Cross-sectional area	= 28.7 m^2
S (Slope)	= .0005
n (Coef.)	= 0.030
Hydraulic radius	= 0.67 m
V (Velocity)	= 0.57 m/sec
Maximum Q	= 16.1 m^3/sec

TYPICAL SECTION
RAMIT LAHA DRAIN
Akkar Plain Project

FIGURE VI-9

TIPTON AND KALMBACH - SCHICK INTERNATIONAL

Table VI-2
Required Excavation for All Drains

Drain Category	Channel Volume Required (1000 m^3)	Existing Cha Volume (1000 m^3)	New Excavation Volume (1000 m^3)
Existing Surface Drains to be Improved			
Natural Surface Drains (Perennial Flow) 11.4 km	60.3	33.1	27.2
Natural Surface Drains (Intermittent Flow) 57.2 km	78.7	39.3	39.4
Constructed Surface Drains 38.5 km	109.7	54.8	54.9
Borrow Pits 13.4 km	18.6	11.1	7.5
		SUBTOTAL	129.0
Proposed New Drains			
Surface Drains 63.3 km	136.2	-	136.2
	SURFACE DRAINS SUBTOTAL		265.2
Subsurface Drains 8.3 km	60.2	-	60.2
	GRAND TOTAL		325.4

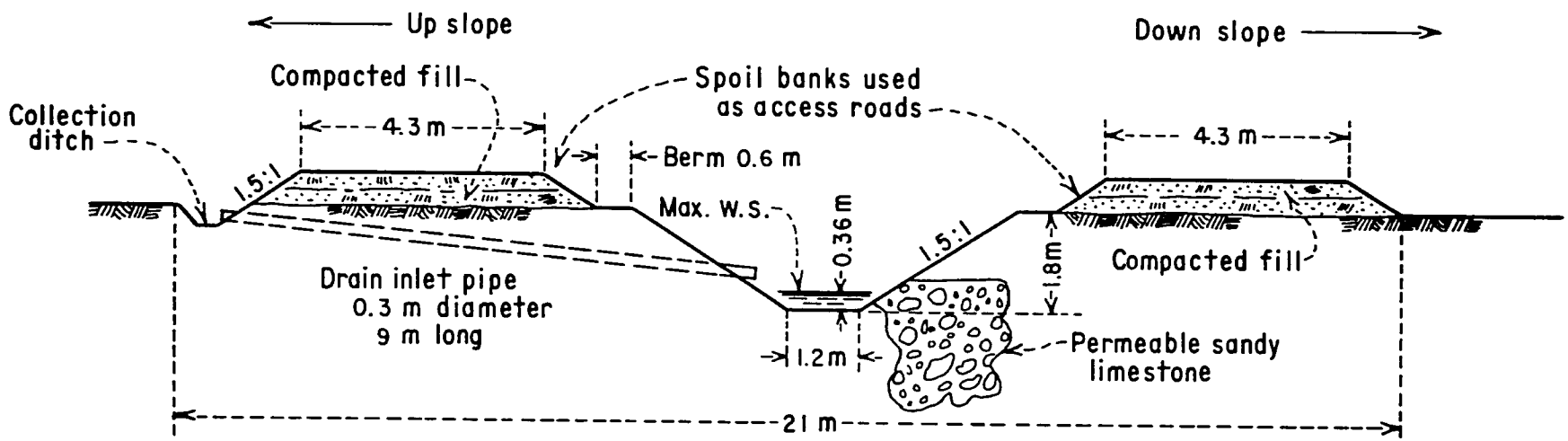
Subsurface Drain Design: There are three separate subsurface drains proposed which total 8.3 kilometers in length. They would be continuous and located parallel to the topographic break, generally between the 15-meter and 20-meter contours, but separated into three drains because of the outlet opportunities for each. The longest drain is designated Subsurface Drain No. 3 with a length of 4.7 kilometers. Since each of the drains would have the same basic design, only Drain No. 3 is described in this Report as shown on Figure VI-6.

The drain would be 1.8 meters deep and would penetrate approximately 0.8 meter into sandy limestone. A deep drain located under these conditions should respond very favorably owing to the permeable nature of the rock materials. The drain would be designed with side slopes of 1.5:1, bottom width of 1.2 meters, and with an operation and maintenance road on each side of the drain. The roads would be constructed from the excavated spoil material and would be used as access roads to adjacent farmlands. The roads would have side slopes of 1.5:1, a top width of 4.3 meters, and be compacted by special equipment travel.

The design provides for a ditch above the drain to collect surface water and to convey it to the subsurface drain via corrugated metal pipe surface water inlets. Drainage inlets would be spaced approximately 300 meters apart. The calculated design flows in the subsurface drains for summer and winter conditions are 0.07 cubic meters per second and 0.48 cubic meters per second, respectively.

Ancillary Drainage Requirement: A drainage waste ditch collection system to serve each farm tract with a surface water outlet is a necessary requirement for all irrigable lands of the Akkar Plain. This system, coupled with improved on-farm cultural practices, would readily eliminate runoff from precipitation and irrigation and thus achieve better production on the irrigable lands. The average spacing required for ditches would be 250 meters. They would convey water to the project drainage system.

The estimated average capacity of the collection waste ditches is 0.10 cubic meters per second. The channel would be only 20 centimeters deep with a bottom width of 30 centimeters and comparatively flat side slopes of 3:1. The top width



HYDRAULIC PROPERTIES
DRAIN NO. 3 (E-9)

Side slopes	= 1.5:1
n (Coef.)	= 0.030
S (Slope)	= 0.003
Bottom width	= 1.2 m
Hydraulic radius	= 0.26 m
Drain depth	= 1.8 m
Cross-sectional area	= 165 m^2
V (Velocity)	= 0.73 m/sec
Q (Max. winter flow)	= 0.46 m^3/sec
Q (Summer flow)	= 0.07 m^3/sec
Length	= 4,680 m

TIPTON AND KALMBACH - SCHICK INTERNATIONAL

TYPICAL SUBSURFACE DRAIN DESIGN
Akkar Plain Project

FIGURE VI-6

would be 1.5 meters. It would be a grass-covered channel and could be used for grazing purposes as well as drainage; the grass would also serve as an erosion control measure.

PHASE II

The works required for development of intensive irrigated agriculture and the infrastructure improvements are placed in Phase II because of the longer time of construction required and because the benefits will be enhanced by the existence of Phase I works.

Surface Storage

It must be re-emphasized that the technical feasibility of surface storage has not yet been satisfactorily established. While it would be possible to construct a dam at one of two sites on the Abrache River, preliminary investigations at the Yazdieh site have indicated a leakage problem of unknown magnitude, and there have been no investigations of the Rihaniyeh site. For the purposes of this Report, it is assumed that one or the other dam will be built.

Rihaniyeh Dam

The downstream dam alternative is located on the Abrache River approximately 600 meters north of the Homs-Tartous expressway as shown on Figure VI-7. Preliminary design details of the dam are shown on Figure VI-8. The total capacity of the reservoir is 77 million cubic meters with a surface area of 590 hectares.

The structure is essentially a rockfill dam with a compacted earth core and concrete gravity spillway section. The embankment is 4.5 kilometers in length and the maximum section is 36 meters high to a crest elevation of 66.5 meters. The highwater line is at elevation 61.5 meters and the minimum pool is at elevation 42 meters. The width of the crest is 10 meters with upstream and downstream slopes of 3 to 1 and 2.5 to 1 respectively. It is likely that with additional materials investigations the slopes of the final design can be made steeper. No grouting has been shown and the need for grout will have to be determined at a future stage of design.

The concrete spillway has a crest length of 50 meters and is keyed into the embankment by a concrete gravity section 80 meters long on each side of the spillway. A temporary opening is provided in the spillway to pass the flow of the Abrache River during construction of the dam. This opening will be plugged after the dam is completed.

The east bank outlet works consist of a 180-centimeter diameter outlet conduit leading from the concrete gravity section near the spillway through the structure then eastward to discharge into the east bank canal system. The west outlet works consist of a 120-centimeter diameter conduit discharging into the west bank canal system. Provision is made to discharge flow from both outlets back into the river in the event the need arises to drain the reservoir. It is anticipated seepage from the reservoir will maintain flow in the river below the dam.

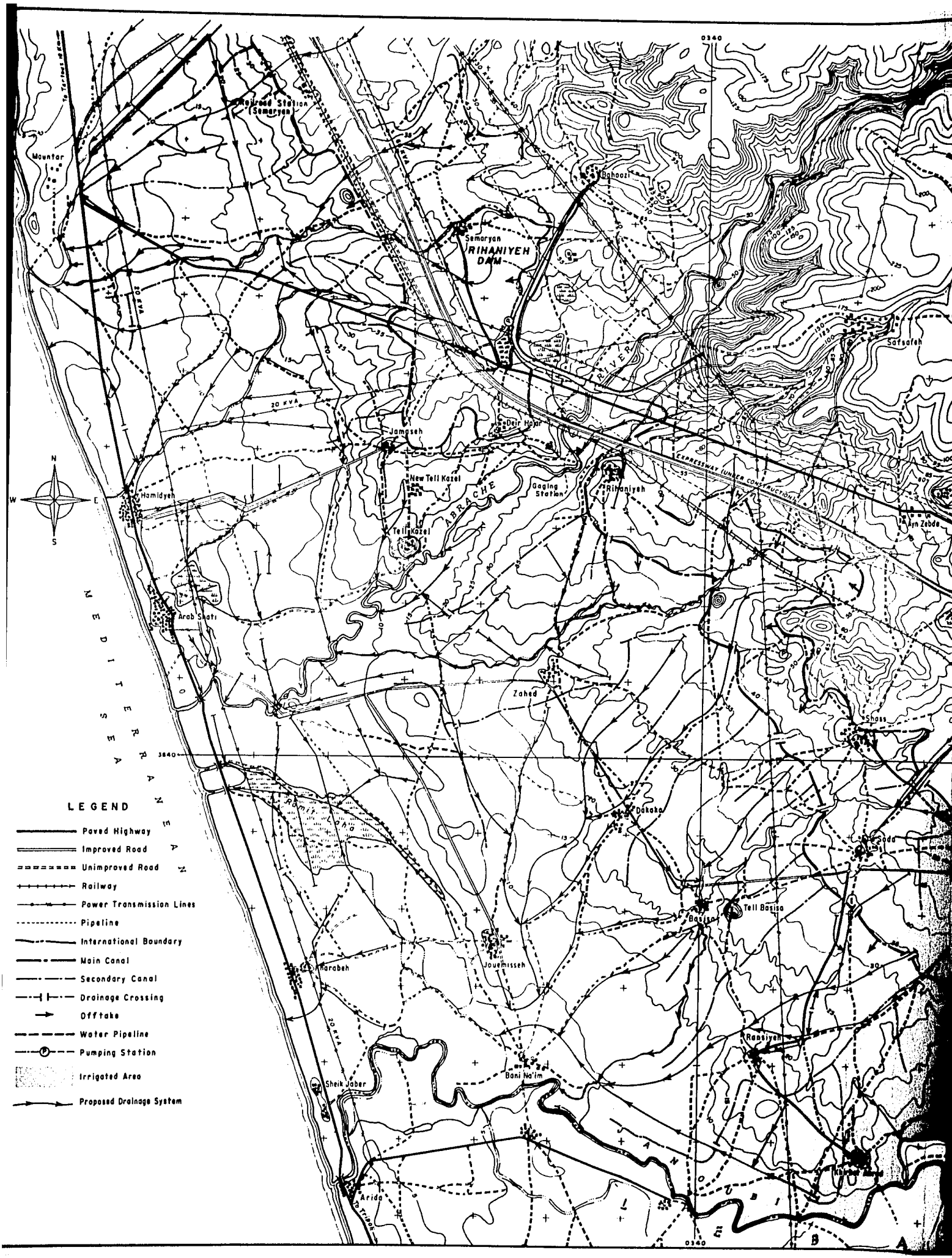
No unusual maintenance problems are anticipated. Normal maintenance will consist of care for the mechanical mechanisms of the outlet works and periodic removal of debris that may periodically be carried into the reservoir by floods.

Yazdieh Dam

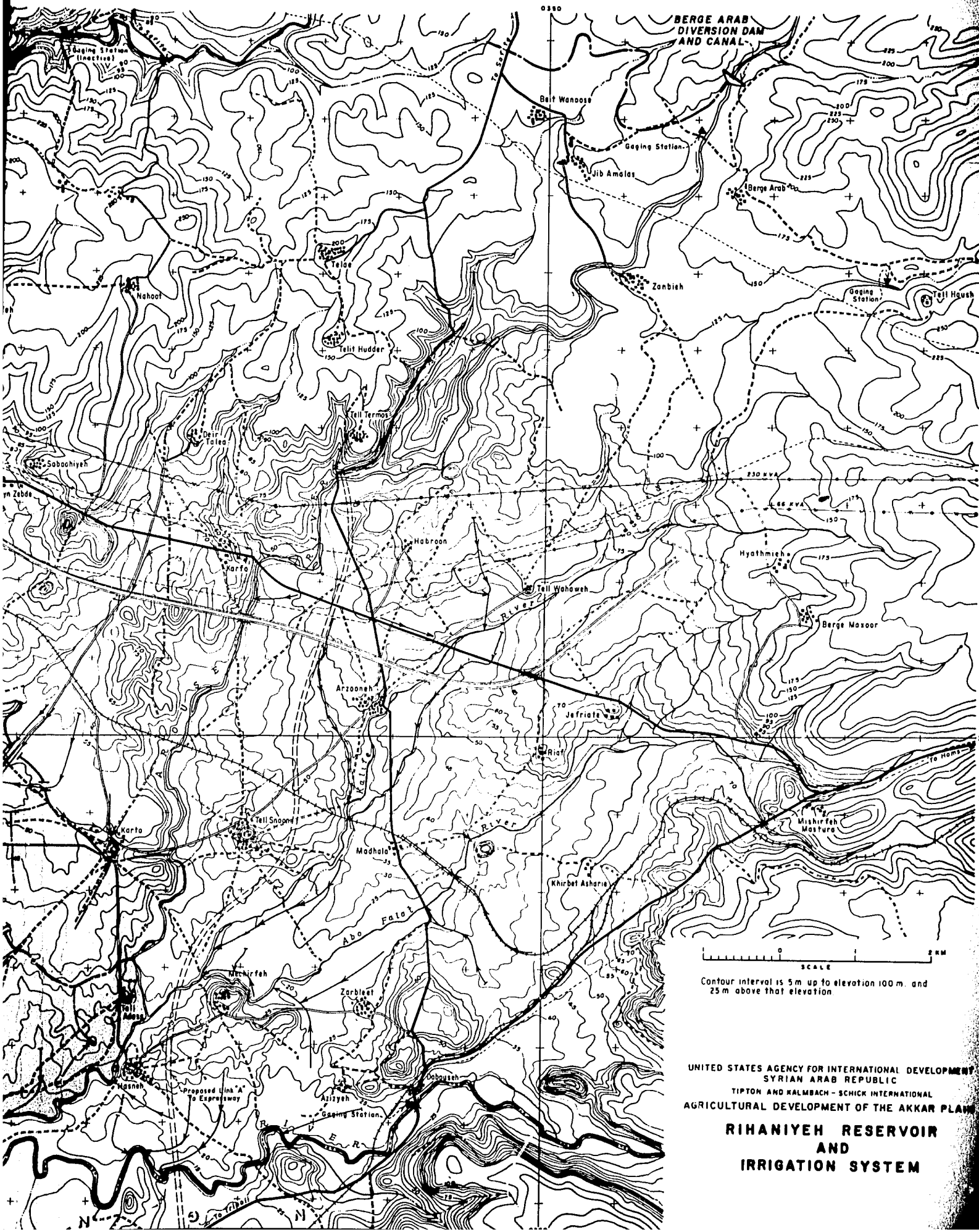
The upper dam alternative is located on the Abrache River about 6 kilometers upstream from the point where the Homs-Tartous expressway crosses the river. A description of the dam and corollary work along with design details are given in the separate report on the structure prepared by Sofrelec.

Storage water is released from the Yazdieh Dam and conveyed in the natural channel of the Abrache River to the Abrache Diversion Dam located about 4 kilometers below the main dam where the water is diverted to the east and west bank canal systems.

Abrache Diversion Dam: In the case of the Yazdieh Dam, a diversion dam on the Abrache River is required to divert water released from the dam into the canal systems. It would be too costly to pipe the flow from the dam to the canals, and the steep canyon walls and geologic considerations prohibit constructing a reasonable canal system from the Yazdieh Dam to the irrigated Plain.


Railroad Station (Semaryan)
Mountar
Semaryan
RIHANIYEH DAM
Ghoozi
Safsafeh
RIVER
Jamaseh
Deir Hanar
New Tell Kazel
Tell Kazel
ARACHE
Gaging Station
Rihaniyeh
EXPRESSWAY (UNDER CONSTRUCTION)
Hamidyen
Ayn Zebde
Arab Shati
MEDITERRANEAN SEA
Zahed
Shaas
Dakaka
Tell Basira
Basira
Jouemisseh
Marabeh
Rassiyeh
Bani Na'im
Sheik Jaber
Arida
JANOUBI
LEGEND
Paved Highway
Improved Road
Unimproved Road
Railway
Power Transmission Lines
Pipeline
International Boundary
Main Canal
Secondary Canal
Drainage Crossing
Offtake
Water Pipeline
Pumping Station
Irrigated Area
Proposed Drainage System

FIGURE


BERGE ARAB DIVERSION DAM AND CANAL
Gaging Station (Inactive)
Beit Wanoose
Gaging Station
Jib Amalas
Berge Arab
Telaa
Nahoot
Zanbieh
Gaging Station
Tell Haush
Telit Hudder
Tell Termos
Deir Talea
Sabachiyeh
Habroon
Hyathmieh
Karfa
Tell Wahaweh
Berge Maxoor
Arzooneh
Jefriate
Riat
Tell Snaoni
Karfa
Madhala
Mishirfeh Mastura
Khirbet Asharie
Abo Falat
Mishirfeh
Zarbleet
Tell Aaas
Hasneh
Proposed Link "A" To Expressway
Azizyeh
Gaging Station
Debousseh
To Homs
To Tripoli
230 KVA
66 KVA
SCALE
0
2 KM
Contour interval is 5 m up to elevation 100 m. and 25 m above that elevation
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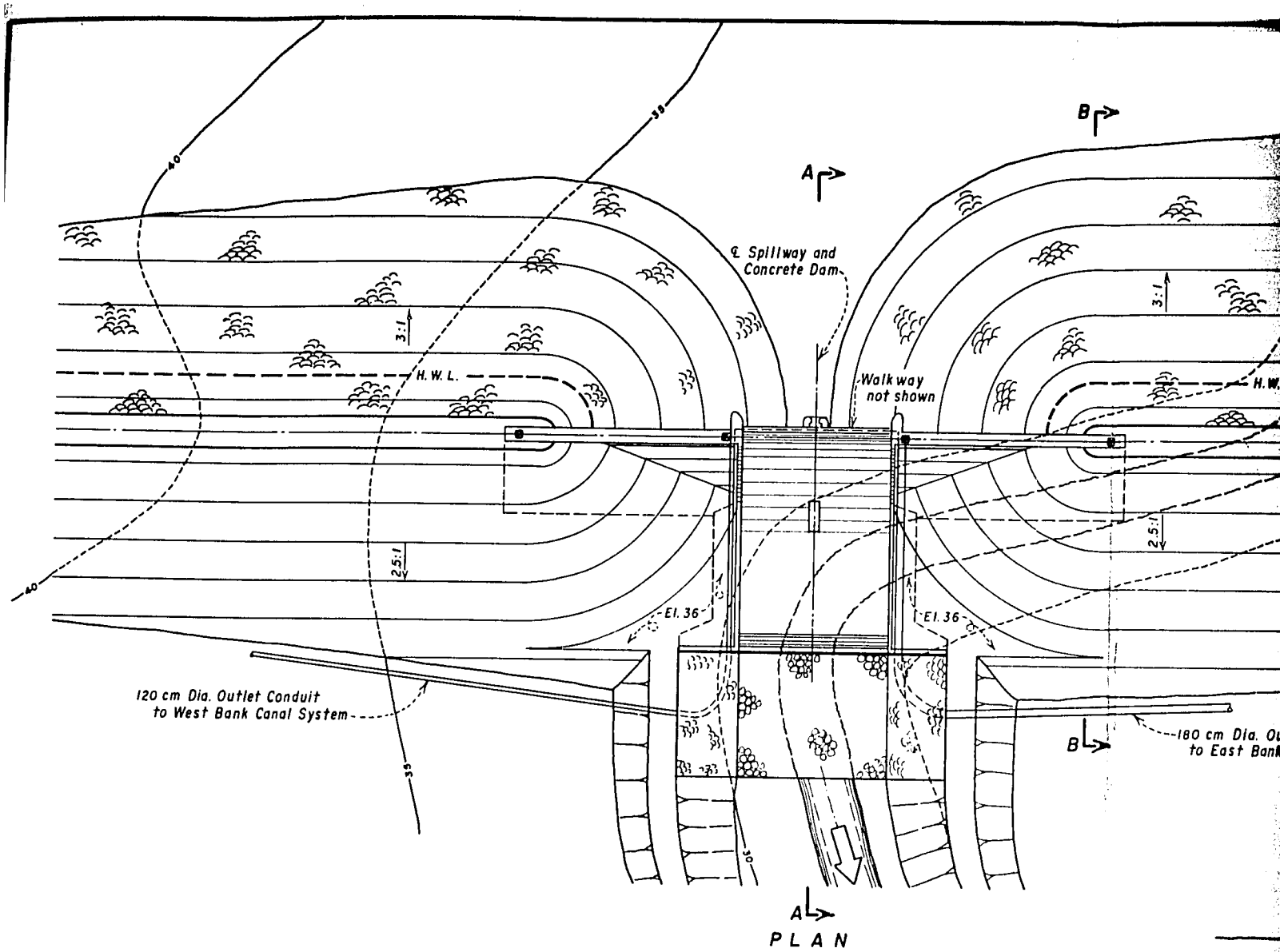
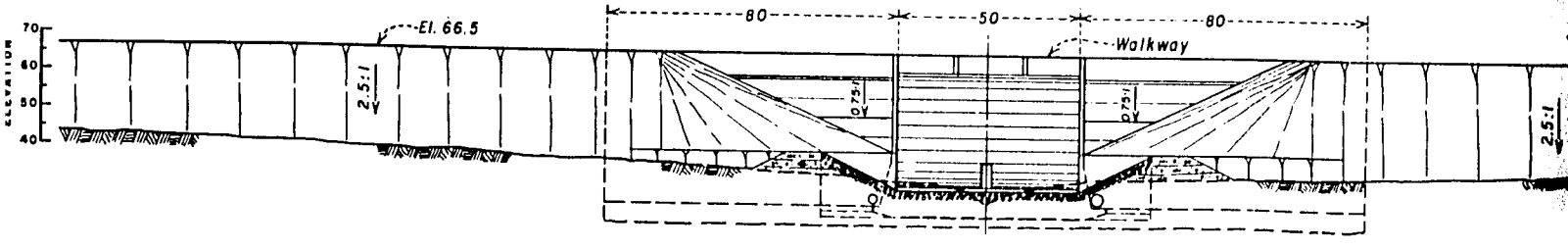
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
RIHANIYEH RESERVOIR
AND
IRRIGATION SYSTEM

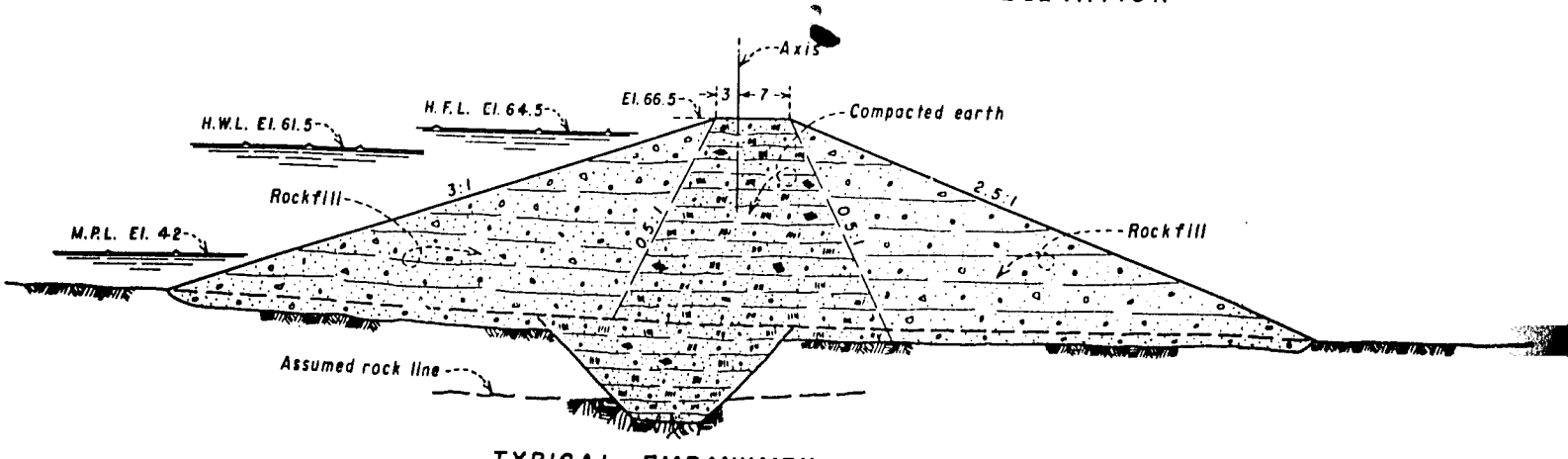


PLAN

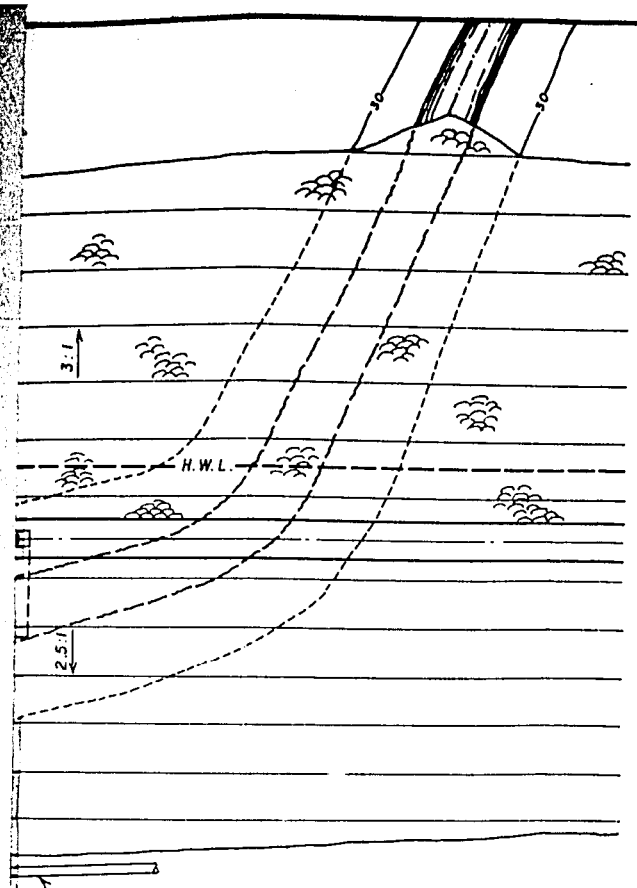
10 0 50 100 METERS
SCALE

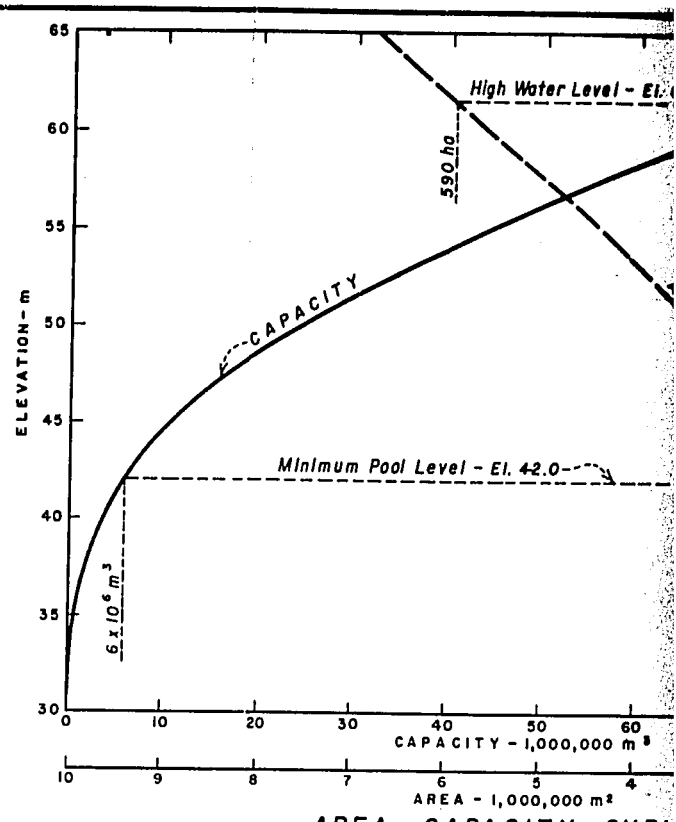


DOWNSTREAM ELEVATION

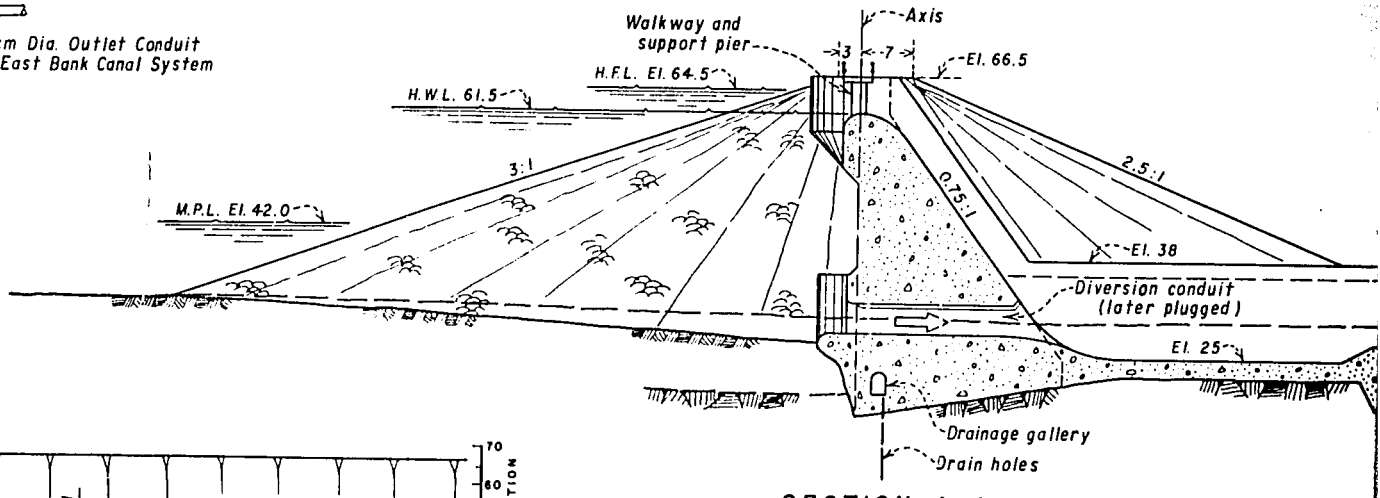


TYPICAL EMBANKMENT SECTION

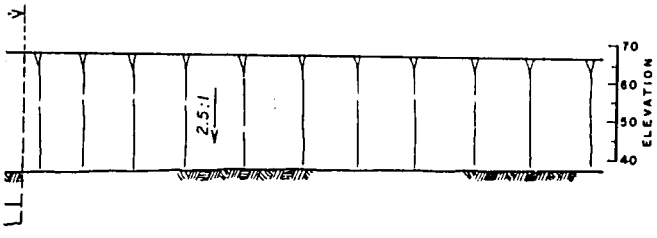


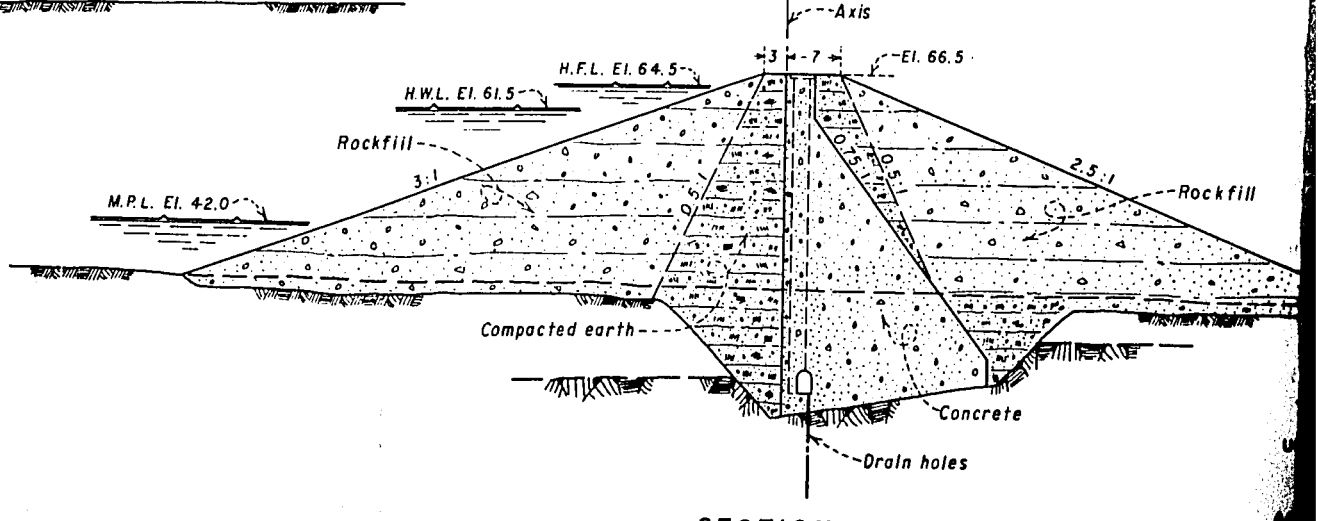


AREA - CAPACITY CURV



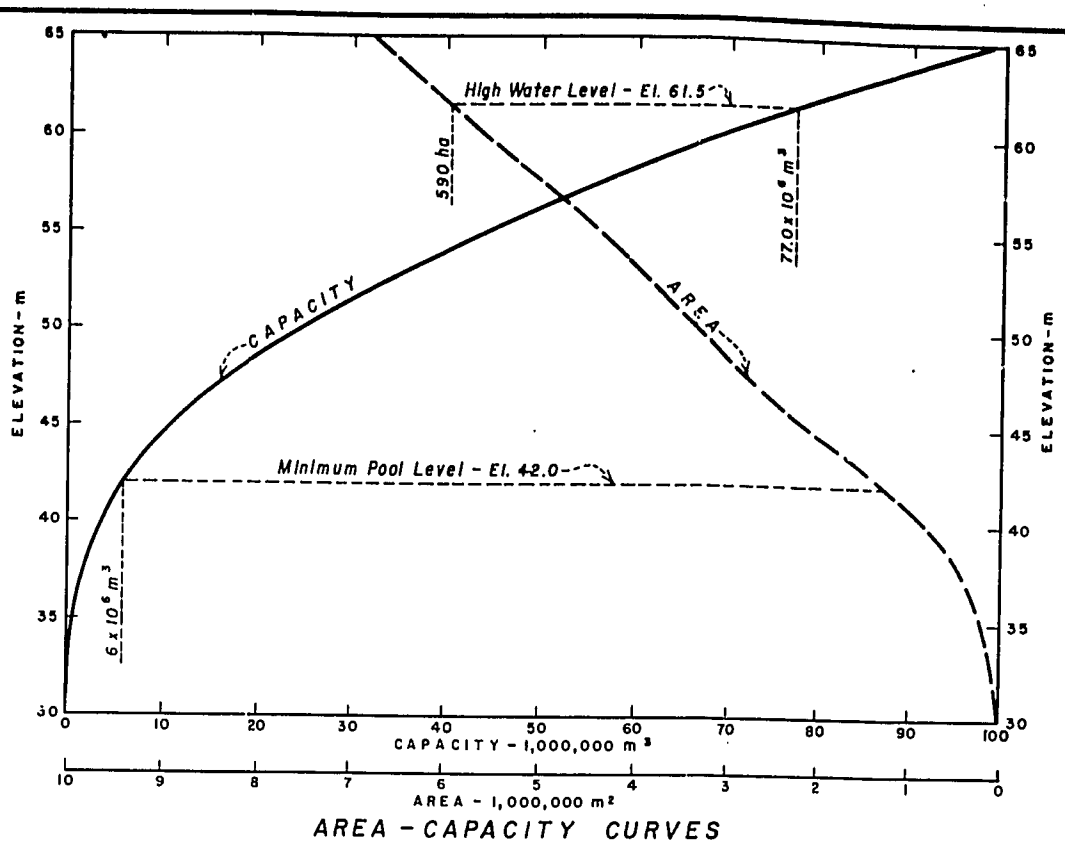
SECTION A-A
(SPILLWAY)



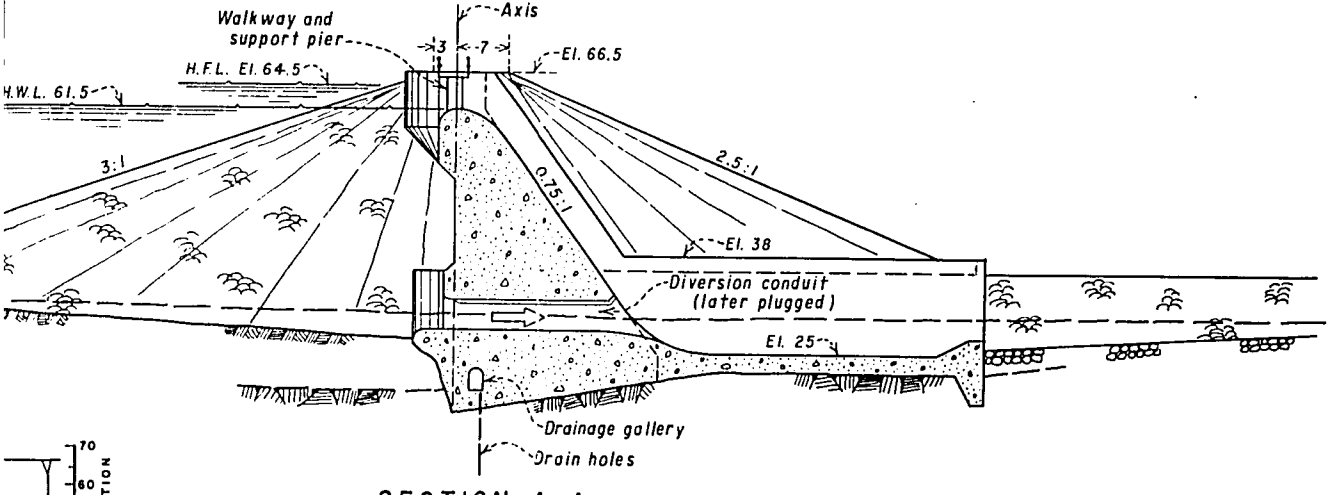


SECTION B-B

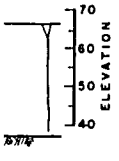
10 0 50 METERS
SCALE

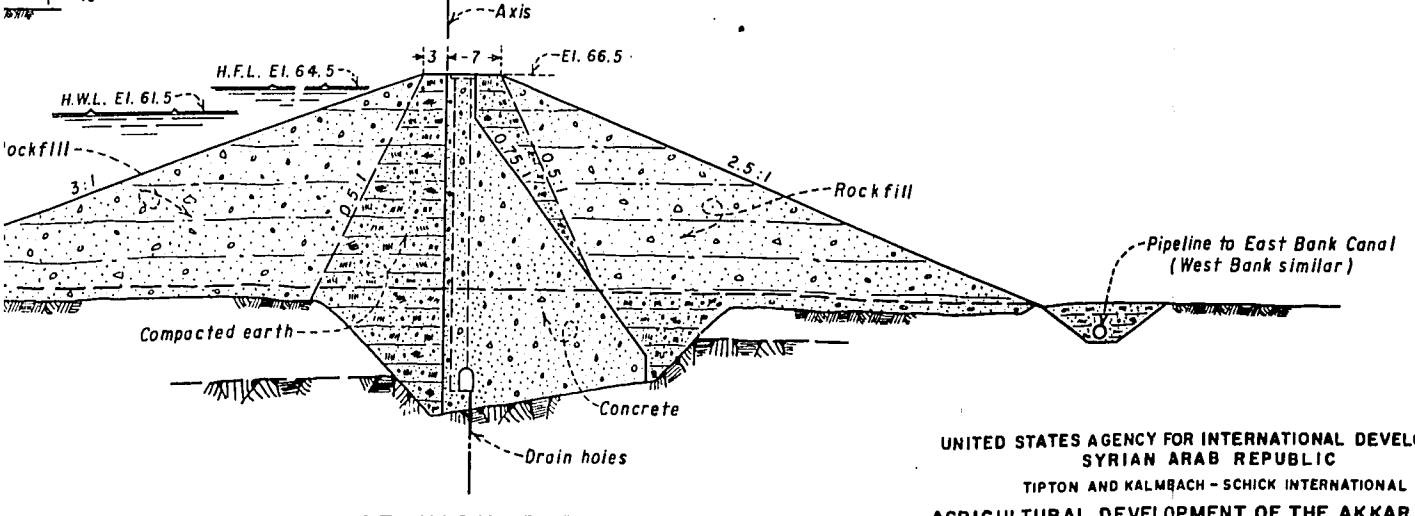


AREA - CAPACITY CURVES



SECTION A-A
(SPILLWAY)





SECTION B-B

50 METERS

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RIHANIYEH DAM

A preliminary site was selected for the diversion near a tell where the elevation of the Abrache River channel is approximately 40 meters. Figure VI-9 shows the location of the structure and design details are shown on Figure VI-10. The diversion dam is a rockfill embankment with a compacted earth core and a crest elevation at 55 meters. The diversion works into the canal systems are located at both right and left abutments and, at the left abutment, are combined with the concrete gravity spillway structure. The spillway section is a concrete gravity structure with a crest elevation of 51 meters and a crest length of 50 meters. Further studies of the river hydrology may show this high an embankment in relation to the spillway elevation is not required. In the preliminary design the spillway will pass the same volume of water capable of being passed through the Yazdieh Dam spillway on the assumption that a storm could occur with the Yazdieh Reservoir full. No provision is made at this time for grouting beneath the spillway or embankment, although more detailed studies may indicate the need for a grouting program.

The east bank diversion consists of a gated conduit through the gravity portion of the dam with a concrete pipe on compacted fill discharging into a drop structure and the canal at 40 meters elevation. A sluiceway is provided to prevent buildup of sediment in front of the offtake. The sluiceway also serves as an outlet for the dam structure and can be used to control the water surface upstream.

The west bank diversion consists of a gated offtake regulator and gated sluiceway. The offtake regulator discharges directly into the west bank canal at a water surface elevation of 50 meters and is controlled by a radial gate with breastwall to prevent overtopping in the event of high water behind the diversion dam. The sluiceway is also controlled by a radial gate without a breastwall as the sluiceway channel below the dam can be constructed to carry the discharge of the structure. A lead channel is required on the upstream side of the diversion to the offtake regulator.

The Abrache Diversion Dam will normally be operated with the water level to elevation 50.5 meters with water just below spillway level. In the event flood flows are released from the Yazdieh Dam, the water surface will rise and pass over

the spillway structure without any abnormal increase in the diversion discharges. The east bank sluiceway may be opened to maintain a flow in the stream below the dam or can be entirely closed, particularly during the later part of the irrigation season, to fully utilize the storage water.

No unusual maintenance is anticipated at this structure. Normal maintenance of the mechanical gates and other portions of the dam as well as some cleaning of channels, particularly on the upstream side near the west bank diversion, may be required.

Berge Arab Diversion and Canal

A diversion structure on the Arouse River and a 6-kilometer long canal to convey the water to the Abrache Basin is required under either storage alternative to increase the yield of the reservoir and to provide additional irrigation water for double-cropping of the Akkar Plain. The works were conceived by Sofrelec and are contained in their report describing the investigations of the two rivers.

Canal Systems

The canal system will consist of main and secondary canals constructed by a combination of cut and fill. Main canals will convey irrigation water from the water supply source and distribute it to the secondary canals which, in turn, deliver water to the farm ditches. The canals constructed under this project will be concrete lined to reduce seepage losses and thus more fully utilize the reservoir storage. Figures VI-7 and VI-9 show the general layout of the canal systems.

The size of the irrigation canals is based upon the peak consumptive use of water under the cropping pattern assumed for the land served by the canal, plus an allowance for transmission losses from the point of diversion to the irrigated field. Irrigation water requirements are discussed in detail in Chapter IV of this Report. The following table shows the development of the diversion requirement used in the design of the canal system.

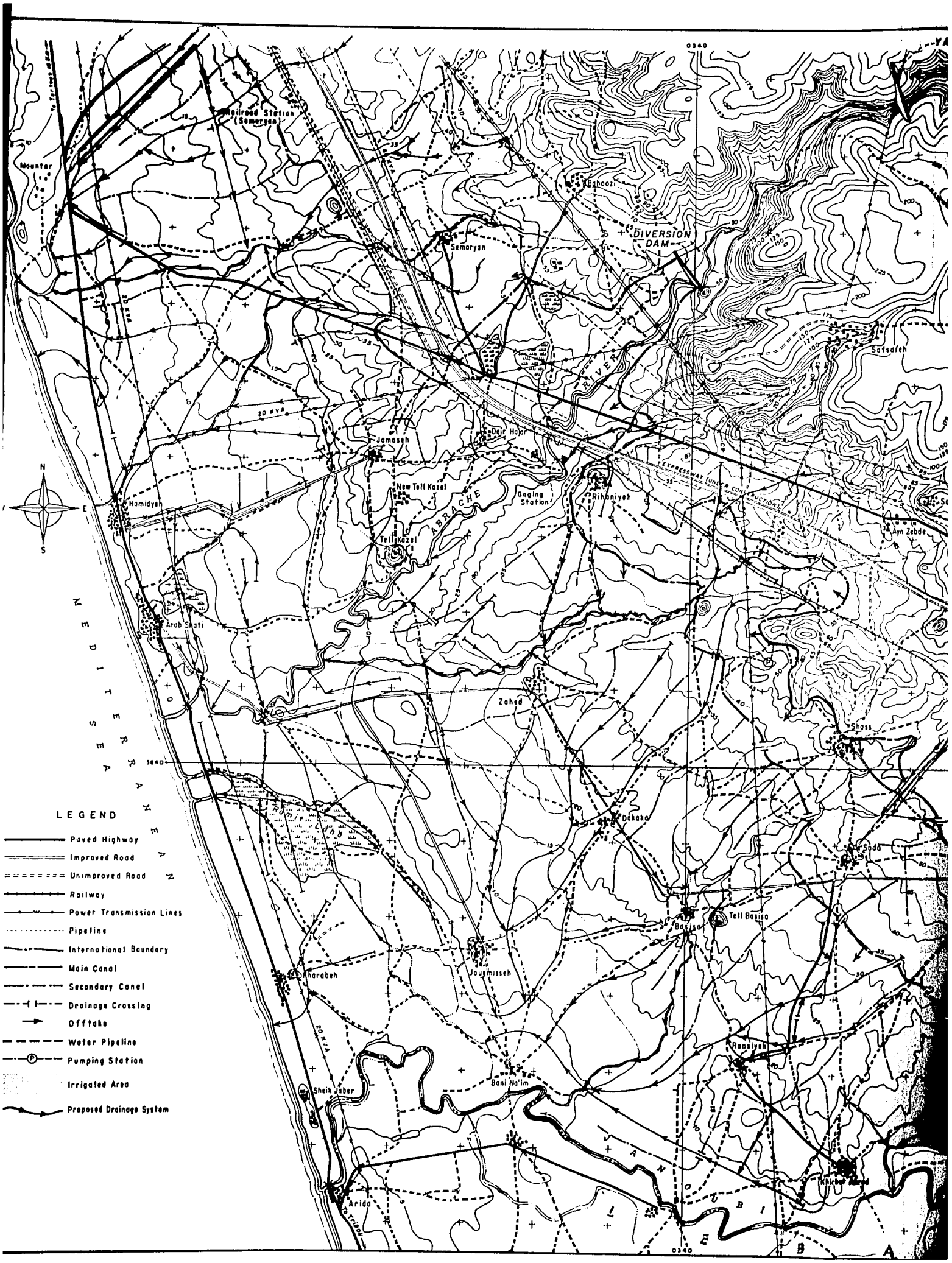
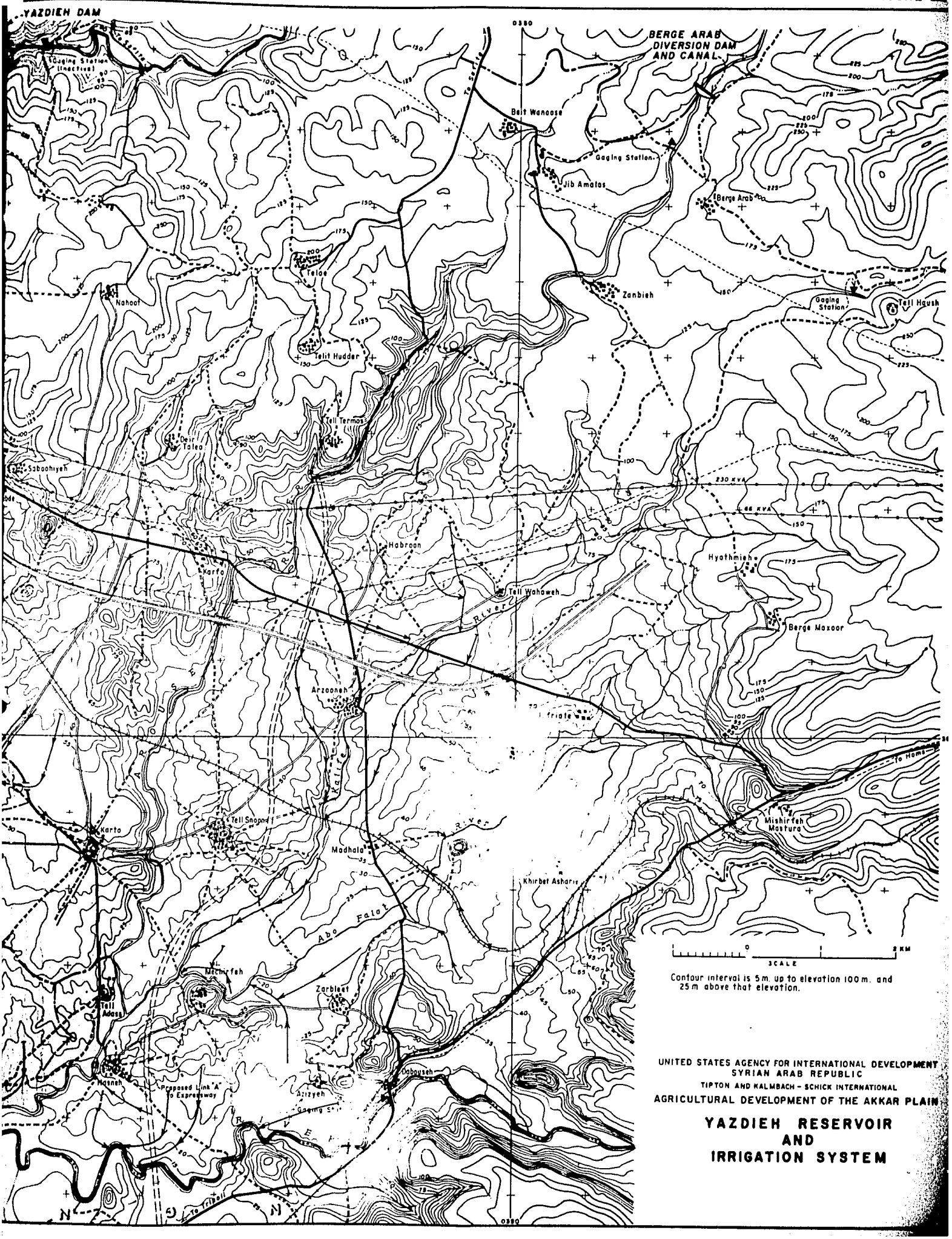
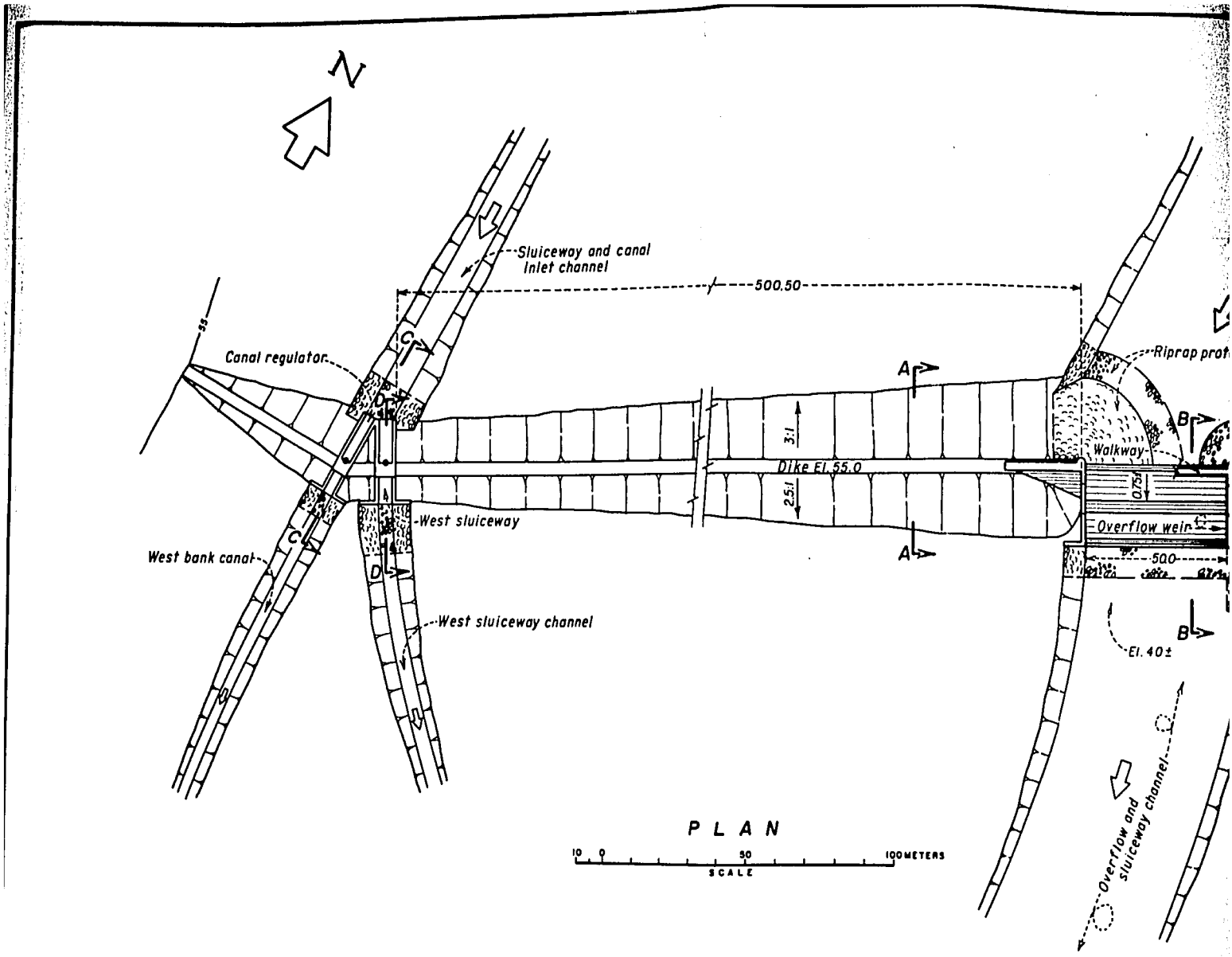
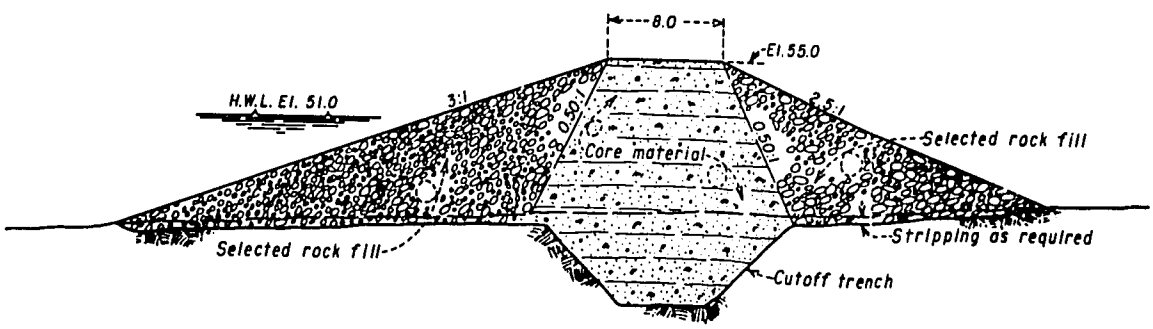

Railroad Station (Semaryan)
Mountar
Bahoozi
DIVERSION DAM
Semaryan
Satsafeh
RIVER
20 KVA
Jamasah
Deir Hajar
EXPRESSWAY (UNDER CONSTRUCTION)
New Tell Kazel
Gaging Station
Rihaniyeh
Hamidyeh
ABRACHE
Tell Kazel
Ayn Zebde
Arab Shati
MEDITERRANEAN SEA
Zahed
Shass
Dakaka
Sada
Tell Basisa
Basisa
Jourmisseh
Kharabeh
Ranaiyeh
Bani Na'im
Sheik Jaber
Arida
To Tripoli
LANO UBI
LEBA
0340
3840
N
E
S
LEGEND
Paved Highway
Improved Road
Unimproved Road
Railway
Power Transmission Lines
Pipeline
International Boundary
Main Canal
Secondary Canal
Drainage Crossing
Offtake
Water Pipeline
Pumping Station
Irrigated Area
Proposed Drainage System

FIGURE 3

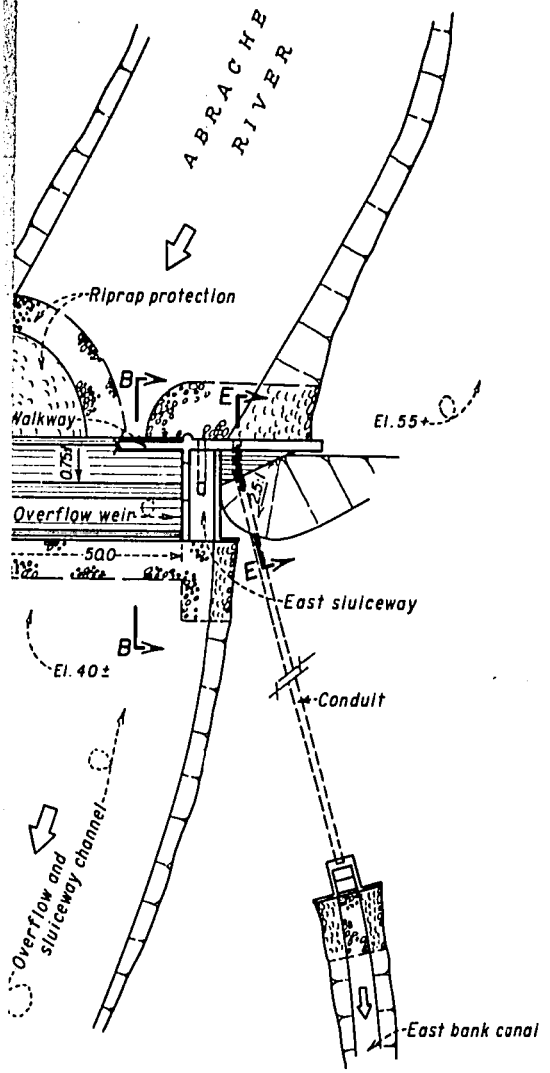

YAZDIEH DAM
Gaging Station (Inactive)
BERGE ARAB DIVERSION DAM AND CANAL
Beit Wanoose
Gaging Station
Jib Amalas
Berge Arab
Telae
Nahoot
Zanbieh
Gaging Station
Tell Haush
Telit Hudder
Tell Termos
Deir Talea
Saboohiyeh
230 KVA
66 KVA
Habroon
Hyothmieh
Karfa
Tell Wahoweh
River
Berge Maxoor
Arzooneh
Kalite
To Homs
Mishirfeh Mastura
Karfa
Tell Snopar
Madhala
River
Khirbet Asharie
Abo Falat
Mechirfeh
Zarbleet
Tell Adass
Masnah
Proposed Link "A" to Expressway
Azizyeh
Gaging St.
Dabousieh
RIVER
To Tripoli
N
0
2 KM
SCALE
Contour interval is 5 m. up to elevation 100 m. and 25 m above that elevation.
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
YAZDIEH RESERVOIR AND IRRIGATION SYSTEM

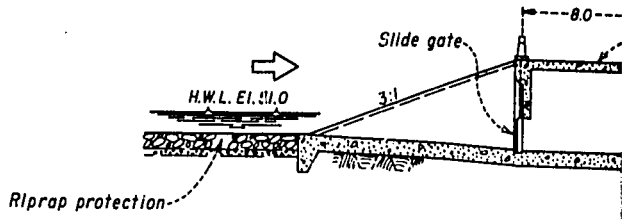




SECTION A-A

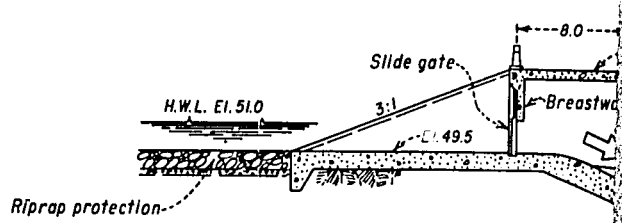
TYPICAL DIKE SECTION





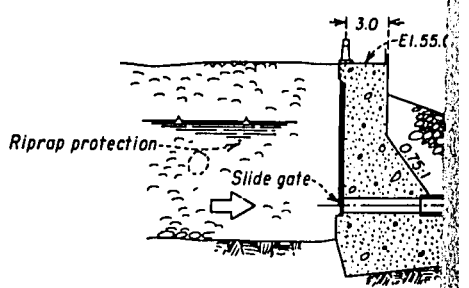
SECTION

CANAL REGULA



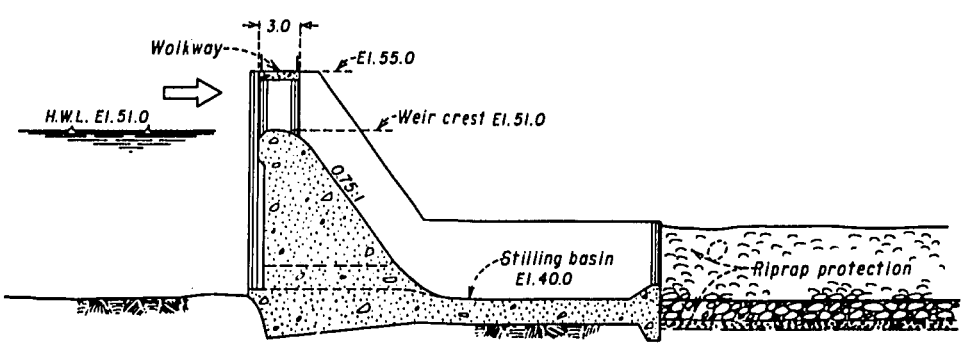
SECTION

SLUICEWAY (WE



SECTION

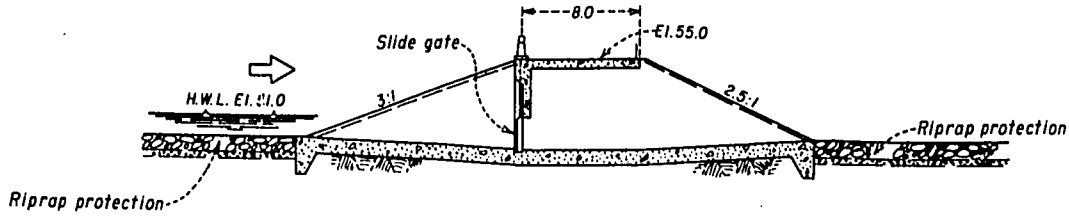
CANAL HEADG



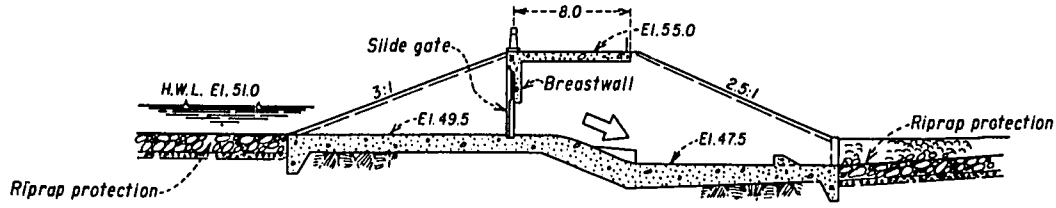
SECTION B-B

OVERFLOW WEIR

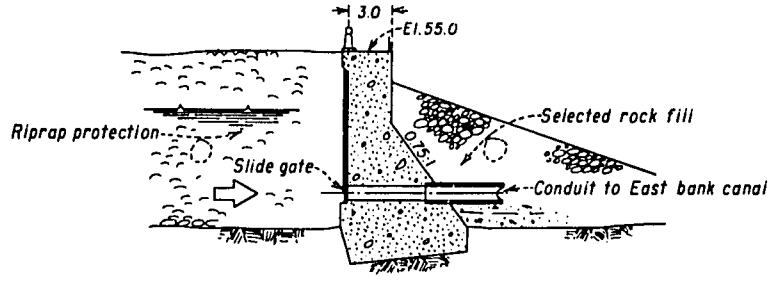
ETERS



SECTION C-C
CANAL REGULATOR



SECTION D-D
SLUICEWAY (WEST)



SECTION E-E
CANAL HEADGATE

nal

El.51.0

B - B
R

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TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN

ABRACHE DIVERSION DAM

DISTRIBUTION OF SUPPLIES BELOW POINT OF DIVERSION
(The values are expressed as decimal fractions of the
Total Water Supply (W) available at the Point of Diversion)

1.	Flow at diversion point	1.00 W
2.	Conveyance losses (0.10) (1)	0.10 W
3.	Delivery to distribution system (1)-(2)	0.90 W
4.	Distribution losses (0.25) (3)	.22 W
5.	Delivery to field (3)-(4)	.68 W
6.	Field losses (0.12) (5)	.08 W
7.	Delivery to crops (5)-(6)	0.60 W
8.	Overall loss (1)-(7)	0.40 W

The irrigation requirement at the point of diversion is the crop irrigation requirement divided by 0.60 or the crop requirement multiplied by 1.67. The main canals are sized to deliver the maximum water requirement determined by the cropping pattern for the land classes served by the canal. The criterion used in sizing the secondary canals is to provide 1.36 liters per second per hectare, the maximum monthly requirement for Class 3 land, to the cropped area; however, the minimum canal section is 0.50 meters wide and 0.50 meters deep. The canal system is assumed to deliver water to within about one kilometer of any lands to be irrigated.

The main and secondary canals are channels lined with concrete 8 centimeters in thickness, constructed by a combination of cut and fill and are illustrated in Figure VI-11. Due to the thin soil overburden, the amount of canal cut has been minimized to avoid the use of blasting in the underlying rock to the extent possible. Borrow for construction of the canal embankment is assumed to come from an area adjacent to and parallel to the canals and, for the main canals, serves to form an interceptor drain on the upslope side of the canal.

The main canals generally follow the topographic contours and are designed on the least slope possible to maintain maximum command of the area with a minimum velocity of 1.0 meter per second. Gated regulator structures are provided to control the flow of water into the secondary canals. The crossings beneath the railway and expressway are through inverted siphons. Bridges or culverts are provided a major

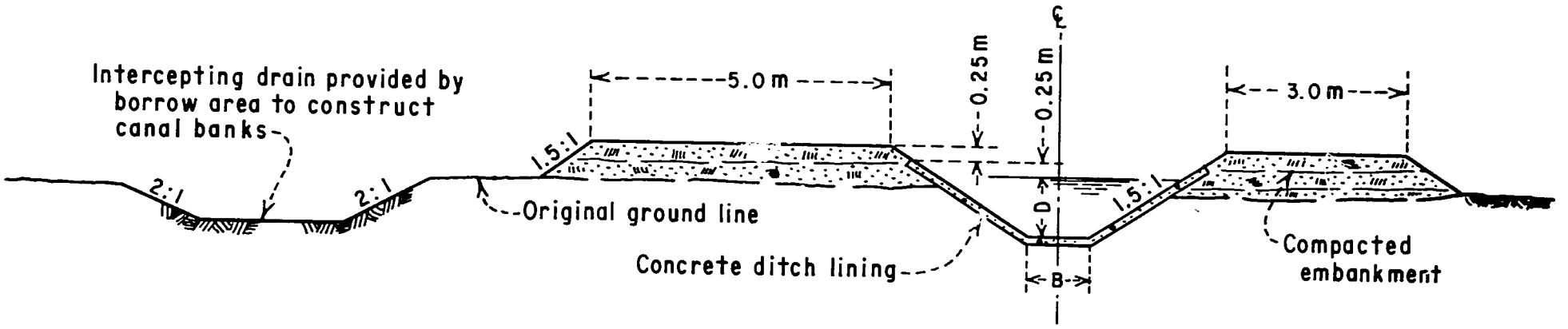
road crossings and, where possible, bridges are combined with regulators. Except for a turnout to the pumping plant to lift water to the 55-meter elevation on the east bank canal, turnouts to secondary canals are provided only on the south bank of the main canals as no land can be irrigated upslope of the main canal. Drainage crossings are provided for both the existing and planned drainage channels and are considered to be aqueducts.

The secondary canals generally run perpendicular to the contours. The minimum depth of lined section is 0.5 meter. The secondary canals are provided with drop structures and check-drop structures to limit the maximum velocity to 3.0 meters per second or the critical velocity, whichever is less. The difference between the drop and check-drop is that there are no gates provided on the drop structures. Operating platforms are provided with each type of structure to allow foot passage across as well as to operate the gates on the check-drops. Offtake structures divert water from both sides of the secondary canals to the field distribution systems. The turnout consists of one or more pipes extending through the bank of the secondary canal and each pipe is fitted with a slide gate at its inlet. Check-drops are located as necessary to control the water surface elevation upstream and allow adequate head into the turnouts to field ditches.

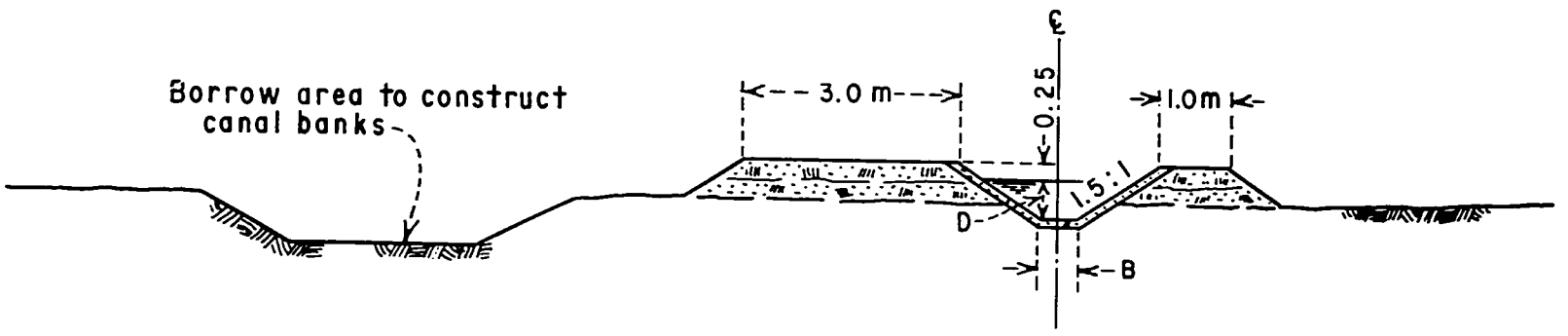
The design parameters of the main and secondary canals are summarized below:

	Main Canal	Secondary Canal
Mannings "n"	0.014	0.014
Velocity at design discharge	1.0 meter per second minimum	3.0 meters per second maximum
Base/depth ratio	1.0 to 1.5	1.0
Freeboard-top of bank above water surface	0.50 meters	0.25 meters
Service road	5 meters south bank 3 meters north bank	3 meters one bank only

Rihaniyeh Reservoir Alternative: Figure VI-7 illustrates the canal system supplied by the Rihaniyeh Dam and Reservoir alternative. Water is taken from a storage reservoir located on the Abrache River approximately 0.6 kilometers north



TYPICAL SECTION
MAIN CANAL



TYPICAL SECTION
SECONDARY CANALS

IRRIGATION SYSTEM
CANALS
TYPICAL SECTIONS
Akkar Plain Project

FIGURE VI-11

TIPTON AND KALMBACH – SCHICK INTERNATIONAL

of the railway and the Homs-Tartous expressway and is piped to a canal system at an elevation of 40 meters on both sides of the river. The capacity of the east canal at its upstream end is 4.7 cubic meters per second with a channel width of 1.5 meters. The canal crosses beneath the expressway and adjacent railway in a 180-centimeter diameter inverted siphon. Below the siphon crossing, the main canal parallels the 40-meter contour with secondary offtaking canals running with the slope of the land to deliver water to the fields.

Approximately four kilometers from the siphon a pumping station is located to take water from the main supply canal and lift it to the elevation 55 meters canal which then distributes water east and west to secondary canals and direct offtakes from the main canal for the purpose of irrigating land between the 40- and 55-meter contours. The pumping plant is designed for a capacity of 1.3 cubic meters per second. Below the turnout to the pumping station, the base of the east bank canal reduces in width to 1.0 meter and further reduces to 0.5 meter near the tail. The estimated irrigable area on the east bank to be supplied by surface water is 3166 hectares plus 996 hectares supplied by pumping between the 40 and 55 meter elevation main canals.

The west bank of the Abrache River is also served by a main canal essentially paralleling the 40-meter contour with 1.68 cubic meters per second capacity at its head. The water is conveyed beneath the expressway and railway in a 120-centimeter diameter inverted siphon. A portion of the canal is conveyed in a 70-centimeter diameter pipeline for 2 kilometers along the railway embankment to avoid crossing beneath the railway as there would be no appreciable increase in area served with a crossing. There is an opportunity of extending the canal further should additional water supplies be available. A total of 1837 hectares of Classes 1, 2, and 3 lands are under command of the west bank main canal, with an estimated net irrigated area of 1485 hectares.

An area west of the Rihaniyeh Dam and north of the expressway is to be served by a 50-meter elevation canal supplied by a pumping station of 0.5 cubic meter per second capacity from the west bank main canal near the reservoir outlet. The canal commands an area of 435 hectares with a net irrigated area of 353 hectares. The

net irrigated area served by the Rihaniyeh Dam, using gravity and pumped water, is 6000 hectares.

Yazdieh Reservoir Alternative: For the Yazdieh alternative the surface distribution begins at a diversion dam located on the Abrache River at a point where the 40-meter contour crosses the river. The elevation of the operating pool at the diversion dam is 51 meters. The east bank supply canal drops to 40 meters after diversion and generally follows the 40-meter contour southward to the siphon crossing beneath the highway and railroad. The topography along the east bank prevents construction of a canal at higher elevation. From a point north of the siphon crossing beneath the expressway, the remaining portion of the canal system is identical to that with the Rihaniyeh Dam alternative described previously, including pumping from 40 meters to 55 meters. The net area irrigated by the east bank canal, including the area between the 40-meter and 55-meter canals, is 4230 hectares.

On the west bank, the main canal will generally parallel the 50-meter contour with a branch provided to convey water beneath the expressway and railway in a 120-centimeter diameter siphon to connect with a 40-meter canal located on the south side of the railway, essentially the same as the lower dam alternative. The total area commanded on the west bank is 2710 hectares with an estimated net irrigated area of 2190 hectares. The total area served by the upper dam, including pumping, is 6420 hectares.

Other Possible Alternatives: In addition to the surface irrigation system described in the preceding sections, which depends upon storage on the Abrache River, other alternatives and/or variations of alternatives are available. Pumping from the lower reaches of the Abrache River can serve an area of 300 hectares on the east bank of the Abrache presently planned as part of the surface irrigation system supplied by storage water. The river in this area is live the year around, fed by groundwater, and construction of Rihaniyeh Dam will likely increase the dry season flow because of seepage from the reservoir. The pumping plant would be located on the east bank of the river and would pump to the higher ground located approximately one kilometer east of the river. A surface canal distribution would then be provided

in roughly the same location as the secondary canal shown in Figure VI-7, thus making the stored water available elsewhere.

An area of 625 hectares along the Janoubi between the Janoubi and Abrache Rivers (Area 6 on Figure II-8) is planned to be served by the east bank canal system. The area presently is irrigated in part by water from the Janoubi through small private pumping installations. Depending upon the yield of future wells in the area, it may be possible to serve this area by groundwater.

Development of groundwater sources within the area now planned to be served by the surface water distribution system would enable the surface water to be used elsewhere, thus extending the total amount of irrigated area. The wells could discharge either directly onto the land or into the surface canal system. These various possibilities can be phased into the overall agricultural development plan as the opportunity and need develop. The canal system can be extended farther to the west, east across the Arouse River, or pumped to a higher elevation on the east or west bank to bring more land under command.

Groundwater Development

Rehabilitation of Existing Wells: It is estimated that 10 percent of the existing drilled wells on the Plain are being pumped at rates far below their potential. Under the Project, a complete inventory of existing wells would be carried out, and the specific capacity of each well determined by pumping with its installed equipment. At those installations where the initial test indicates a significantly higher potential, step drawdown tests would be performed using a variable speed pump capable of discharging from 20 liters per second to 60 liters per second.

From the data obtained from the step drawdown tests, the optimum discharge and pump setting would be derived, and the appropriate pump and driver would be specified. The service area to be irrigated from the individual well would then be delineated, an irrigation schedule drawn up, and the well turned over to the operation section for pump and driver installation and operation. It is estimated that at least 1200 hectares in addition to previously irrigated area can be furnished with

water by this means. If 24-hour irrigation is practiced, as it should be, the additional area will be about doubled. With the examples shown in Chapter IV, the irrigated area might be increased about seven times on a daytime irrigation schedule only.

This work should be initiated very early in the project implementation, as little capital cost is required and benefits will be immediate. Equipment requirements are a portable diesel driver, an appropriate pump, a truck-mounted boom and winch for pulling and setting pumps, appropriate transportation, and miscellaneous hydrologic tools.

Some existing wells would be deepened in an effort to improve their performance. No attempt has been made to identify specific holes to be deepened. However, wells E-8, E-10, and E-11 all have low specific capacities and are less than 40 meters in depth. Such wells should be deepened to 75-100 meters and retested.

New Wells: New project wells would be drilled to further develop the shallow aquifer. First priority would be given those areas in which it is planned to develop citrus orchards as it will be possible to furnish canal water in only about 100 hectares of the citrus areas. Development Areas 1, 3, 4, and 6 offer the most promising opportunities for further shallow groundwater abstraction. About 50 wells are anticipated, with an average discharge of approximately 20 liters per second.

The wells would be drilled by cable tool method with about 35-centimeter bore diameter to a minimum of 100 meters in depth. Casing and screen will be installed where necessary and the wells would be developed by surging and overpumping. The wells will then be tested using the step drawdown technique and the appropriate pumping unit installed.

Exploration for deep Cretaceous aquifers should also be started at the earliest opportunity to better assess the magnitude of the groundwater resource. A program of 10 to 12 exploratory wells 300-400 meters in depth is contemplated. The wells would be drilled by the rotary method and carefully sampled each 1.5 meters. After drilling, the bores would be logged by geophysical methods as well as measured by a caliper and surveyed with a current meter while pumping.

Whereas the bore holes are intended primarily for information, successful holes would be completed and equipped as irrigation wells. The suggested locations for the first 5 bore holes are shown on Figure II-8. The locations were chosen to give maximum information on apparent Landsat imagery lineations and suspected geologic structural features. Subsequent bore holes would be located after study of the data obtained from the initial drilling.

INFRASTRUCTURE

Adequate infrastructure for villages within the Project Area is important for balanced social and economic development. The Development Plan provides for upgrading the existing infrastructure facilities and providing new facilities which should bring about the desired level of social and economic development under the Project, Figure VI-12.

Educational Facilities

Schools at all levels would be enlarged and/or upgraded. First priority should be given to raising the standard of the primary school system by:

1. Enlarging existing school buildings or construction of new buildings to reduce the number of students per room and class and provide the teachers required;
2. Upgraded existing facilities to provide adequate light, heat, ventilation, desks, blackboards, books and supplies;
3. Provide paved playground areas with adequate equipment;
4. Provide separate toilets for boys and girls with water closets and lavatories where existing community water systems permit or as soon as such systems have been installed.

The possibility of consolidating the primary schools into several new schools and busing the students should be considered. Busing students would be feasible with the proposed new and upgraded project roads and better school facilities could be provided with a more desirable ratio of students per teacher.

Secondary and intermediate schools should be upgraded to bring them up to accepted current standards including recreational and athletic facilities.

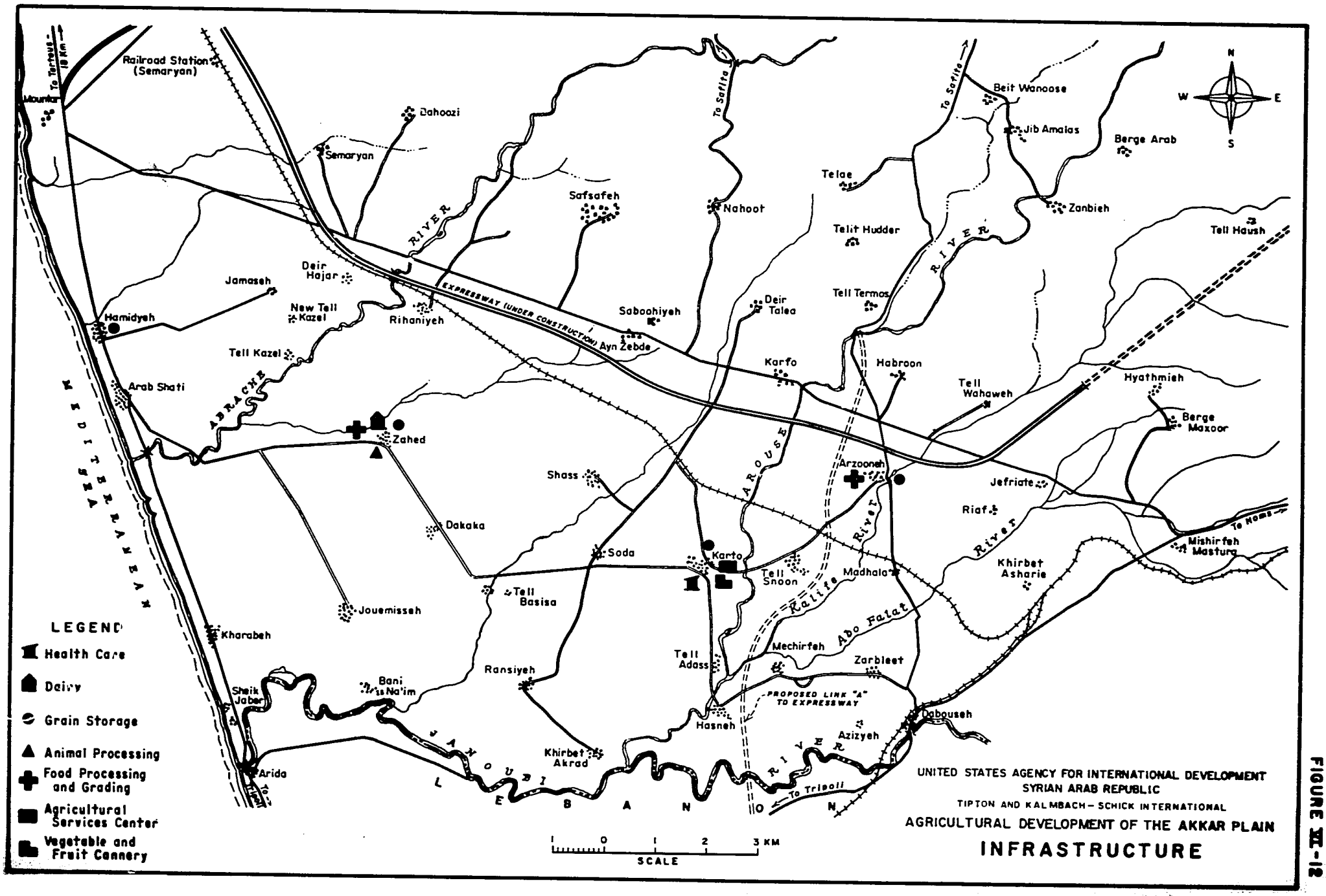
Health Facilities

A new health care center would be established at Karto. Karto was selected for the location of the health facility because it is centrally located in the Project, has a new culinary water system, telephone service, new secondary school, was scheduled to have electrical power service by 1978 and has been selected for other important infrastructure facilities. The center would be staffed with two doctors, two dentists and three or more nurses. The center would have the capability to handle general dentistry, minor surgery including oral surgery, special maternity cases, fractures, diseases, emergencies and general health care. Doctors and nurses from the health center would visit the schools periodically for inoculation and examinations for general health.

Farm-to-Market Roads

A comprehensive system of all season roads to all project villages, which would permit the unrestricted transportation of agricultural products from farm to market and the flow of traffic between villages, was investigated but was found to be too costly. The Development Plan would provide a two-lane bituminous-surfaced highway east to west through the Project from Arzooneh to Arab Shati. The highway would connect with the Safita-Lebanon highway on the east and the Tartous-Lebanon highway on the west. These highways would provide access to the Homs-Lattakia expressway presently under construction and the new railroad at Semaryan. The proposed highway would pass near Karto and Zahed where it is proposed to locate grain elevators, food processing plants, Agricultural Service Center, and health care facilities. A connecting highway would pass over the expressway to a junction with the present Tartous-Homs highway near the west center of the project, Figure VI-13. The overpass will be constructed with the expressway. Graded and gravel surfaced roads would be constructed to provide an all-weather road to all main villages within the Project Area.

The total construction program would comprise widening approximately 8 kilometers of existing road and applying new bituminous surfacing, Figure VI-14; construction of 11 kilometers of new bituminous surfaced highway, Figure VI-15;



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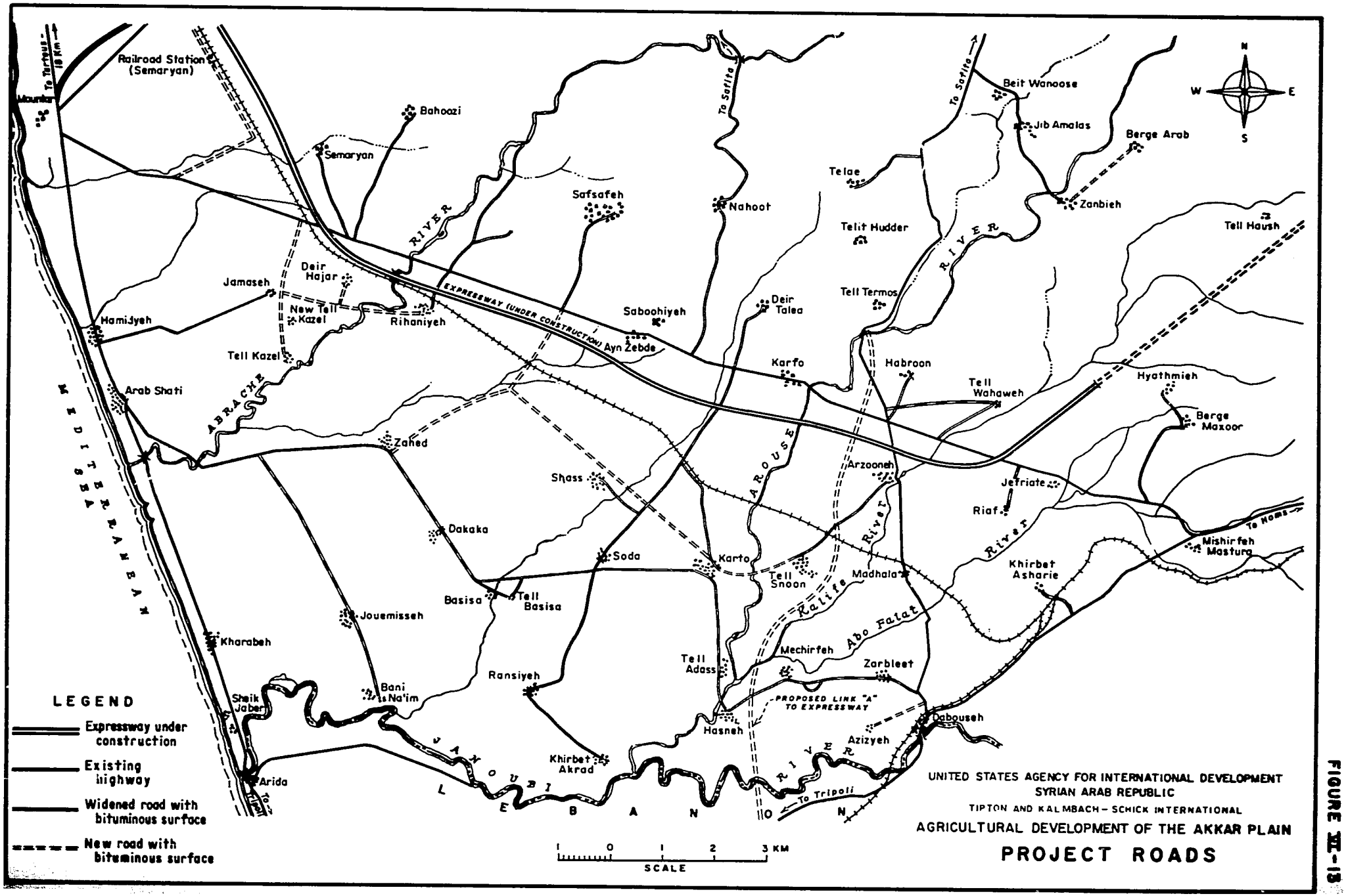
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
INFRASTRUCTURE

FIGURE XI-12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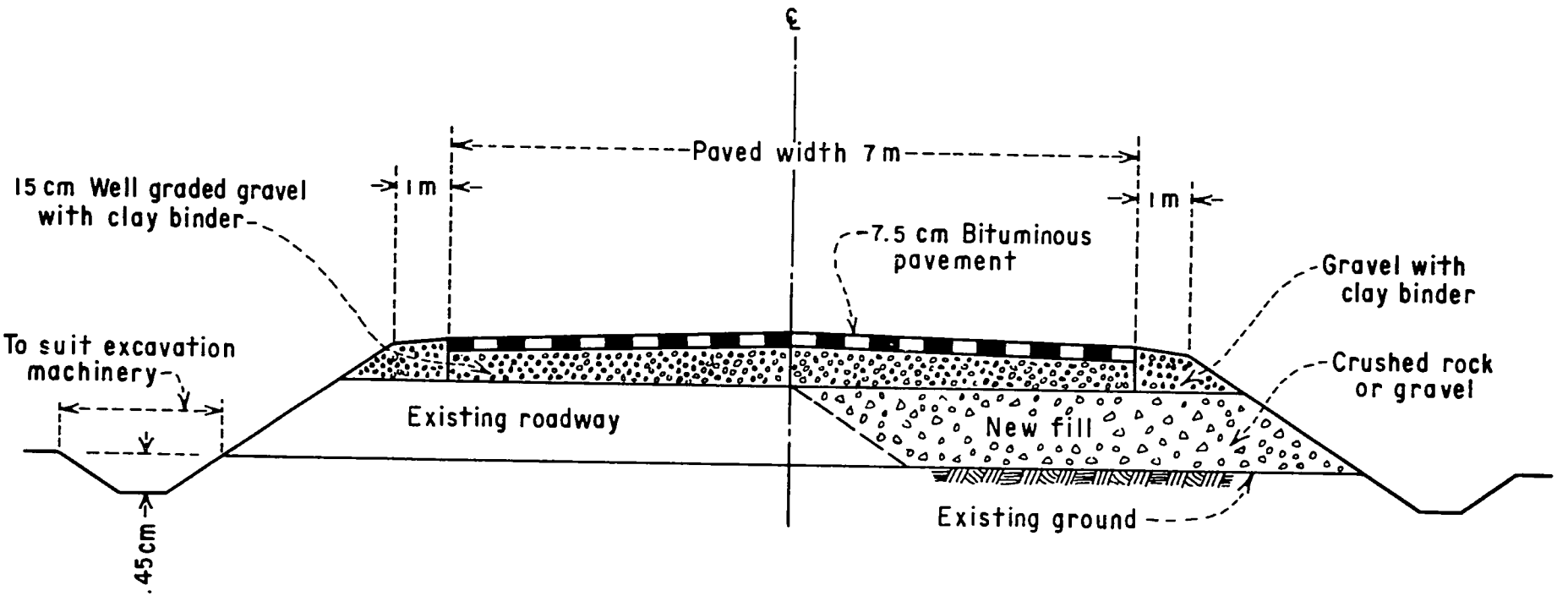
TIPTON AND KALMBACH – SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN
PROJECT ROADS
LEGEND
Expressway under construction
Existing highway
Widened road with bituminous surface
New road with bituminous surface
SCALE
1 0 1 2 3 KM
N
S
E
W
MEDITERRANEAN
LEBANON
To Tartous
Mounita
Railroad Station (Semaryan)
Bahoozi
Semaryan
Safsafeh
Nahoot
To Sarfita
Telae
Telit Hudder
Tell Termos
Beit Wanoose
Jib Amalas
Berge Arab
Zanbieh
Tell Housh
Deir Hajar
Jamaseh
New Tell Kazel
Rihaniyeh
Hamidyeh
Tell Kazel
Arab Shati
ABRACHE RIVER
EXPRESSWAY (UNDER CONSTRUCTION)
Ayn Zebde
Saboohiyeh
Deir Talea
Karfo
Habroon
Tell Wahaweh
Hyathmieh
Berge Maxoor
Zahed
Shass
Arzooneh
AROUSE RIVER
Jefriate
Riaf
To Homs
Mishirfeh Masturg
Dakaka
Soda
Karto
Tell Snoon
Madhala
Khirbet Asharie
Basisa
Tell Basisa
Jouemisseh
Kharabeh
Ralife River
Abo Fatat River
Mechirfeh
Zarbleet
Tell Adass
Ransiyeh
Bani Na'im
Sheik Jaber
PROPOSED LINK "A" TO EXPRESSWAY
Dabouseh
Hasneh
Azizyeh
Khirbet Akrad
Arida
To Tripoli
JAOUBI RIVER

FIGURE VI-13

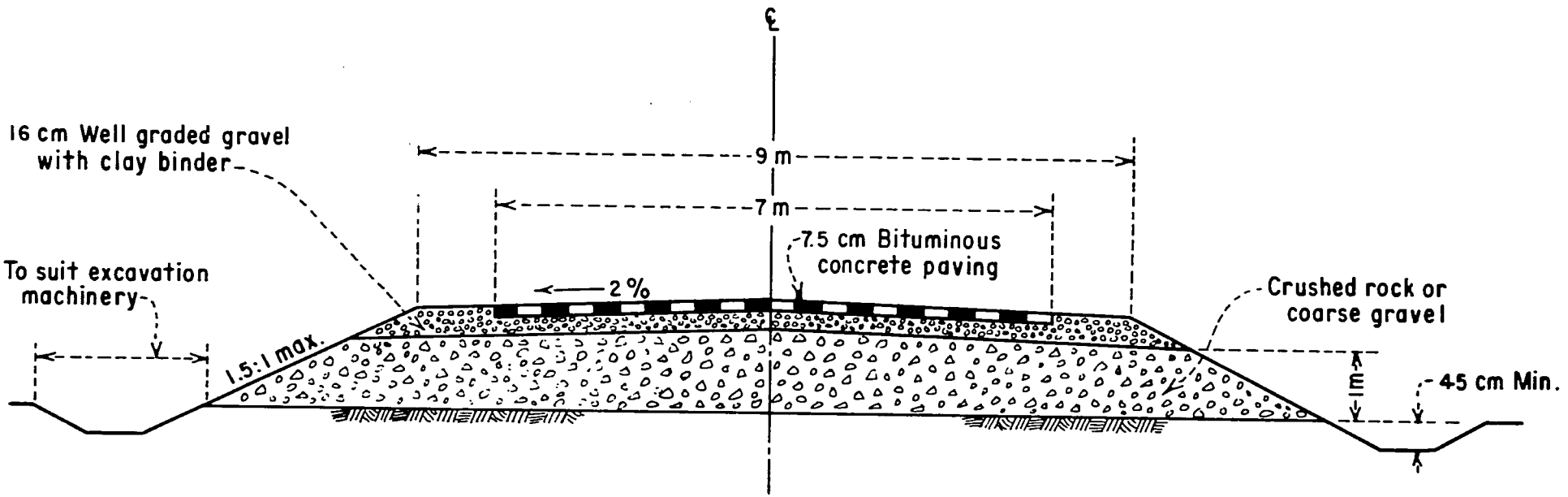


EXISTING ROAD WIDENED AND RESURFACED

Akkar Plain Project

TIPTON AND KALMBACH – SCHICK INTERNATIONAL

FIGURE VI-14



NEW HIGHWAY
BITUMINOUS CONCRETE SURFACE
Akkar Plain Project

TIPTON AND KALMBACH-SCHICK INTERNATIONAL

FIGURE VI-15

and construction of 22 kilometers of new gravel surfaced road, Figure VI-16. Construction and maintenance of the road system would be under the Transportation Department at Tartous.

Agricultural Service Center

The economic viability of the Akkar Plain Project will be determined to a considerable extent by the rapidity of adoption of improved agricultural practices by local farmers. Thus, the improvement of agricultural research and application thereof are of major importance in enhancing the success of the project. To achieve full project development, sound research is essential to provide information on major crops in the following areas:

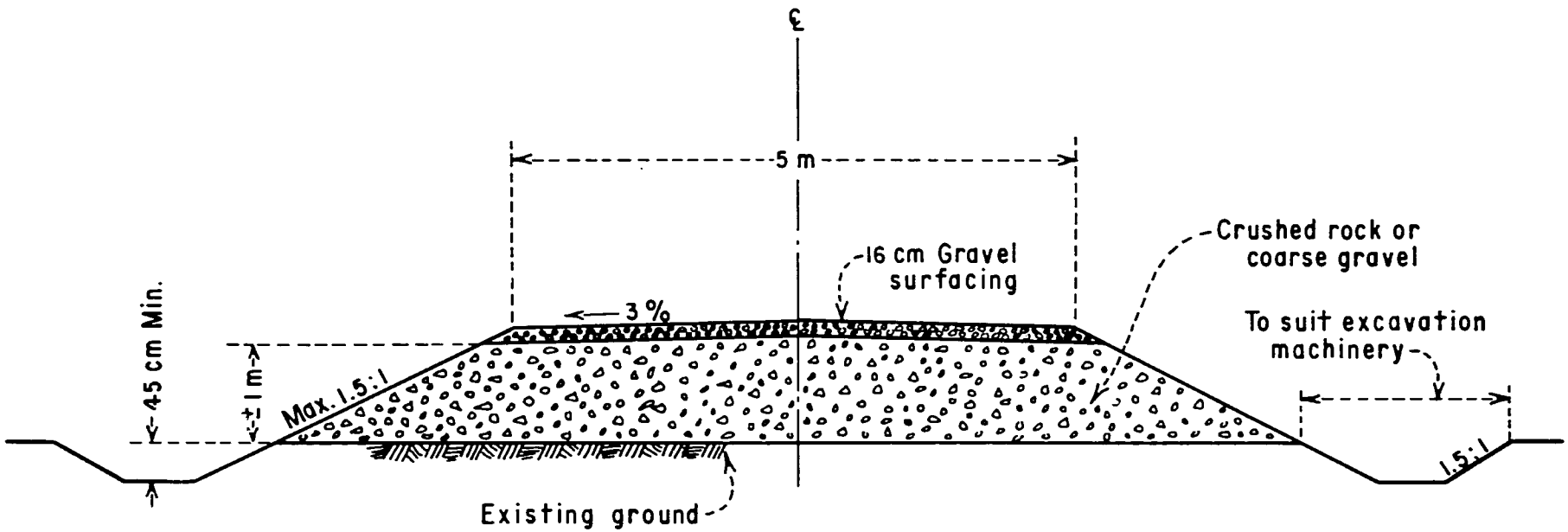
1. Fertilization - type, rate and time of application.
2. Pest Control - chemical and biological.
   a. disease
   b. insects
   c. weeds (herbicides)
3. Irrigation Practices - application and drainage.
4. Variety Testing - vegetable and field crops
5. Plant Improvement - where suitable varieties do not presently exist
   a. selection
   b. development of new varieties by breeding
6. Cultural Practices and Soil Management
   a. plowing
   b. seed-bed preparation
   c. weed control - cultivation
7. Diagnosing causes of crop failure, especially those that appear to be due to plant pathogens.
8. Livestock and Dairy Production
9. Storage and Preservation of Foods for home use during the off-season
   a. dehydration
   b. pickling
   c. canning
   d. storage in common root cellars, etc.

To meet these requirements in a timely and practical way, the project plan provides that an Agricultural Service Center be constructed on the project at Karto. It would be multi-functional and be under administration of the Regional Office at Tartous. The Center would include 2 medium-sized greenhouses and 25 to 30 hectares of suitable land for experimental use. This size would permit the land to be well cared for and srill be adequate for rotation, some seed production, etc., and provide areas where trainees, professionals, farmers and interns could obtain actual practice in all types of cultural operations such as planting and in operating machinery. The plan calls for staffing the Center as follows:

1. Horticulturist-Farm Manager - with experience with vegetable crops under irrigated conditions, with a capacity to conduct experimental work, especially variety trials and seed production. He should also be familiar with weed control methods.
2. Research Training Specialist-Coordinator - this staff member would coordinate all training activities, arrange field days, coordinate meetings and other educational experiences and arrange for resource people who might come from the Ministry of Agriculture or from the universities. He would be the primary contact for other research-type personnel and for farmers who come to the Center. Experience in communication, knowledge transfer techniques would be desirable. He would also supervise village workers (agents) and arrange for local in-service training at the Center.
3. Agricultural Engineer (Irrigation and Soils) - this staff member would work on irrigation and soils research and assist village agents in the areas of his competence.
4. Pest Control Specialist - first priority should be for disease control. He should have some knowledge of entomology and weed control. He would conduct pertinent research and assist field agents in areas of his competence.
5. Secretarial

These are only minimal personnel requirements. Others could and should be added as justified and as funding permits. These professionals could be used as advisors on other programs in Syria.

To adequately service the needs of the farmers, agents would be assigned to four key villages in the Project Area. These agents would be responsible for



GRAVEL SURFACED ROAD

Akkar Plain Project

TIPTON AND KALMBACH – SCHICK INTERNATIONAL

FIGURE VI-16

supervising demonstration plots on farmers' fields using information generated at the Agricultural Service Center. They would be the primary contact between the Center and the farmers, relaying information concerning improved practices, soliciting help on problems in their area, and in generating interest in field days, demonstrations, new seeds, availability of pest control chemicals, etc. The field agents would be assigned to major villages where strong farmer cooperatives are present, such as Zahed, Arizooneh, Hamidyeh, Karto, or others. Extensive training programs would be conducted by the field agents through the farmer cooperative. Small villages without cooperatives would be encouraged to organize a cooperative or to participate with cooperatives in nearby villages. The Agricultural Service Center should be constructed under Phase I to increase farmer technical skills prior to irrigation development under Phase II.

The Center includes adequate office space for the listed staff members, horticulture laboratory, lecture and visual aids room, library, and shop for training key farmers in repair of motors and farm machinery, and parking facilities.

Small Grain Storage

Small grain production under full project development will annually exceed on-farm storage by approximately 8,500 metric tons. This will require that the Government, which controls the sale and price, purchase the grain as it is harvested and move it to market centers for sale or storage. Since there is no grain storage available in the area except on the Tartous harbor, which is used for loading and unloading ships, the Government may choose to provide additional storage in the project. If so, it is recommended that storage bins be located at Karto, Zahed and Hamidyeh.

Animal Slaughtering and Processing

There are approximately 2,400 hectares of land under the Project which is not suitable for irrigation. A portion of this land would be planted to vetch and pasture grasses and utilized for grazing. A slaughtering and processing plant would be constructed at Zahed to maximize returns of grazing stock. The plant would

handle 100 cattle per day or equivalent in other animals and associated by-products. The plant would feature custom slaughtering for individual farmers with only a few head of livestock.

Dairies

A dairy would be constructed near Zahed to utilize production from Land Capability Class IV land and to improve the general diet of the people in the Project Area. The dairy would have an initial capacity of 300 cows but corrals and milking facilities could be expanded to handle twice this number.

The Government completed a dairy cow quarantine station near Karto during 1978 which has a capacity of 600 cows per month. Dairy cattle imported from Europe and other countries are processed through this station for distribution throughout Syria.

Grading and Packing Facilities - Fruits and Vegetables

Maximum benefits to be derived from the Project are not only dependent upon production capacity but prices to be received for the products. Prices received for agricultural products depend on proper grading, handling and packing, which are lacking at the present time. Therefore, the Development Plan provides for construction of grading and packing facilities in the Project Area. These facilities would be constructed at Zahed and Arizonneh, which would provide access to farmers throughout the Project Area.

Vegetable and Fruit Cannery

A vegetable and fruit cannery would be provided at Karto, near the center of the project, to permit full utilization of those crops which cannot be fully marketed fresh. Also, during depressed market conditions, crops can be processed and canned for sale under better market conditions. The cannery would handle vegetables (fresh and frozen), fruits (fresh, jam and juice), groundnut butter, and meats.

Water, Electricity and Telephone Service

Water, electricity and telephone service are being provided to project villages by the Syrian Government. The schedules for completion of these facilities are shown on Figures III-4, III-5 and III-6.

It is recommended that construction schedules be revised as required to provide full services to proposed project centers to permit orderly development of infrastructure concomitant with agricultural development under the project.

ON-FARM DEVELOPMENT

The Development Plan proposes a well-managed, efficient irrigation system in conjunction with high intensity farming which utilizes double-cropping of high income crops. To achieve this goal, a high level of mechanization and efficient farm management will be a prerequisite. Also, all facets of the economy will be brought into play, including adequate infrastructure and other support facilities.

Land Leveling

Leveling on the Class 2 and 3 soils, which comprise two-thirds of the irrigated area, is not practicable because of the shallow soil which averages less than one meter in depth and the slopes which range up to 5 percent. However, for efficient irrigation and full production, land smoothing or planing is necessary to eliminate dead furrows, erosion and minor surface deformities. Land-smoothing work will be planned and supervised by the Agricultural Service Center. On-farm development and ancillary drainage will require six 120 horsepower tractors with land planes and ditchers.

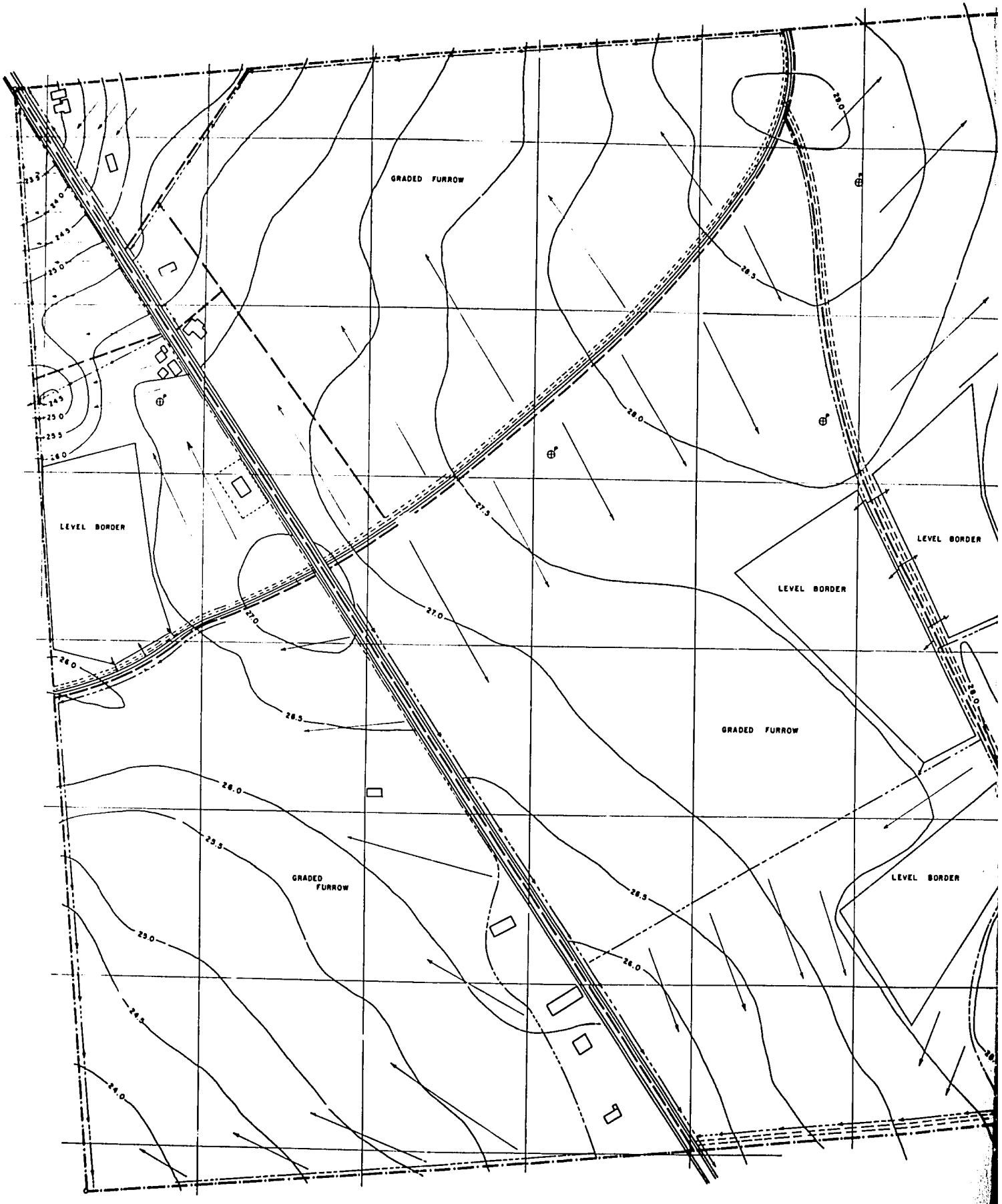
Irrigation Methods

An important characteristic of agricultural soil is its ability to take up and hold water. Associated with this is the intake rate of the soil which affects the method of irrigation application, length of runs and time of application. The heavy clay soils which are predominant in the project have a relatively low intake rate of

about 8 millimeters per hour. Thus the irrigation method must provide adequate application time for the required amount of water to penetrate the soil. To satisfy this requirement, two methods of irrigation are recommended for the project lands. It is recommended that the level-border (basin) method shown on Figure VI-17 be utilized for irrigation of the flat areas. The irrigation lateral system would be designed to supply sufficient water for quick, uniform flooding of the tracts. This system of irrigation is good for tight soils, is efficient, inexpensive, and is adaptable to a variety of crops. For the steeper terrain, the graded furrow method of irrigation is recommended as shown on Figure VI-17. It is further recommended that light-weight, non-rigid plastic pipe be utilized to convey water from the laterals to the furrows. The plastic pipe is inexpensive, can be set up and moved with minimum labor, and can be utilized for more than one tract. Outlet devices can be installed in the pipe to regulate the rate of flow to each furrow regardless of furrow spacing. The pipe eliminates the need for head ditches and can be rolled for convenient, off-season storage.

Sprinkler irrigation is being used widely throughout the world. It consists of conveying water under pressure through pipe and utilizing nozzles to spray water into the air. The water falls onto the soil, similar to rain. This method of irrigation has been used successfully on most crops except rice and is particularly suited to soils with high intake rates, soils too shallow to be leveled, and especially for steep, irregular topography. Fertilizer and fungicides can also be applied through the system. In the past the most serious constraints to sprinkler irrigation have been soils with low infiltration rates, wind, land use, and economics. These conditions are present on the Akkar Plain; soils are predominantly tight; ownerships are small with a wide variety of crops; and winds are prevalent, about 75 percent of the time with velocities to 60 kilometers per hour. Wind breaks up the application pattern of sprinkler irrigation and the higher the wind the greater the distortion. Fine spray would be required for the heavy Akkar Plain soils which would result in above-normal water losses by wind action.

Advanced design technology is now providing wide flexibility in sprinkler equipment with good control of application rates and coverage. Therefore, it is


GRADED FURROW
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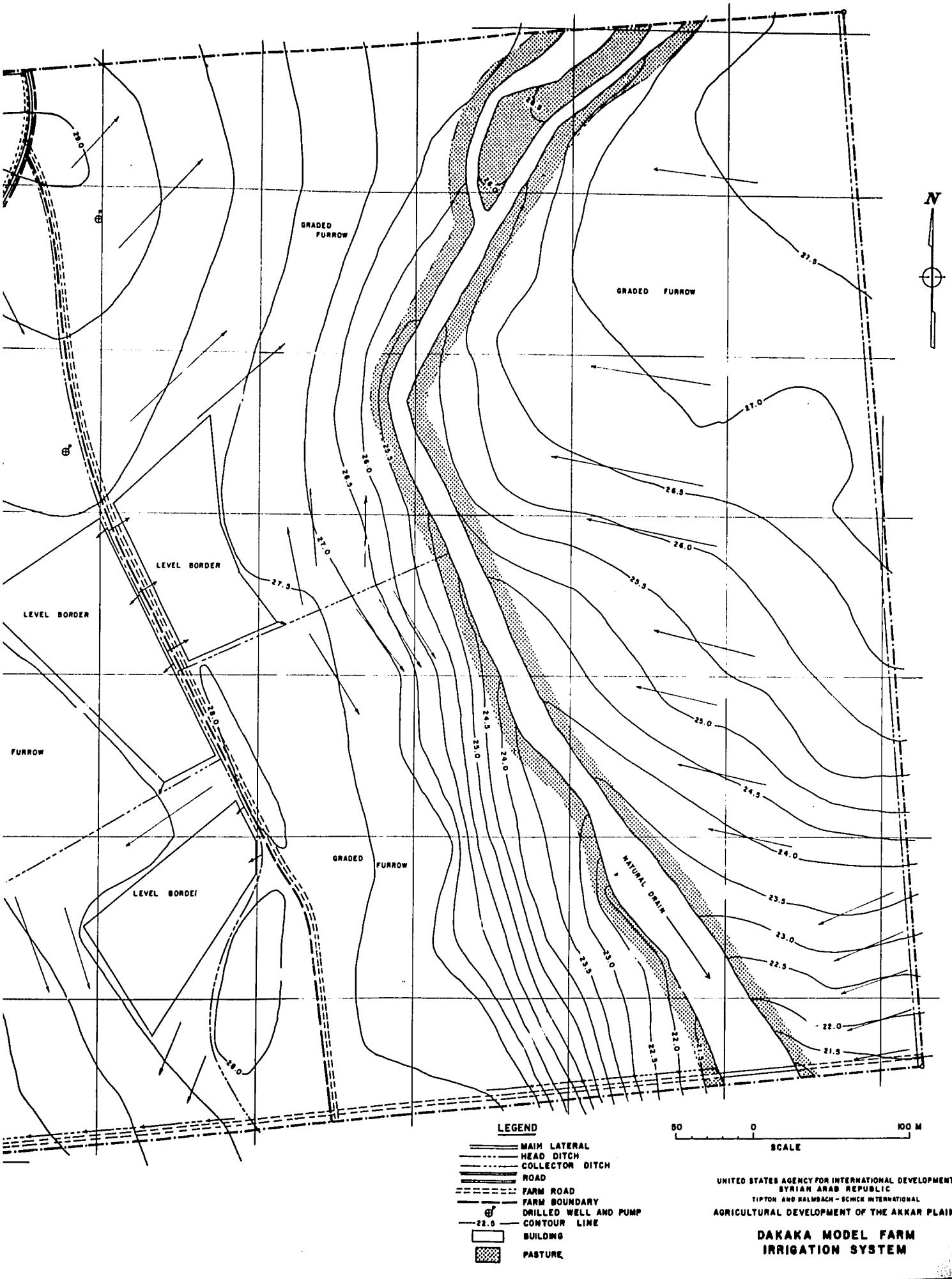


UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SYRIAN ARAB REPUBLIC
TIPTON AND KALMBACH - SCHICK INTERNATIONAL
AGRICULTURAL DEVELOPMENT OF THE AKKAR PLAIN

DAKAKA MODEL FARM IRRIGATION SYSTEM

believed that sprinkler irrigation would have limited application on the Akkar Plain. However, successful use of this system would require expert design and be custom-engineered to fit specific areas on the Plain. Since land ownership is small, it may be desirable to group several farms together under one sprinkler irrigation system and grow the same crop. This would also permit more efficient use of wheel move or other mobile sprinkler systems.

Although sprinkler irrigation is considered to have rather limited use on the Akkar Plain, there are a number of important benefits associated with its use; namely, cooling when temperature is 32°C or above, are adjustable to provide fine spray for germination of small vegetable seeds, provide efficient application of fertilizer and fungicides, and releases farm labor for other productive uses.

The cost of sprinkler irrigation is higher than the other methods of irrigation described but would eliminate some of the cost of land smoothing.

System Layout

Topography of the Akkar Plain is available with a 5-meter contour interval and scale of 1:25,000 which is not adequate for laying out an irrigation system. A detailed survey was made of three representative tracts in the Project Area. Each area comprised from 60 to 100 hectares and represented slopes and conditions most common to irrigation under the Project. Systems were designed for an area utilizing the level border method and an area utilizing the graded furrow method as recommended in the Report and shown on Figure VI-17. Land ownership plats or surveys were not available; therefore, the tracts were laid out in accordance with topography to represent typical size ownership. Field roads were relocated or added to provide:

1. Ease of operating the irrigation system
2. Ready access to all areas of the farm
3. Transportation of products from the farm
4. Dryness and usability of the road

Cultural Practices

The owner's tilling, planting and harvesting methods and farm machinery requirements must be resolved prior to planning the final on-farm development.

The heavy clay soils on the Akkar Plain will require wide variability in tillage management. Clay soils should be worked when the moisture content is near or slightly below optimum to minimize clodding and development of undesirable soil structure. In practice this is difficult since the farmer of a small farm is not justified to own all of the required farm machinery. Under these conditions, to permit the farmer to work his land at the optimum time, he will have to depend on custom work or to obtain equipment from the farmer cooperative, which may not be available.

Two-way moldboard plows are considered the most adaptable for use on the Project. This type of plow breaks up and loosens the heavy soil and eliminates dead furrows. Deep plowing to about 60 centimeters should be done every four to five years to prevent the formation of plow soles and to mix the soils and to provide desired aeration. Clod buster attachments should be used on the plows which break clods while the soil is moist and will usually eliminate one trip over the field with a disk or harrow. Since at times the formation of clods will be inevitable, a clod buster is necessary. A "Power Harrow" or equivalent is recommended for seedbed preparation. This type of harrow loosens and breaks up the soil by a vertical and horizontal motion which also aerates the soil. The low draft and other characteristics of this harrow permit the farmer to work the soil a week or two earlier than with other types of equipment and reduces the need for additional harrowing or leveling. On heavy soils, overmechanization causes compaction which destroys structure and aeration. For field operations other than tillage, the soil should be as dry and firm as possible.

CONSTRUCTION METHODS

It is contemplated that construction of the storage dam and the major components of the irrigation systems will be carried out under separate construction contracts. The dam construction contract will be sufficiently large to justify international

tendering. It is believed that Syrian construction firms are technically and financially qualified to undertake the construction of the drainage works and part or all of the irrigation systems.

A dragline and one or more backhoes will be required for the Janoubi River channel improvement and the drainage works. Heavy earth-moving equipment and a large-capacity concrete batch plant will be required for the construction of the storage dam. Canal trimming and lining machines will be required to construct the canals of the irrigation systems. All of such equipment will probably have to be imported to the extent that suitable similar equipment is not available from other on-going projects at the time the work is undertaken on the Akkar Plain. The most economical construction period will be that which results in early agricultural development of the area. Furthermore, the size of the project is such that a highly mechanized construction operation will absorb most of the presently unemployed labor force in the area.

CONSTRUCTION PROBLEMS

No unusual or particularly difficult construction problems are foreseen in constructing the project works. The logistics of supply should pose no more difficult problems than are common to other large water development projects. The fact that housing and services in the area are inadequate to accommodate the large work force that will be employed on the construction work will probably make it necessary to establish campsites for each major construction contract. Each camp will include headquarters office, shops, storage facilities, and housing for all supervisory and skilled personnel. Temporary satellite camps would be provided as necessary in the more remote areas of construction activity.

The dry summer season will provide excellent climatic conditions for construction. During the winter season, the frequent and often prolonged rains will periodically interrupt most earthwork operations and may suspend work, particularly on compacted earth fills as dry periods between rains are seldom of sufficient duration to reduce the moisture content of such materials to an acceptable level. All construction roads will have to be stabilized with granular materials as earth roads become impassable in the rainy season.

CONSTRUCTION SCHEDULE

Figure VI-18 shows a reasonable construction schedule for the works proposed. The schedule assumes that funds will be made available in the middle of a calendar year. The necessary fieldwork, design and contracting can then be completed in time for the following construction season.

The construction of several of the principal works are interrelated. In Phase I the Ramit Laha drain must not be excavated until the Janoubi River Channel Improvement is accomplished. In Phase II the conveyance system must await a decision on the reservoir location and should be completed concurrently with the dam.

PROJECT COSTS

In analyzing the cost of the project works, a distinction is made between the capital costs of building the works and the operation, maintenance, and replacement costs. Capital costs are the costs of construction, which include an allowance for contingent or unforeseen costs, and the cost of engineering and administration. Land acquisition costs have not been included in the estimates. The estimates are based on Spring 1978 cost levels.

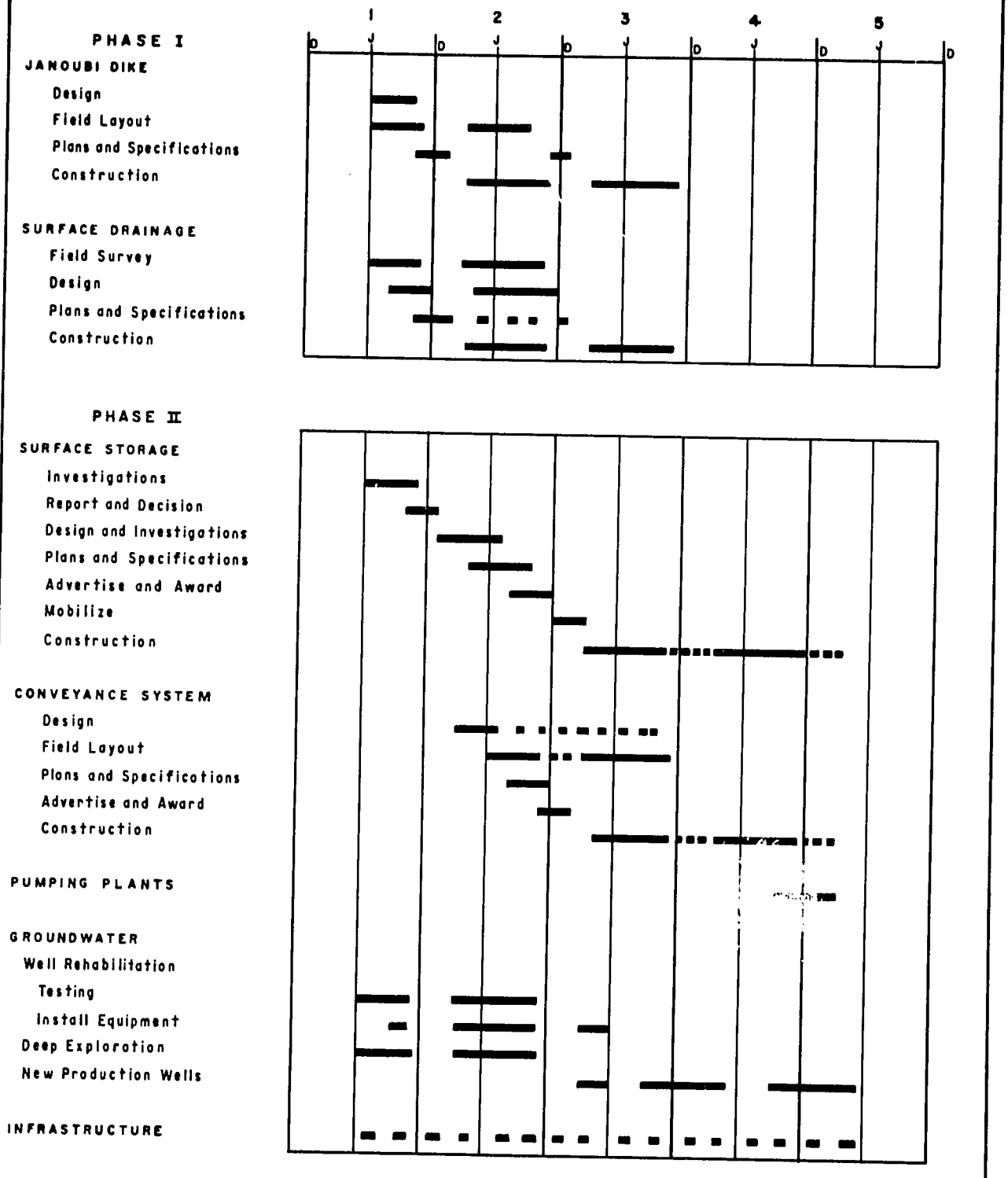
The operation, maintenance, and replacement costs comprise the annual costs of operation and maintenance, the cost of energy of pumping, and the costs of replacing equipment having a useful life shorter than that of the Project.

Capital Costs

The capital costs were determined for the various segments of the Development Plan. In preparing the estimates, the foreign currency cost and local currency costs have been estimated separately.

Civil Works: The construction of the civil works, consisting of the channel improvement and drainage works of Phase I and the surface irrigation works of Phase II, Stage 1, are similar to other works which have recently been constructed in Syria and construction contracts can be of the fixed unit price type.

CONSTRUCTION SCHEDULE



Preparation of construction costs involves preparing summaries of the quantities of various kinds of work required to complete the project. Estimates were made of channel improvement, drainage, and canal excavation; borrow excavation for material for the banks and access roads; compacted embankment; canal slope trimming; and concrete canal lining. For the canal system, estimates were made of the numbers and types of structures required for a portion of the Project Area and an overall cost of the distribution system per hectare of net irrigable land was developed. This value was then used for estimating the total cost of the distribution system for the total irrigable area served. Separate estimates of quantities of work were made for other features, such as pumping plants, dams, siphons, drain construction and channel improvement. Similar estimates were made for the other major works; namely, the Rihaniyeh Dam. Costs for the Berge Arab Diversion were taken from the Sofrelec Report on Yazdieh Dam.

Unit prices for the various items of work were developed from a number of sources within Syria as well as comparisons made with construction costs in the United States using current bid tabulations and U.S. Bureau of Reclamation estimating data. The Syrian sources included the Sofrelec estimate for the Yazdieh Dam, unit prices used in the construction of a cement plant by local contractors from Tartous and Lattakia, and costs obtained from three contracts for portions of the Homs-Tartous highway.

To the foregoing estimated costs, an allowance of 20 percent has been included to cover contingent or unforeseen costs. This allowance is intended to reflect the preliminary nature of many of the estimates rather than providing for future escalation in construction costs. In addition to the construction cost, an amount equivalent to 15 percent of the construction cost is incorporated in the estimates to cover the costs of administration and engineering related to construction of the Project. This sum is made up of an allowance of 3 percent for general administrative costs of the entity administering the work and 12 percent for engineering design and supervision of the construction work.

The estimated capital cost of the civil works of the Development Plan is shown on Table VI-3.

Table VI-3
Capital Cost Summary
Phase I and Phase II

Phase	Item	Cost		Total Cost		Foreign Exchange %
		Foreign SP x 10^3	Local SP x 10^3	SP x 10^3	U.S. $ x 10^3	
I	Janoubi River Channel Improvement	783	2,150	2,933	752	27
	Drainage System	815	5,620	6,435	1,650	13
	Ancillary On-Farm Drainage	1,348	660	2,008	515	67
	Subtotal - Phase I	2,946	8,430	11,376(1)	2,917(1)	26
II	Stage 1					
	Surface Irrigation					
	Rihaniyeh Dam	103,490	103,600	207,090	53,100	50
	Canal System	14,980	34,940	49,920	12,800	30
	Berge Arab Diversion Dam and Canal	6,080	13,810	19,890	5,100	31
	Subtotal - Phase II, Stage 1	124,550	152,350	276,900(1)	71,000(1)	45
II	Stage 2					
	Groundwater Irrigation					
	Pumps and Engineering	8,424	936	9,360	2,400	90
	New Wells	1,764	654	2,418	620	73
	Well Improvement	800	799	1,599	410	50
	Dry Wells(2)	2,931	1,086	4,017	1,030	73
	Contingencies(3)	4,181	1,045	5,226	1,340	80
	Subtotal - Phase II, Stage 2	18,100	4,520	22,620	5,800	80
	Estimated Total Project Cost	145,596	165,300	310,896	79,717	47

(1) Total costs include 20% contingencies and 15% engineering and administration
(2) 30% of estimated construction, equipment and engineering costs
(3) 30% of estimated construction, equipment, engineering and dry hole costs

Groundwater Development: The capital costs of Phase II, Stage 2, Groundwater Irrigation, consist of the costs of testing existing wells and installing proper size pumping equipment after testing; of improving existing wells by deepening and installing proper pumping equipment; of drilling and testing new shallow wells and fitting them with pumping equipment; and drilling and testing deep wells and supplying the pumping equipment. The costs include the cost of engineering and an allowance for drilling wells which would not be suitable for production wells. In addition to the estimated costs of construction and equipment, a contingent allowance of 30 percent is included to account for the preliminary nature of the estimates.

The estimated capital cost of groundwater development is shown on Table VI-3.

Infrastructure: The capital cost of the infrastructure which is required to provide the maximum benefits of the Development Plan is shown on Table VI-4. The costs for the infrastructure works were developed largely from the costs of similar works of other projects.

Annual Costs

The annual costs of the Development Plan comprise the cost of operation and maintenance of channel improvement, drainage and surface water irrigation system; and the cost of pumping, operation and maintenance of the groundwater irrigation system.

Channel Improvement, Drainage and Surface Water Irrigation System: The annual operation and maintenance costs of the drainage and surface water irrigation system, including the dam and channel improvement are based upon the assumption that a project organization for operation and maintenance will be established. The organization includes a chief engineer, assistant engineers, and clerical and office staff for administrative purposes. Serving under the chief engineer would be nine sub-project engineers, each with a staff, or approximately nine persons for maintenance of the facilities. Each sub-project engineer would be responsible for

Table VI-4
Infrastructure Cost Summary

	Cost		Total Cost(1)		Foreign Exchange %
	Foreign (SP x 10^3)	Local (SP x 10^3)	(SP x 10^3)	(U.S. $ x 10^3)	
Educational Facilities	-	7,293.0	7,293.0	1,870.0	0
Farm to Market Roads - Plan B	-	13,159.0	13,159.0	3,374.1	0
Agricultural Service Center	456.0	767.0	1,223.0	313.6	37
Health Care Center	823.7	1,464.8	2,288.5	586.8	36
Animal Slaughter and Processing Plant	202.8	689.5	892.3	228.8	23
Dairy	63.7	731.3	795.0	203.8	8
Grading and Packing Facilities	-	928.4	928.4	238.1	0
Vegetable and Fruit Cannery	1,953.5	1,858.8	3,812.3	977.5	51
Grain Storage	1,359.1	436.0	1,795.1	460.3	76
Estimated Total Infrastructure Cost	4,858.8	27,327.8	32,186.6	8,253.0	15

(1) Includes engineering and contingencies but does not include cost of land for sites.

two or more lateral systems totaling not more than 1,000 hectares plus a sub-project engineer for dam and dike maintenance. In addition to the cost of personnel, the annual cost includes the cost of equipment operation and replacement, vehicles, office supplies, and pumping costs of pumping plants.

The estimated annual cost for this portion of the Development Plan is shown on Table VI-5.

Groundwater Development: The annual operation and maintenance costs of the groundwater development comprise diesel fuel, oil, grease, filters and other consumable supplies; spare parts for the pump and engine; repair labor; operation labor; and operation and maintenance of the irrigation system not included in the on-farm costs.

The estimated annual cost of groundwater development is shown on Table VI-5.

Replacement Costs

It is assumed that the pumps and motors of the groundwater development have a life of 15 years and the wells have a useful life of 30 years. These items must be replaced at the intervals indicated. It is further assumed that the investigations will show that the deep aquifer is a viable groundwater source and a number of the shallow wells will be replaced by larger yielding deep wells.

The estimated cost of replacement of pumping equipment and wells is shown on Table VI-6.

Table VI-5
Annual Operation and Maintenance Costs
(U.S. $ x 10^3)

Phase	Item		Cost
I	Janoubi Channel Improvement		1.0
	Drainage System		5.4
	Subtotal - Phase I		6.4
II	Stage 1		
	Surface Irrigation System		320.0
II	Stage 2		
	Groundwater Irrigation(1)		735.0
	Subtotal - Phase II		1,055.0
	Total Annual Cost	(U.S. $ x 10^3)	1,061.4
		(SP x 10^3)	4,140.0

(1) Based on annual cost of U.S. $148/hectare

Table VI-6
Replacement Costs of Wells and Pumping Equipment
Phase II, Stage 2

Item	Cost	
	SP x 10^3	U.S. $ x 10^3
Wells		
70 shallow wells @ SP 7,000	490.0	125.6
50 deep wells @ SP 300,000	15,000.0	3,846.4
Subtotal - Wells	15,490.0	3,972.0
Pumping Equipment		
70 shallow well units @ SP 18,000	1,260.0	323.0
50 deep well units @ SP 50,000	2,500.0	641.0
Subtotal - Pumping Equipment	3,760.0	964.0
Total - Wells and Pumping Equipment	19,250.0	4,936.0

CHAPTER VII

ECONOMIC EVALUATION

The economic evaluation of the project was made for the total project and for its various segments as shown in Table VII-1.

Table VII-1
Economic Analysis Summary

Analysis	Project Phase	Segment of Project
1	I	Channel Improvement
2	I	Drainage
3	I	Channel Improvement and Drainage
4	II	Stage 1, Surface Irrigation
5	II	Stage 2, Groundwater Irrigation
6	II	Stage 1 and Stage 2
7	I and II	Total Project

The parameters adopted for the economic evaluation are the economic internal rate of return (EIRR) and for a selected discount rate, the benefit-cost ratios.

These parameters provide somewhat different insights into the economics of the project development. The benefit-cost ratio is defined as the relation:

$$\frac{\text{present worth of benefits}}{\text{present worth of costs}}$$

For a given discount rate, the benefit-cost ratio indicates the profitability of a project.

The economic internal rate of return gives the average annual return on the investment. In effect, the economic internal rate of return is the discount rate at which the project would show a benefit-cost ratio of unity.

In order for the present worth parameters to provide valid bases for economic evaluation, the selected discount rate must reflect the true value of capital in the economy. A discount rate of 8 percent was selected; however, because of the growing demand

for foodstuffs and the increasing dependence upon imports to meet its food requirements, it is believed that SARG could accept a lower discount rate than the 8 percent used in the analyses.

COSTS

Cash Flow of Costs

The construction costs of the project are shown in Table VI-3 and the annual operation and maintenance costs of the project are shown in Table VI-5. To the costs shown in the above tables must be added the replacement costs of the project wells and their pumping equipment. The costs shown in Table VI-3 are based on the Rihaniyeh Dam alternative. The estimated percentage of the capital costs to be expended in each construction year is shown in Figure VII-1 and the cash flow of capital costs during the construction period is shown in Table VII-2.

The cash flow of all costs including capital, operation and maintenance and replacement during the construction period and project life are shown on Table VII-3.

BENEFITS

Project benefits accrue to the agricultural economy from increased agricultural production resulting from flood control, drainage and irrigation. As a result of the increased activity in the agricultural sector, economic activity in the entire region would be stimulated and indirect benefits would accrue to many people who are not cultivators.

Direct Benefits

The direct net project benefits would accrue to the cultivators as a result of the development. These benefits are fully described in Appendix A VIII, Economics, and are presented in terms of gain to the cultivator as a result of the Development Plan. The benefits from drainage in Phase I are expressed as the difference between future farm net income with development and the net farm income without development. Flood control benefits of Stage 1 are expressed as the value of the reduction of crop damage resulting from the construction of the flood control works.

PROJECT SCHEDULE

PROJECT PHASE	PERIOD—YEARS 1	2	3	4	5	6						54
CONSTRUCTION												
PHASE I												
CHANNEL IMPROVEMENT	50%	50%										
DRAINAGE	50%	50%										
PHASE II												
STAGE 1												
SURFACE IRRIGATION	25%	25%	25%	25%								
INFRASTRUCTURE	25%	25%	25%	25%								
STAGE 2			33%	33%	34%							
BENEFITS												
PHASE I												
CHANNEL IMPROVEMENT		25%	50%	75%	100%							
DRAINAGE		25%	50%	75%	100%							
PHASE II												
STAGE 1												
SURFACE IRRIGATION				25%	50%	75%	100%					
INFRASTRUCTURE				25%	50%	75%	100%					
STAGE 2				25%	50%	75%	100%					

Table VII-2
Cash Flow of Capital Costs

Phase	Item	Construction Year (U.S. $ x 10^3) 1	2	3	4	5	Total Cost (SP x 10^3)	(U.S. $ x 10^3)
I	Channel Improvement	376.0	376.0	-	-	-	2,933	752.0
	Drainage	825.0	825.0	-	-	-	6,435	1,650.0
	Ancillary On-Farm Costs	257.5	257.5	-	-	-	2,008	515.0
II	Stage 1							
	Surface Irrigation							
	Rihaniyeh Dam	13,725.0	13,275.0	13,275.0	13,275.0	-	207,090	53,100.0
	Canal System	3,200.0	3,200.0	3,200.0	3,200.0	-	49,920	12,800.0
	Berge Arab Diversion	1,275.0	1,275.0	1,275.0	1,275.0	-	19,890	5,100.0
II	Stage 2							
	Groundwater Irrigation							
	Pumps and Engineering	-	-	792.0	792.0	816.0	9,360	2,400.0
	New Wells	-	-	204.6	204.6	210.8	2,418	620.0
	Well Improvement	-	-	135.3	135.3	139.4	1,599	410.0
	Dry Wells (30%)	-	-	339.9	339.9	350.2	4,017	1,030.0
	Contingencies (30%)	-	-	442.2	442.2	455.6	5,226	1,340.0
	Totals	19,208.5	19,208.5	19,664.0	19,664.0	1,972.0	310,896	79,717.0

Table VII-3
Summary - Cash Flow of Costs

Project Year	Phase I		Phase II			Phase I and Phase II Total Costs	
	Capital Costs (U.S. $ × 10^3)	O & M Costs (U.S. $ × 10^3)	Capital Costs (U.S. $ × 10^3)	O & M Costs (U.S. $ × 10^3)	Replacement Costs (U.S. $ × 10^3)	(SP × 10^3)	(U.S. $ × 10^3)
Construction							
1	1,458.5	0	17,750.0	0	0	74,913.2	19,208.5
2	1,458.5	0	17,750.0	0		74,913.2	19,208.5
3	0	6.4	19,664.0	0		76,714,6	19,670.4
4			19,664.0	0		76,714.6	19,670.4
Project Life			1,972.0	320		8,963.8	2,298.4
1			0	1,055.0		4,139.5	1,061.4
2							
14					0	4,139.5	1,061.4
15					964	7,899.1	2,025.4
16					0	4,139.5	1,061.4
29					0	4,139.5	1,061.4
30					4,936.0	23,389.9	5,997.4
31					0	4,139.5	1,061.4
50	0	6.4	0	1,055.0	0	4,139.5	1,061.4

In the surface irrigation area of Phase II, Stage 1, the net project benefits are presented in terms of the gain to the cultivator as a result of the Development Plan, after deducting costs of agricultural production but excluding the costs associated with the construction of the project works and their operation and maintenance. In the well area of Phase II, Stage 2, the net project benefits are presented in terms of the gain to the cultivator, after deducting costs of agricultural production but excluding the costs associated with construction of wells, pumping equipment, annual operation and maintenance and replacement of wells and pumping equipment. In the irrigated areas developed as part of Phase II, on-farm costs such as construction of irrigation ditches from the main canals to the farms and the on-farm distribution system are included in the cost of production. The on-farm costs are included as part of the farmer's capital investment and the interest on this investment is considered to be an annual production cost.

The annual net benefits to the cultivators for the various segments of the project are shown in Table VII-4.

Table VII-4
Annual Net Direct Farm Benefits

Analysis	Project Phase	Segment	Annual Net Benefits (SP x 10^3)	Annual Net Benefits (U.S. $ x 10^3)
1	I	Channel Improvement	397.8	102.0
2	I	Drainage System	3,549.0	910.0
3	I	Channel Improvement & Drainage	3,946.8	1,012.0
4	II	Stage 1, Surface Irrigation	28,002.0	7,180.0
5	II	Stage 2, Groundwater Irrigation	22,542.0	5,780.0
6	II	Stage 1 and Stage 2	50,544.0	12,960.0
7	I and II	Total Project	54,490.8	13,972.0

Cash Flow of Annual Direct Farm Benefits

The estimated percentage of the net benefits to be realized in each year of the construction period and project life are shown on Figure VII-1 and the cash flow of all direct benefits during the construction period and project life are shown in Table VII-5.

Table VII-5
Cash Flow of Annual Net Direct Farm Benefits

Project Year	Phase I (U.S. $ x 10^3)	Phase II Stage 1 (U.S. $ x 10^3)	Phase II Stage 2 (U.S. $ x 10^3)	Phase I and Phase II Total Benefits (SP x 10^3)	Phase I and Phase II Total Benefits (U.S. $ x 10^3)
Construction					
1	-	-	-	-	-
2	253	-	-	986.7	253
3	506	-	-	1,973.4	506
4	759	1,795	1,445	15,596.1	3,999
Project Life					
1	1,012	3,590	2,890	29,218.8	7,492
2	↕	5,385	4,335	41,854.8	10,732
3	↕	7,180	5,780	54,490.8	13,972
4	↕	↕	↕	↕	↕
5	↕	↕	↕	↕	↕
6	↕	↕	↕	↕	↕
7	↕	↕	↕	↕	↕
8	↕	↕	↕	↕	↕
50	1,012	7,180	5,780	54,490.8	13,972

As shown in Table VII-5, the Phase I benefits would begin to accrue in the second year of construction, assuming the timely implementation of the Agricultural Service Center. Maximum benefits would be realized in the first year of the project life, which is the third year after the completion of the Phase I works. The net project benefits build up during this 4-year period as the farmers, with the assistance of Agricultural Service Center, would rapidly change their cultural practices.

Phase II, Stage 1, benefits would begin to accrue in the fourth year of construction as the project works near completion and some water becomes available for irrigation. A four-year period is allowed for the build up to full benefits. It is assumed that the infrastructure facilities would be constructed simultaneously with the surface irrigation, thus furnishing the necessary technological inputs to the farmer as well as providing marketing and processing facilities.

Benefits of Phase II, Stage 2, development would begin to accrue in the second year of groundwater development, and a four-year period to reach full development has been allowed. The immediate benefits would come from double-cropping and improved irrigation practices.

Indirect Benefits

Economic activity would be stimulated by the increased activity on farms as a result of the project. The economic multiplier and accelerator would begin to function as quickly as farmers started providing additional inputs, including labor, and would gain strength when additional products were harvested. Both farm costs and returns would function in generating indirect benefits throughout Syria until the functions stop or transfer out of the country. These benefits exceed the direct benefits because they occur each time the costs or receipts change hands.

Annual indirect benefits for Phase I are estimated to be SP 15,077,000 (U.S. $3,866,000) and Phase II to be SP 59,904,000 (U.S. $15,360,000). These benefits would be very important to Syria since they spread the economic impact due to the net direct farm benefits. Indirect benefits impact more people than the direct benefits.

Intangible Benefits

Intangible benefits cannot be measured in monetary terms, but they would be significantly important in the Akkar Plain Project. Improved personal income of those receiving both direct and indirect benefits would allow children greater educational opportunities and a greater variety of experiences. Improved domestic water supplies, more adequate diets, and additional doctors and clinics on the Plain would improve the health of the people, making their lives more enjoyable and capable of greater productivity.

The economic activity generated by the development would provide opportunities for young people just entering the labor market, thus allowing them to remain in the area where they can associate with family members and friends. The people of Syria have strong family relationships and value their friendships with others. The economic activity of the Akkar Plain would allow more of them to remain at their birthplaces and to enjoy their families and customs.

Production of additional food items during the periods of normal scarcity would lessen the tension of the large metropolitan areas. The Akkar Plain Project individually would not prevent all food shortages in Syria, but it would significantly reduce the problem. Also, less stress would be put on international imports, which may allow the people to import needed items that have been difficult or impossible to import previously.

Syria as a whole would be strengthened by the full development of the Akkar Plain land and water resources. The Government would have additional production that could be taxed for revenue needed for other objectives. Improved trade balance would lessen the strain of operating the financial aspects of the country.

ECONOMIC ANALYSIS

An economic analysis was performed for each segment of the project, for each phase of the project, and the total project, including the determination of the economic internal rates of return and the benefit-cost ratios. The economic analyses were performed by including all of the project costs previously discussed except the

infrastructure costs and the net direct farm benefits. As the infrastructure generates most of the indirect and intangible benefits as well as a part of the direct benefits, it was believed that should the infrastructure costs be included in the analysis, the indirect benefits should also be included. Since it is difficult to accurately quantify the indirect benefits, it is believed that the method of analysis adopted; i.e., project cost less infrastructure costs and net direct farm benefits, best portrays the economic impact of the project. The summary of the analyses is shown in Table VII-6.

Table VII-6
Summary - Economic Analyses Including
Economic Internal Rates of Return (EIRR) and Benefit-Cost Ratios

Analysis	Project Phase	Segment	EIRR %	Benefit-Cost Ratio at 8% Discount Rate
1	I	Channel Improvement	12.0	1.5
2	I	Drainage System	32.8	4.6
3	I	Channel Improvement & Drainage	27.7	3.9
4	II	Stage 1, Surface Irrigation	8.1	1.0
5	II	Stage 2, Groundwater Irrigation	75.6	4.5
6	II	Stage 1 and Stage 2	12.4	1.5
7	I and II	Total Project	13.0	1.6

It is seen that the total project and each of its segments are economically viable. Stage 1 of Phase II, surface irrigation, as an individual component of the Development Plan, demonstrates the least economic viability. This segment of the project represents 89 percent of the capital cost of the project and 30 percent of the annual operation and maintenance costs at full development. This segment of the project, however, provides 51 percent of the net project benefits and would be the key element to the full development of the land and water resources of the Akkar Plain.

A computer program has been developed for the analysis and evaluation of the various economic parameters. Tables VII-7, VII-8, and VII-9 showing the analysis of the total project are included to show the methodology used in the analyses.

Table VII-7 shows the cash flow of costs and benefits during the construction stage and project life, a total of 54 years. The net benefits, defined as benefits

Table VII-7
Cash Flow of Costs and Benefits
Phase I and Phase II
(U.S. $ x 10^3)

Project Year		Year	COSTS: Capital Costs Phase I[1]	Capital Costs Phase II[1]	O & M Phase I[2]	O & M Phase II[2]	Replacements[3]	Total Costs (2)+(3)+(4)+(5)+(6)	BENEFITS: Phase I	Phase II	Total Benefits (8) + (9)	Net Benefits (-7) + (10)	Cumulative Net Benefits
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Const.	1	1	1,458.5	17,750.0	-	-	-	19,208.5	-	-	-	-19,208.5	-19,208.5
	2	2	1,458.5	17,750.0		-	-	19,208.5	253.0	-	253.0	-18,955.5	-38,164.0
	3	3	-	19,664.0	6.4	-	-	19,670.4	506.0	-	506.0	-19,164.4	-57,328.4
Const.	4	4	-	19,664.0	6.4	-	-	19,670.4	759.0	3,240.0	3,999.0	-15,671.4	-72,999.8
Proj. Life	1	5	-	1,972.0	6.4	320.0	-	2,298.4	1,012.0	6,480.0	7,492.0	5,193.6	-67,806.2
	2	6	-	-	6.4	1,055.0	-	1,061.4	1,012.0	9,720.0	10,732.0	9,670.6	-58,135.6
	3	7	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	-45,225.0
	4	8	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	-32,314.4
	5	9	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	-19,403.8
	6	10	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	-6,493.2
	7	11	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	6,417.4
	8	12	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	19,328.0
	9	13	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	32,238.6
	10	14	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	45,149.2
	11	15	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	58,059.8
	12	16	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	70,970.4
	13	17	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	83,881.0
	14	18	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	96,791.6
	15	19	-	-	6.4	1,055.0	964.0	2,025.4	1,012.0	12,960.0	13,972.0	11,946.6	108,738.2
	16	20	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	121,648.8
	17	21	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	134,559.4
	18	22	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	147,470.0
	19	23	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	160,380.6
	20	24	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	173,291.2
	21	25	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	186,201.8
	22	26	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	199,112.4
	23	27	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	212,023.0
	24	28	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	224,933.6
	25	29	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	237,844.2
	26	30	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	250,754.8
	27	31	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	263,665.4
	28	32	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	276,576.0
	29	33	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	289,486.6
	30	34	-	-	6.4	1,055.0	4,936.0	5,997.4	1,012.0	12,960.0	13,972.0	7,974.6	297,461.2
	31	35	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	310,371.8
	32	36	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	323,282.4
	33	37	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	336,193.0
	34	38	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	349,103.6
	35	39	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	362,014.2
	36	40	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	374,924.8
	37	41	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	387,835.4
	38	42	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	400,746.0
	39	43	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	413,656.6
	40	44	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	426,567.2
	41	45	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	439,477.8
	42	46	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	452,388.4
	43	47	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	465,299.0
	44	48	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	478,209.6
	45	49	-	-	6.4	1,055.0	-[4]	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	491,120.2
	46	50	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	504,030.8
	47	51	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	516,941.4
	48	52	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	529,852.0
	49	53	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	542,762.6
Proj. Life	50	54	-	-	6.4	1,055.0	-	1,061.4	1,012.0	12,960.0	13,972.0	12,910.6	555,673.2
		Totals	2,917.0	76,800.0	332.8	52,015.0	5,900.0	137,964.8	52,118.0	641,520.0	693,638.0	555,673.2	

Notes: (1) Capital costs shown in Table VI-3
(2) Operation and maintenance costs shown in Table VI-5
(3) Replacement costs of pumping sets in Years 19 and 34

70 shallow sets	$323,000
50 deep sets	641,000
	$964,000

Replacement of wells in Year 34

70 shallow wells	$ 125,600
50 deep wells	3,846,400
	$3,972,000

(4) Replacement costs of pumping sets in Year 49 assumed to be equal to salvage value of pumping sets and wells at end of project life.

Table VII-8
Present Worth of Costs and Benefits
@ 8% Discount Rate
Phase I and Phase II
(U.S. $ x 10^3)

Project Year (1)		Year (2)	Costs (3)	Benefits (4)	Present Worth @ 8% Factor (5)	Cost (6)	Benefits (7)	Net Benefits (8)	Cumulative Net Benefits (9)
Const.	1	1	19,208.5	-	.9259	17,785.2	-	-17,785.2	-17,785.2
	2	2	19,208.5	253.0	.8573	16,467.4	216.9	-16,250.5	-34,035.7
	3	3	19,670.4	506.0	.7938	15,614.4	401.7	-15,212.7	-49,248.4
Const.	4	4	19,670.4	3,999.0	.7350	14,457.7	2,939.3	-11,518.4	-60,766.8
Proj. Life	1	5	2,298.4	7,492.0	.6806	1,564.3	5,099.1	3,534.8	-57,232.0
	2	6	1,061.4	10,732.0	.6302	668.9	6,763.3	6,094.4	-51,137.6
	3	7	1,061.4	13,972.0	.5835	619.3	8,152.7	7,533.4	-43,604.2
	4	8	1,061.4	13,972.0	.5403	573.5	7,549.1	6,975.6	-36,628.6
	5	9	1,061.4	13,972.0	.5002	530.9	6,988.8	6,457.9	-30,170.7
	6	10	1,061.4	13,972.0	.4632	491.6	6,471.8	5,980.2	-24,190.5
	7	11	1,061.4	13,972.0	.4289	455.2	5,992.6	5,537.4	-18,653.1
	8	12	1,061.4	13,972.0	.3971	421.5	5,548.3	5,126.8	-13,526.3
	9	13	1,061.4	13,972.0	.3677	390.3	5,137.5	4,747.2	-8,779.1
	10	14	1,061.4	13,972.0	.3405	361.4	4,757.5	4,396.1	-4,383.0
	11	15	1,061.4	13,972.0	.3152	334.6	4,404.0	4,069.4	-313.6
	12	16	1,061.4	13,972.0	.2919	309.8	4,078.4	3,768.6	3,455.0
	13	17	1,061.4	13,972.0	.2703	286.9	3,776.6	3,489.7	6,944.7
	14	18	1,061.4	13,972.0	.2502	265.6	3,495.8	3,230.2	10,174.9
	15	19	2,025.4	13,972.0	.2317	469.3	3,237.3	2,768.0	12,942.9
	16	20	1,061.4	13,972.0	.2145	227.7	2,997.0	2,769.3	15,712.2
	17	21	1,061.4	13,972.0	.1987	210.9	2,776.2	2,565.3	18,277.5
	18	22	1,061.4	13,972.0	.1839	195.2	2,569.5	2,374.3	20,651.8
	19	23	1,061.4	13,972.0	.1703	180.8	2,379.4	2,198.6	22,850.4
	20	24	1,061.4	13,972.0	.1577	167.4	2,203.4	2,036.0	24,886.4
	21	25	1,061.4	13,972.0	.1460	155.0	2,039.9	1,884.9	26,771.3
	22	26	1,061.4	13,972.0	.1352	143.5	1,889.0	1,745.5	28,516.8
Proj. Life	23	27	1,061.4	13,972.0	.1252	132.9	1,749.3	1,616.4	30,133.2
Proj. Life	24	28	1,061.4	13,972.0	.1159	123.0	1,619.4	1,496.4	31,629.6
	25	29	1,061.4	13,972.0	.1073	113.9	1,499.2	1,385.3	33,014.9
	26	30	1,061.4	13,972.0	.0994	105.5	1,388.8	1,283.3	34,298.2
	27	31	1,061.4	13,972.0	.0920	97.6	1,285.4	1,187.8	35,486.0
	28	32	1,061.4	13,972.0	.0852	90.4	1,190.4	1,100.0	36,586.0
	29	33	1,061.4	13,972.0	.0789	83.7	1,102.4	1,018.7	37,604.7
	30	34	5,997.4	13,972.0	.0730	437.8	1,020.0	582.2	38,186.9
	31	35	1,061.4	13,972.0	.0676	71.8	944.5	872.7	39,059.6
	32	36	1,061.4	13,972.0	.0626	66.4	874.6	808.2	39,867.8
	33	37	1,061.4	13,972.0	.0580	61.6	810.4	748.8	40,616.6
	34	38	1,061.4	13,972.0	.0537	57.0	750.3	693.3	41,309.9
	35	39	1,061.4	13,972.0	.0497	52.8	694.4	641.6	41,951.5
	36	40	1,061.4	13,972.0	.0460	48.8	642.7	593.9	42,545.4
	37	41	1,061.4	13,972.0	.0426	45.2	595.2	550.0	43,095.4
	38	42	1,061.4	13,972.0	.0395	41.9	551.9	510.0	43,605.4
	39	43	1,061.4	13,972.0	.0365	38.7	510.0	471.3	44,076.7
	40	44	1,061.4	13,972.0	.0338	35.9	472.3	436.4	44,513.1
	41	45	1,061.4	13,972.0	.0313	32.0	421.0	389.0	44,902.1
	42	46	1,061.4	13,972.0	.0290	30.8	405.2	374.4	45,276.5
	43	47	1,061.4	13,972.0	.0269	28.6	375.8	347.2	45,623.7
	44	48	1,061.4	13,972.0	.0249	26.4	347.9	321.5	45,945.2
	45	49	1,061.4	13,972.0	.0230	24.4	321.4	297.0	46,242.2
	46	50	1,061.4	13,972.0	.0213	22.6	297.6	275.0	46,517.2
	47	51	1,061.4	13,972.0	.0197	20.9	275.2	254.3	46,771.5
	48	52	1,061.4	13,972.0	.0183	19.4	255.7	236.3	47,007.8
	49	53	1,061.4	13,972.0	.0169	17.9	236.1	218.2	47,226.0
	50	54	1,061.4	13,972.0	.0157	16.7	219.4	202.7	47,428.7
		Totals	137,964.8	693,638.0		75,292.9	122,721.6	47,428.7	

Benefit-Cost Ratio $\frac{122,721.6}{75,292.9}$ = 1.63 @ 8% Discount Rate

Table VII-9
Present Worth of Costs and Benefits
@ 13% Discount Rate
Phase I and Phase II
(U.S. $ x 10^3)

Project Year (1)		Year (2)	Costs (3)	Benefits (4)	Present Worth @ 13% Factor (5)	Cost (6)	Benefits (7)	Net Benefits (8)	Cumulative Net Benefits (9)
Const.	1	1	19,208.5	-	.8850	16,999.5	-	-16,999.5	-16,999.5
	2	2	19,208.5	253.0	.7831	15,042.2	198.1	-14,844.1	-31,843.6
	3	3	19,670.4	506.0	.6931	13,633.6	350.7	-13,282.9	-45,126.5
Const.	4	4	19,670.4	3,999.0	.6133	12,063.9	2,452.6	-9,611.3	-54,737.8
Proj. Life	1	5	2,298.4	7,492.0	.5428	1,247.6	4,066.7	2,819.1	-51,918.7
	2	6	1,061.4	10,732.0	.4803	509.8	5,154.6	4,644.8	-47,273.9
	3	7	1,061.4	13,972.0	.4251	451.2	5,939.5	5,488.3	-41,785.6
	4	8	1,061.4	13,972.0	.3762	399.3	5,256.3	4,857.0	-36,928.6
	5	9	1,061.4	13,972.0	.3329	353.3	4,651.3	4,298.0	-32,630.6
	6	10	1,061.4	13,972.0	.2946	312.7	4,116.2	3,803.5	-28,827.1
	7	11	1,061.4	13,972.0	.2607	276.7	3,642.5	3,365.8	-25,461.3
	8	12	1,061.4	13,972.0	.2307	244.9	3,223.3	2,978.4	-22,482.9
	9	13	1,061.4	13,972.0	.2042	216.7	2,853.1	2,636.4	-19,846.5
	10	14	1,061.4	13,972.0	.1807	191.8	2,524.7	2,332.9	-17,513.6
	11	15	1,061.4	13,972.0	.1599	169.7	2,234.1	2,064.4	-15,449.2
	12	16	1,061.4	13,972.0	.1415	150.2	1,977.0	1,826.8	-13,622.4
	13	17	1,061.4	13,972.0	.1252	132.9	1,749.3	1,616.4	-12,006.0
	14	18	1,061.4	13,972.0	.1108	117.6	1,548.1	1,430.5	-10,575.4
	15	19	2,025.4	13,972.0	.0981	198.7	1,307.7	1,109.0	-9,466.5
	16	20	1,061.4	13,972.0	.0868	92.1	1,212.8	1,120.7	-8,345.8
	17	21	1,061.4	13,972.0	.0768	81.5	1,073.0	991.5	-7,354.3
	18	22	1,061.4	13,972.0	.0680	72.2	950.1	877.9	-6,476.4
	19	23	1,061.4	13,972.0	.0601	63.8	839.7	775.9	-5,700.5
	20	24	1,061.4	13,972.0	.0532	56.5	743.3	686.8	-5,013.7
	21	25	1,061.4	13,972.0	.0471	50.0	658.1	608.1	-4,405.6
	22	26	1,061.4	13,972.0	.0417	44.3	582.6	538.3	-3,867.3
Proj. Life	23	27	1,061.4	13,972.0	.0369	39.2	515.6	476.4	-3,390.9
Proj. Life	24	28	1,061.4	13,972.0	.0326	34.6	455.5	420.9	-2,970.0
	25	29	1,061.4	13,972.0	.0289	30.7	403.8	373.1	-2,596.9
	26	30	1,061.4	13,972.0	.0256	27.2	357.7	330.5	-2,266.4
	27	31	1,061.4	13,972.0	.0226	24.0	315.8	291.8	-1,974.6
	28	32	1,061.4	13,972.0	.0200	21.2	279.4	258.2	-1,716.4
	29	33	1,061.4	13,972.0	.0177	18.8	247.3	228.5	-1,487.9
	30	34	5,997.4	13,972.0	.0157	94.2	219.4	125.2	-1,362.7
	31	35	1,061.4	13,972.0	.0139	14.8	194.2	179.4	-1,183.3
	32	36	1,061.4	13,972.0	.0123	13.1	171.9	158.8	-1,024.5
	33	37	1,061.4	13,972.0	.0109	11.6	152.3	140.7	-883.8
	34	38	1,061.4	13,972.0	.0096	10.2	134.1	123.9	-759.9
	35	39	1,061.4	13,972.0	.0085	9.0	118.8	109.8	-650.1
	36	40	1,061.4	13,972.0	.0075	8.0	104.8	96.8	-553.3
	37	41	1,061.4	13,972.0	.0067	7.1	93.6	86.5	-466.8
	38	42	1,061.4	13,972.0	.0059	6.3	82.4	76.1	-390.7
	39	43	1,061.4	13,972.0	.0052	5.5	72.7	67.2	-323.5
	40	44	1,061.4	13,972.0	.0046	4.9	64.3	59.4	-264.1
	41	45	1,061.4	13,972.0	.0041	4.4	57.3	52.9	-211.2
	42	46	1,061.4	13,972.0	.0036	3.8	50.3	46.5	-164.7
	43	47	1,061.4	13,972.0	.0032	3.4	44.7	41.3	-123.4
	44	48	1,061.4	13,972.0	.0028	3.0	39.1	36.1	-87.3
	45	49	1,061.4	13,972.0	.0025	2.7	34.9	32.2	-55.1
	46	50	1,061.4	13,972.0	.0022	2.3	30.7	28.4	-26.7
	47	51	1,061.4	13,972.0	.0020	2.1	27.9	25.8	-0.9
	48	52	1,061.4	13,972.0	.0017	1.8	23.8	22.0	21.1
	49	53	1,061.4	13,972.0	.0015	1.6	21.0	19.4	40.5
	50	54	1,061.4	13,972.0	.0014	1.5	19.6	18.1	58.6
		Totals	137 964.8	693.638.0		63,579.7	63,638.8	58.6	

Benefit-Cost Ratio $\frac{63,638.8}{63,579.7}$ = 1.00 @ 13% Discount Rate

less costs, show significant deficits in the first four years of the project and surpluses through the balance of the period. The total of the project benefits over the 54-year period is U.S. $ 693.64 million (SP 2,705 million) and the costs are U.S. $ 137.97 million (SP 538 million), resulting in net benefits of U.S. $ 555.67 million (SP 2,167 million) and a benefit-cost ratio of 5.03 for a zero discount rate.

The present worths of the total project costs and benefits, discounted at 8 percent, are shown in Table VII-8. As shown therein, the present worth of benefits over a 54-year period is U.S. $ 122.72 million (SP 479 million) and the present worth of costs is U.S. $ 75.29 million (SP 294 million). The resulting benefit-cost ratio is 1.63, and the present worth of net benefits is U.S. $ 47.43 million (SP 185 million).

The determination of the economic internal rate of return of the total project is shown in Table VII-9. As previously described, the economic internal rate of return is the discount rate at which the project would show a benefit-cost ratio of unity. As shown therein, the economic internal rate of return is about 13.0 percent; i.e., with a discount rate of 13.0 percent the present worth of costs and benefits are equal (U.S. $63.6 million or SP 248 million), the benefit-cost ratio is 1, and the present worth of net benefits is zero.

Sensitivity Analysis

Sensitivity tests were performed for each segment of the project, for each phase of the project, and for the total project. The tests were made for inputs of various combinations of benefit reductions and cost increases and determining the benefit-cost ratios and economic internal rates of return for the assumed conditions. The results of the tests for Phase I, Phase II and Phase I and II are shown in Table VII-10. It is clear from the analysis that the Akkar Plain Project shows a high order of economic feasibility by any reasonable method of analysis.

Table VII-10
Summary - Sensitivity Tests

Phase	Factors used in Test: Benefits	Factors used in Test: Costs	Benefit-Cost Ratio @ 8% Discount Rate	Economic Internal Rate of Return %
I	1.00 (base)	1.00	3.85	27.75
	1.00	1.10	3.50	25.54
	1.00	1.20	3.21	23.68
	0.90	1.00	3.46	25.32
	0.90	1.10	3.15	23.30
	0.80	1.00	3.08	22.84
	0.80	1.20	2.56	19.44
II	1.00 (base)	1.00	1.54	12.36
	1.00	1.10	1.40	11.30
	1.00	1.20	1.29	10.39
	0.90	1.00	1.39	11.19
	0.90	1.10	1.26	10.20
	0.80	1.00	1.23	9.98
	0.80	1.20	1.03	8.26
I and II	1.00 (base)	1.00	1.63	13.02
	1.00	1.10	1.48	11.89
	1.00	1.20	1.35	10.94
	0.90	1.00	1.46	11.78
	0.90	1.10	1.33	10.75
	0.80	1.00	1.30	10.51
	0.80	1.20	1.08	8.72

CHAPTER VIII

FINANCIAL ANALYSIS

The preceding evaluation of agricultural benefits and costs demonstrates that irrigation of the Akkar Plain is clearly a viable undertaking. That evaluation, however, does not directly disclose the timing and magnitude of funds required to construct and operate the project works. The discussion of these subjects in this chapter is predicated on a number of assumptions regarding sources of funds, interest rates, repayment periods, water charges and related items. For this reason, the results of the financial analysis are only intended to illustrate a rational approach to financing of the irrigation development, it being recognized that governmental policies and decisions that may be made from time to time or alterations of some of the assumptions regarding funding will modify the results accordingly.

CRITERIA

At present, SARG does not have a repayment policy which would apply to the Akkar Plain Project and it was necessary to make some assumptions based on knowledge of financing of other irrigation projects. In many other cases, revenue has not been adequate to cover expenditures, and much of the repayment of project costs has been borne by allocations from the national budget. This is not an unusual, nor intolerable, situation for irrigation projects anywhere, and particularly those which are undertaken in underdeveloped areas. Commonly, the preproject economic base is so low that most of the direct benefits of development are absorbed in the process of elevating the economy to a tolerable level. Even under these conditions--in fact, especially under these conditions--the project pays out, but a part of the revenues are derived from indirect and intangible benefits--chiefly tax revenues and reduced welfare and subsidy payments, rather than from direct levies on the cultivator.

With respect to the Akkar Plain Project, it is clear from a qualitative appraisal of the potential payment capacity of the irrigators compared to the capital and annual costs given in Chapter VI that such costs could never be fully recovered by levies against the direct benefits realized by the individual farmers. It follows that the financial analysis of the project must include provisions for the allocations of funds from other sources to meet the deficits. To provide an estimate of the magnitude and timing of these deficits, financial analyses have been made for both the Phase I development and the Phase I and Phase II development. The criteria employed in the formulation of the financial analyses follow.

Costs

Cash flows for all categories of project costs are developed from the appropriate tables in Chapter VI. The cost of the Agricultural Service Center and its estimated operation and maintenance costs are included in Phase I as project costs. The capital cost of the remainder of the infrastructure facilities are shown in the Phase II costs. However, in the financial analysis it is assumed that these facilities, including the farm-to-market roads, will be constructed and maintained by other government agencies and are not included in the project costs. All operation, maintenance and replacement costs are considered to be incurred in local currency, although it is recognized that some of the replacement costs of pumping equipment and wells would be incurred in foreign exchange.

Financing

The local currency requirements would be provided by SARG grants which are free of interest or other financial charges. Foreign currency requirements would be provided by loans from international lending institutions. The loans would carry interest inclusive of all financial charges at the rate of 7 percent per annum from time of disbursement. For purposes of determining carrying charges, it is assumed that all disbursements are made at midyear. Repayment will be deferred until the third year following the final year of disbursemont, after which the proceeds of the loan plus accrued interest will be amortized over a period of 30 years.

Revenues

It is assumed that no irrigation charges will be levied as a result of the construction of the channel improvement and drainage system of Phase I. Irrigation charges will be made as a result of the construction of surface and groundwater facilities of Phase II. Levies against irrigators will be deferred through the initial development period until the eighth year of the project. The water charges to be levied are based on the payment capacity of the irrigators in the amount of 25 percent of the project's payment capacity. No differentiation has been made between irrigators using surface water and groundwater supplies. The analysis assumes that irrigation revenues are assigned first to defray annual costs of operation, maintenance and replacement, with any residual in revenues being used to repay foreign currency debt charges and local currency capital expenditures.

ANALYSIS

Table VIII-1 presents the flow of costs for Phase I; Table VIII-2, the flow of costs for Phase II, Stage 1; Table VIII-3, the flow of costs for Phase II, Stage 2; and Table VIII-4, the flow of costs for Phase I and Phase II. These Tables show the cost requirements in local currency and foreign currency and are summarized on page VIII-8. The costs include the capital costs of all project works and all infrastructure works, the operation, maintenance and replacement costs of all project works and the operation and maintenance costs of the Agricultural Service Center.

Table VIII-1
Phase I - Local and Foreign Currency Requirements

Year	Channel Improvement and Drainage System Costs				Infrastructure Costs(1)				Total Costs	
	Capital Costs		O & M Costs(2)		Capital Costs		O & M Costs(2)			
	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)
1	4,215	378	-	0	767	117	-	0	4,982	495
2	4,215	377	-		0	0	274		4,489	377
3	0	0	25						299	0
4										
5										
6										
53										
54	0	0	25	0	0	0	274	0	299	0
Total	8,430	755	1,300	0	767	117	14,522	0	25,019	872

Total Cost - Local + Foreign expressed in:					
(SP x 10^3)	11,376	1,300	1,223	14,522	28,421
(U.S. $ x 10^3)	2,917	333	314	3,723	7,287

(1) Infrastructure cost includes only capital cost and operation and maintenance cost of Agricultural Service Center
(2) Operation and maintenance costs

Table VIII-2
Phase II, Stage 1 - Local and Foreign Currency Requirements

Year	Surface Irrigation System Costs				Infrastructure Costs(1)				Total Costs	
	Capital Costs		O & M Costs(2)		Capital Costs		O & M Costs(2)(3)			
	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)
1	38,088	7,984	-	0	6,641	283	0	0	44,729	8,267
2	38,087	7,984	-		6,640	282			44,727	8,266
3	38,088	7,984	-		6,640	282			44,728	8,266
4	38,087	7,984	-		6,640	282			44,727	8,266
5	0	0	1,248		0	0			1,248	0
6										
53										
54	0	0	1,248	0	0	0	0	0	1,248	0
Total	152,350	31,936	62,400	0	26,561	1,129	0	0	241,311	33,065

Total Cost - Local + Foreign expressed in:					
(SP x 10^3)	276,900	62,400	30,964	0	370,264
(U.S. $ x 10^3)	71,000	16,000	7,939	0	94,939

(1) Capital Costs of infrastructure include all costs shown on Table VI-4 except Agricultural Service Center
(2) Operation and maintenance costs
(3) O & M costs not considered project costs

Table VIII-3
Phase II, Stage 2 - Local and Foreign Currency Requirements

Year	Groundwater Irrigation System Costs				Infrastructure Costs(1)				Total Costs	
	Capital Costs		O, M & R Costs(2)		Capital Costs		O & M Costs			
	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)
1	-	-	-	0	0	0	0	0	-	-
2	-	-	-						-	-
3	1,492	1,531	-						1,492	1,531
4	1,492	1,531	-						1,492	1,531
5	1,536	1,579	-						1,536	1,579
6	0	0	2,867						2,867	0
18			2,867						2,867	
19			6,627						6,627	
20			2,867						2,867	
33			2,867						2,867	
34			22,117						22,117	
35			2,867						2,867	
53										
54	0	0	2,867	0	0	0	0	0	2,867	0
Total	4,520	4,641	163,493	0	0	0	0	0	168,013	4,641

Total Cost - Local + Foreign expressed in:					
(SP x 10^3)	22,620	163,493	0	0	186,113
(U.S. $ x 10^3)	5,800	41,921	0	0	47,721

(1) No infrastructure costs in Phase II, Stage 2
(2) Operation, maintenance and replacement costs

Table VIII-4
Phases I and II - Local and Foreign Currency Requirements

Year	Project Works Costs(1)				Infrastructure Costs(2)				Total Costs	
	Capital Costs		O, M & R Costs(3)		Capital Costs		O & M Costs(4)			
	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)	Local (SP x 10^3)	Foreign (U.S. $ x 10^3)
1	42,303	8,362	-	0	7,408	400	-	0	49,711	8,762
2	42,302	8,361	-		6,640	282	274		49,216	8,643
3	39,580	9,515	25		6,640	282			46,519	9,797
4	39,579	9,515	25		6,640	282			46,519	9,797
5	1,536	1,579	1,273		0	0			3,083	1,579
6	0	0	4,140						4,414	0
18			4,140						4,414	
19			7,900						8,174	
20			4,140						4,414	
33			4,140						4,414	
34			23,390						23,664	
35			4,140						4,414	
53										
54	0	0	4,140	0	0	0	274	0	4,414	0
Total	165,300	37,332	227,193	0	27,328	1,246	14,522	0	434,343	38,578

Total Cost - Local + Foreign expressed in:					
(SP x 10^3)	310,896	227,193	32,187	14,522	584,798
(U.S. $ x 10^3)	79,717	58,254	8,253	3,723	149,947

(1) For Project Works, see Tables VIII-1, VIII-2 and VIII-3
(2) For Infrastructure, see Tables VIII-1 and VIII-2
(3) Operation, maintenance and replacement costs
(4) Operation and maintenance costs

Item	Phase I	Phase II, Stage 1	Phase II, Stage 2	Phase I and Phase II
Project Works				
Capital Costs				
Local (SP x 10^3)	8,430	152,350	4,520	165,300
Foreign (U.S. $ x 10^3)	755	31,936	4,641	37,332
O, M and Replacement Costs				
Local (SP x 10^3)	1,300	62,400	163,493	227,193
Foreign (U.S. $ x 10^3)	0	0	0	0
Infrastructure				
Capital Costs				
Local (SP x 10^3)	767	26,561	0	27,328
Foreign (U.S. $ x 10^3)	117	1,129	0	1,246
O and M Costs				
Local (SP x 10^3)	14,522	0	0	14,522
Foreign (U.S. $ x 10^3)	0	0	0	0
Total Cost				
Expressed in:				
(SP x 10^3)	28,421	370,264	186,115	584,798
(U.S. $ x 10^3)	7,287	94,939	47,721	149,947

The annual payment capacity of the irrigated area, as discussed in Chapter V, is estimated to be SP 53,063,000. For the financial analysis it is assumed that 25 percent of this amount, SP 13,266,000, is returned to the project as water charges. This amount, when applied to the gross irrigated farm area of 11,670 hectares, is equivalent to an annual water charge of SP 1137 per hectare.

Table VIII-5 presents the flow of costs and revenues for the Phase I development over a period of 54 years. As there are no irrigation revenues in Phase I, the entire flow of costs is a deficit. As shown in Column (10), the total deficit including debt service charges on foreign currency loans is SP 35,159,000 or an average annual amount of SP 651,000.

Table VIII-6 presents the flow of costs and revenues for the complete development plan (Phase I and Phase II) over a period of 54 years. Revenues derived from the water charges are indicated in Column (6). Column (7) shows the amounts available for repayment of capital expenditures, including interest on foreign currency loans after payment of the recurring costs of operation, maintenance and replacement. Debt service charges on foreign currency loans are shown in

Table VIII-5
Financial Analysis
Phase I
(All values in SP x 10^3)

Project Year	Capital Expenditures			O & M	Irrigation Revenues		Foreign Currency Loans		Surplus or (Deficit)
	Local	Foreign	Total	Local	Gross	Net	Disbursements	Debt Service	
			(2) + (3)			(6) -(5)			(7) + (8) -(4) -(9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	4,982	1,931	6,913	0	0	0	1,931	0	(4,982)
2	4,215	1,471	5,686	274	0	-274	1,471	0	(4,489)
3	0	0	0	299	0	-299	0	0	(299)
4	0	0	0	299	0	-299	0	0	(299)
5	0	0	0	299	0	-299	0	338	(637)
6	0	0	0	299	0	-299	0	338	(637)
7	0	0	0	299	0	-299	0	338	(637)
8	0	0	0	299	0	-299	0	338	(637)
9	0	0	0	299	0	-299	0	338	(637)
10	0	0	0	299	0	-299	0	338	(637)
11	0	0	0	299	0	-299	0	338	(637)
12	0	0	0	299	0	-299	0	338	(637)
13	0	0	0	299	0	-299	0	338	(637)
14	0	0	0	299	0	-299	0	338	(637)
15	0	0	0	299	0	-299	0	338	(637)
16	0	0	0	299	0	-299	0	338	(637)
17	0	0	0	299	0	-299	0	338	(637)
18	0	0	0	299	0	-299	0	338	(637)
19	0	0	0	299	0	-299	0	338	(637)
20	0	0	0	299	0	-299	0	338	(637)
21	0	0	0	299	0	-299	0	338	(637)
22	0	0	0	299	0	-299	0	338	(637)
23	0	0	0	299	0	-299	0	338	(637)
24	0	0	0	299	0	-299	0	338	(637)
25	0	0	0	299	0	-299	0	338	(637)
26	0	0	0	299	0	-299	0	338	(637)
27	0	0	0	299	0	-299	0	338	(637)
28	0	0	0	299	0	-299	0	338	(637)
29	0	0	0	299	0	-299	0	338	(637)
30	0	0	0	299	0	-299	0	338	(637)
31	0	0	0	299	0	-299	0	338	(637)
32	0	0	0	299	0	-299	0	338	(637)
33	0	0	0	299	0	-299	0	338	(637)
34	0	0	0	299	0	-299	0	338	(637)
35	0	0	0	299	0	-299	0	0	(299)
36	0	0	0	299	0	-299	0	0	(299)
37	0	0	0	299	0	-299	0	0	(299)
38	0	0	0	299	0	-299	0	0	(299)
39	0	0	0	299	0	-299	0	0	(299)
40	0	0	0	299	0	-299	0	0	(299)
41	0	0	0	299	0	-299	0	0	(299)
42	0	0	0	299	0	-299	0	0	(299)
43	0	0	0	299	0	-299	0	0	(299)
44	0	0	0	299	0	-299	0	0	(299)
45	0	0	0	299	0	-299	0	0	(299)
46	0	0	0	299	0	-299	0	0	(299)
47	0	0	0	299	0	-299	0	0	(299)
48	0	0	0	299	0	-299	0	0	(299)
49	0	0	0	299	0	-299	0	0	(299)
50	0	0	0	299	0	-299	0	0	(299)
51	0	0	0	299	0	-299	0	0	(299)
52	0	0	0	299	0	-299	0	0	(299)
53	0	0	0	299	0	-299	0	0	(299)
54	0	0	0	299	0	-299	0	0	(299)
Total	9,197	3,402	12,599	15,822	0	-15,822	3,402	10,140	(35,159)

Table VIII-6
Financial Analysis
Phase I and Phase II
(All values in SP x 10^3)

Project Year	Capital Expenditures			O & M and Replac.	Irrigation Revenues		Foreign Currency Loans		Surplus or (Deficit)
	Local	Foreign	Total	Local	Gross	Net	Disbursements	Debt Service	
			(2) + (3)			(6) - (5)			(7) + (8) -(4) -(9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	43,070	33,068	76,138	0	0	0	33,068	0	(43,070)
2	42,302	32,608	74,910	274	0	-274	32,608	0	(42,576)
3	39,580	37,109	76,689	299	0	-299	37,109	0	(39,879)
4	39,579	37,109	76,688	299	0	-299	37,109	0	(39,878)
5	1,536	6,158	7,694	1,547	0	-1,547	6,158	0	(3,083)
6	0	0	0	4,414	0	-4,414	0	0	(4,414)
7	0	0	0	4,414	0	-4,414	0	0	(4,414)
8	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
9	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
10	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
11	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
12	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
13	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
14	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
15	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
16	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
17	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
18	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
19	0	0	0	8,174	13,266	5,092	0	16,391	(11,299)
20	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
21	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
22	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
23	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
24	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
25	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
26	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
27	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
28	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
29	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
30	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
31	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
32	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
33	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
34	0	0	0	23,664	13,266	-10,398	0	16,391	(26,789)
35	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
36	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
37	0	0	0	4,414	13,266	8,852	0	16,391	(7,539)
38	0	0	0	4,414	13,266	8,852	0	0	8,852
39	0	0	0	4,414	13,266	8,852	0	0	8,852
40	0	0	0	4,414	13,266	8,852	0	0	8,852
41	0	0	0	4,414	13,266	8,852	0	0	8,852
42	0	0	0	4,414	13,266	8,852	0	0	8,852
43	0	0	0	4,414	13,266	8,852	0	0	8,852
44	0	0	0	4,414	13,266	8,852	0	0	8,852
45	0	0	0	4,414	13,266	8,852	0	0	8,852
46	0	0	0	4,414	13,266	8,852	0	0	8,852
47	0	0	0	4,414	13,266	8,852	0	0	8,852
48	0	0	0	4,414	13,266	8,852	0	0	8,852
49	0	0	0	4,414	13,266	8,852	0	0	8,852
50	0	0	0	4,414	13,266	8,852	0	0	8,852
51	0	0	0	4,414	13,266	8,852	0	0	8,852
52	0	0	0	4,414	13,266	8,852	0	0	8,852
53	0	0	0	4,414	13,266	8,852	0	0	8,852
54	0	0	0	4,414	13,266	8,852	0	0	8,852
Total	166,067	146,052	312,119	241,715	623,502	381,787	146,052	491,730	(276,010)

Column (9). Column (10) indicates the annual surplus or deficit in the project accounts. The project is expected to show a surplus in the annual balance of payments in Project Year 38 after all foreign loans are repaid. The cumulative deficit over the 54-year period of analysis amounts to SP 276,010,000 (Column (10)). To eliminate this deficit, an increase of the water charge from SP 1137 per hectare to almost SP 1640 per hectare would be required beginning with Project Year 8. However, to project such an increase would be unrealistic in view of present water charge policy in Syria. Furthermore, it would be viewed as unrealistically high in highly developed agricultural areas, as for example in the United States.

The cumulative net irrigation revenue; i.e., the gross revenue less the costs of operation, maintenance and replacements, shown in Column (7) is SP 381,787,000. This amount is larger than the cumulative capital expenditures of SP 312,119,000 shown in Column (4). It therefore is seen that the projected irrigation revenues could repay all capital costs, all costs of operation, maintenance and replacement and have a surplus of SP 69,668,000 to be applied to the interest on the foreign currency loan.

The cumulative deficit over the 54-year period of analysis of SP 276,010,000 amounting to an average annual deficit of SP 5.1 million (U.S. $ 1.3 million) is manageable. The Government could assume the deficit as a general public obligation which is recovered from the indirect benefits of the project. As discussed in Chapter VII, the indirect benefits of the project are estimated to be SP 75 million per year.

The financial analysis shown in this Chapter demonstrates one rational and feasible approach to the financing of the project. Water charges to the farmers are reasonable and realistic. The ultimate deficit which is to be borne by the Government will be more than recovered from the indirect benefits of the project. It is concluded, therefore, that the irrigation development is financially feasible.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

Although no unusual risks, nor particularly difficult or hazardous problems, are involved in constructing the project works of the Akkar Plain Project, it is nevertheless a major undertaking for the Syrian Arab Republic Government. The conclusions expressed herein are based, in part, on the following assumptions:

1. Further investigations will confirm that a suitable storage site is available on the Abrache River for the storage of approximately 77 million cubic meters of water at a construction cost of approximately U.S. $ 53 million or less.
2. Further investigations of the groundwater resources will confirm that supplies are adequate to irrigate approximately 4,970 hectares by groundwater supplies.

The Development Plan, including the above assumptions, is feasible and is the only means of transforming a subsistence agricultural area into an important productive agricultural area.

FEASIBILITY

Technical Feasibility

The various works of the Development Plan present no unusual or difficult construction problems. The supplies, materials, equipment, manpower and technical knowledge required for the construction of the project are presently available in Syria or are readily available in the world market.

Economic Feasibility

Irrigation of the Akkar Plain clearly is feasible by the economic standards commonly applied to projects of this nature and magnitude, and according to the

criteria which have been adopted in evaluating the direct benefits of the project. In the latter connection, it should be emphasized that, although the projected yields of irrigated crops are high by local standards, they have already been exceeded in developed areas of the world; and they are not unreasonable according to contemporary experience of developing areas where Government has taken an active and effective role in promoting irrigation development.

The values of the economic parameters derived from the evaluation studies described in Chapter VII are favorable for projects of this kind. Accepting these values, the project must be rated as a potentially profitable enterprise and one that is worthy of careful consideration in the long-range program of development of agriculture in Syria.

The above relates economic feasibility only to direct project benefits. According to the projections given in Chapter VII, indirect benefits will exceed the direct benefits at full development by a ratio of 1.4:1. As only the infrastructure costs are charged against the indirect benefits, the balance is a credit to the general economy of Syria. Indirect benefits are difficult to quantify; but if the above concepts are accepted in principle, the irrigation of the Akkar Plain is unquestionably an economically feasible undertaking.

In addition to the direct and indirect benefits which can be quantified, intangible benefits which cannot be expressed in monetary terms will flow with the project. These benefits, consisting of greater economic stability, increased vocational skills, better health conditions and increased job opportunities for the young people of Akkar Plain, will greatly enhance the well-being of the entire population of the region.

Financial Feasibility

As shown in Chapter VIII, the properly allocable capital and annual costs of irrigation cannot be recovered in a reasonable period of payout by levies against the direct benefits of development which are realized by the individual cultivators. This is not an uncommon forecast for a large-scale irrigation project which involves

major storage works to serve broad areas of undeveloped land. It applies to virtually all of the irrigation developments which have been constructed in the Western United States under the program of the U.S. Bureau of Reclamation. This, despite the fact that these projects collectively are considered as world standards for government-sponsored irrigation development, and individually they are favored with very generous repayment terms compared to those postulated for the Akkar Plain Project.

In any event, as shown in Chapter VIII, direct revenues from irrigation can pay all annual costs of irrigation and also make a substantial contribution toward the capital costs of the project works. The remaining deficits in revenues to repay the costs of the project works would be accounted for by appropriations from general tax revenues which, in effect, are drafts on the secondary benefits of development. This method of financing is realistic in the sense that it recognizes that the primary beneficiary of successful irrigation development is the general economy, and a portion of the direct costs of project development should properly be borne by revenues derived from indirect benefits which accrue to the economy.

From the foregoing it may be concluded that the project is financially feasible from the standpoint of repayment of capital costs and the payment of annual costs.

IMPACT ON THE ECONOMY

Change in Per Capita Income

Under present conditions, the estimated cash income per farm household on the Akkar Plain is SP 741. The disposable cash income, which includes a return to the farm from interest on fixed assets, is SP 5,000 or 515 pounds per capita. With the project, this disposable income would increase to SP 39,000 per household or a per capita disposable cash income of SP 3,980.

This substantial increase in the disposable income of the farmers on the Akkar Plain is due to fully utilizing the existing resources. The estimated farm area of 11,670 hectares under the command of the surface water and groundwater irrigation systems will be irrigated with a 100 percent supply. Of this area, 50 percent will be

intensely double-cropped with high yield vegetables and 50 percent double-cropped with other field crops.

The cropping pattern will not change significantly and no new crops will be introduced. The emphasis is placed on full water requirement irrigation, improved cultural practices, and generally intensifying the agriculture.

Increase in Products Produced and Impact on Imports

Table IX-1 compares the project production and value of production for the future-without-project and future-with-project. The net annual increase in the value of production as shown in Column (12) is U.S. $ 44,854,636 (SP 174,933,000). The net increase in feed grain production consisting of wheat, sorghum and grain corn is 31,850 tons (Column (11)), having a value of U.S. $ 4,627,608 (SP 18,048,000), which would decrease the requirement of importing this amount of these commodities. The value of the net increase in vegetable production is U.S. $ 37,865,619 (SP 147,676,000) as shown in Column (12). It is estimated that 40 percent of the increase in vegetable production could be exported, which would improve SARG's balance of payments of foreign trade.

The increase in agricultural production, along with the increase of disposable income on the Akkar Plain, will have a significant economic impact on the financial position of the Syrian Arab Republic. This impact will not only be felt in the immediate production area of the Akkar Plain, but will be noted throughout Syria and other parts of the Middle East.

INFRASTRUCTURE REQUIREMENTS

To fully realize the benefits of the agricultural development of the Akkar Plain, it is essential that the infrastructure facilities of the Project Area be enlarged and improved. These essential facilities include:

1. Agricultural Service Center--To provide technical guidance and agricultural research.

Table IX-1
Projected Crop Production on the Akkar Plain

Crop	Unit Price	Future-Without-Project (17,179 ha)		Future-With-Project: Drainage (5,055 ha)		Future-With-Project: Surface and Groundwater Irrigation (11,670 ha)		Future-With-Project: Total		Net Increase	
	(U.S. $/ton)	Production (tons)	Total Value (U.S. $)	Production (tons)	Total Value (U.S. $)	Production (tons)	Total Value (U.S. $)	Production (5) + (7) (tons)	Total Value (6) + (8) (U.S. $)	Production (9) - (3) (tons)	Total Value (10) - (4) (U.S. $)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Feed Grains											
Wheat	155.76	7,748	1,206,828	2,709	421,954	26,048	4,057,236	28,757	4,479,190	21,009	3,272,362
Sorghum	123.11	2,165	266,533	785	96,641	3,260	401,339	4,045	497,980	1,880	231,447
Maize (grain)	125.41	-	-	-	-	8,961	1,123,799	8,961	1,123,799	8,961	1,123,799
Subtotal - Feed Grains		9,913	1,473,361	3,494	518,595	38,269	5,582,374	41,763	6,100,969	31,850	4,627,608
Groundnuts											
Peanuts	400.00	4,838	1,935,200	1,550	620,000	-	-	1,550	620,000	(3,288)	(1,315,200)
Vegetables(1)	105.13	87,172	9,164,392	27,976	2,941,117	419,375	44,088,894	447,351	47,030,011	360,179	37,865,619
Dry Beans	194.87	-(2)	-	-(2)	-	13,384	2,608,140	13,384	2,608,140	13,384	2,608,140
Vetch	44.00	-	-	-	-	10,409	457,996	10,409	457,996	10,409	457,996
Maize (table)	177.00	-(2)	-	-(2)	-	3,449	610,473	3,449	610,473	3,449	610,473
Total			12,572,953		4,079,712		53,347,877		57,427,589		44,854,636
											(SP 174,933,000)

(1) Vegetables include:
tomatoes, eggplant, cucumbers, squash, melons, etc.
(2) Included with vegetables

2. Farm-to-Market Roads--To improve existing roads and to construct new roads required for transporting products to market and for access to educational and other facilities.

3. Educational Facilities--To upgrade existing schools and to construct new facilities to improve the standard of the school system.

4. Health Care Center--To provide improved health facilities and care and thus increase the productivity of farm management and labor.

5. Dairy--To utilize production from Land Capability Class IV and improve the general diet of the people in the Project Area.

6. Processing Plants--To process food, dairy products and livestock and thus obtain maximum return from products produced in the Project Area.

7. Grading and Packing Facilities--To provide uniform grading and better packing of project products and thus improve their price structure.

8. Small Grain Storage--To provide storage for the volume of small grains which will exceed the capacity of the on-farm storage.

INTERNATIONAL IMPLICATIONS

Under the Development Plan, the quantity and quality of the Janoubi River, which in its lower reaches is the boundary between Syria and Lebanon, will be altered by:

1. Diverting much of the flow of the Arouse River into the Abrache River Basin.

2. Channel improvement of the lower Janoubi River.

3. Increased return flow from the project lands.

The Arouse River would be diverted at Berge Arab into the Abrache River Basin, which would essentially dry up the stream at that point during periods of low flow. However, several spring-fed accretions to the stream occur below the point of diversion and these are expected to increase under project operations as a result of return flow from project lands.

The Janoubi River Channel Improvement will change significantly the hydraulic properties of the channel. The 10-year frequency flood flows will be contained in the improved channel and thus reduce the flood hazards to bordering

lands in Lebanon and Syria. Some productive land will be lost on both sides of the river to provide for the required berms and spoil banks. Trees and brush would be removed from both sides of the river to improve the channel hydraulics which would decrease the natural habitat for fish and wildlife. Until the river banks can be stabilized with appropriate grasses, the sediment load of the stream will increase and will be deposited at the Janoubi River estuary. However, the sea is very rough during the stormy periods and very little local sedimentation is expected. The construction of the Janoubi River Channel Improvement works will require the approval of the Government of Lebanon.

Under the Development Plan, the dry season flows of the Janoubi River will be increased substantially as a result of return flow from project lands. These return flows are expected to contain additional contamination than the existing water as a result of the increased use of fertilizers, herbicides and pesticides on project lands. This should not create any significant problem in the lower reaches of the Janoubi River. It is anticipated that there will be increased algae growth in the Janoubi River estuary due to the increased nitrogen in the water resulting from the expanded use of nitrogen fertilizer.

RECOMMENDATIONS

Akkar Plain Authority

An Akkar Plain Authority should be established to oversee the development as soon as the decision is made to implement the project. The complete development scheme affects most of the people of Syria, either as recipients of benefits or as a result of the monetary commitment of SARG to finance the construction. Therefore, it is recommended that an authority or directorate be established directly under the Minister of Agriculture that would be responsible for the utilization of funds and the implementation of the plan. The utilization of the Ministry of Agriculture is considered essential since the plan is to develop the agricultural resources and all designs, scheduling, and plans should be reviewed and approved by those familiar with agricultural practices and agricultural development in the entire country.

Additional Studies

The various field investigations and office studies which were made in the course of preparation of this Report have established the feasibility of the irrigation development from the standpoints of all technical and economic considerations except to confirm the availability of storage on the Abrache River and to quantify the groundwater movement under the Akkar Plain. These studies must be completed before Phase II of the Development Plan can be implemented.

Rihaniyeh Damsite Investigations: A study must be undertaken to verify the economic feasibility of the Rihaniyeh Dam and Reservoir. The study should determine the most feasible location of the dam which could be located as much as 2 kilometers upstream of the proposed site. The investigation should include the drilling of exploration holes at the dam axis and reservoir area to determine the properties of the foundation materials. From this information it will be possible to prepare preliminary designs of the works required to reduce seepage at the dam, at the brim of the reservoir or in the reservoir. The investigations should also include an inventory of construction materials including earth, gravel and rock which would be required for the construction of the proposed earth-rockfill dam and its concrete spillway and appurtenant structures. A detailed cost estimate should then be made and the estimated costs resulting from the study should be compared with the costs used in this Report to evaluate the economic feasibility of the storage site.

Groundwater Investigations: The groundwater information presently available is not adequate to quantify the groundwater resource, and thus it is not possible to specify the works required for full development of the resource. A program of 10-12 exploratory wells 300-400 meters in depth properly distributed across the Akkar Plain is required to obtain the necessary information about the aquifers. After the borehole has been carefully logged, a pumping test should be performed to obtain the characteristics of the aquifers and the specific capacity of the well. Pumping tests should also be conducted at existing drilled wells to determine the actual specific capacity of the well. Following the completion of the tests, the well owners should be furnished with recommendations which would fully develop the potential of the well.

Topographic Surveys: Topography of the Akkar Plain is available with a 5-meter contour interval and scale of 1:25,000, which is not adequate for laying out an irrigation system. The area which includes the project works should be mapped at a scale of 1:5,000 with a contour interval of one meter in the plain area and two meters in the relatively rugged and broken terrain of the bordering areas. This work can be carried out most expeditiously and economically by aerial photogrammetric mapping methods. Alignment and profile surveys of all of the main conveyance canals and drains would also be made. In addition, the sites of dams and major structures should be mapped at a scale of 1:1,000 and contour interval of one-half meter.

Materials Investigations: Additional field and laboratory studies should be made to make a final selection of the most favorable sites for producing satisfactory concrete aggregates, gravel and riprap.

Hydrologic Studies: The hydrologic studies which have been undertaken to determine all pertinent aspects of the regional hydrology of the area, including climate, runoff and occurrence of groundwater, should be continued and intensified.

IMPLEMENTATION

Implementation of the total Development Plan cannot be carried out until the results of the investigations for the Rihaniyeh Dam and groundwater are fully known. However, the works described in Phase I of the plan; a part of infrastructure works described in Phase II, Stage 1; and a portion of the groundwater development described in Phase II, Stage 2 could be undertaken immediately. Implementation of these works involves firstly the securing of firm financial arrangements for funding the works and the preparation of detailed designs, plans and specifications for the works described.

Janoubi River Channel Improvement

The Janoubi River Channel Improvement should begin immediately with the final design and field studies done during the dry season and construction to follow

immediately. Improvements should be made to both sides of the channel which will require an agreement with the Government of Lebanon. In this work, earth materials would be excavated from the river banks to form the dikes and roads and thus increase the hydraulic capacity of the channel. The required excavating equipment would probably have to be imported; however, skilled equipment operators are presently available in Syria.

Drainage Improvement

The improvement of the surface drainage system on the Akkar Plain should be started concurrently with the Janoubi River Channel Improvement. The work is primarily earthwork and the required excavating equipment would probably have to be imported. Syrian operators are available to operate the equipment. The work also involves some concrete work including a small pumping plant. It is believed that the undertaking of this work is within the capability of the Syrian construction forces.

Agricultural Service Center

The construction of the Agricultural Service Center and its staffing should be undertaken immediately.

Groundwater Development

The improvement and enlargement of the existing wells should be undertaken immediately. Following the groundwater exploration described in the previous section, the plan for the full development of the groundwater resource should be finalized. The drilling of additional wells to develop the full potential should be undertaken as soon as the plan is finalized. As shown in Chapter VII, this part of the Development Plan produces the highest benefit-cost ratio and should be undertaken at the earliest opportunity. The drilling equipment for drilling the deep wells would have to be imported and the operation of the equipment could be accomplished by skilled Syrian workmen. The development and testing of the wells should be performed by a foreign contractor who is experienced in this type of work.

Infrastructure Development

The infrastructure requirements, other than the Agricultural Service Center, are scheduled for Phase II, Stage 1. SARG has already started improving many of the infrastructure items and its efforts should be accelerated and coordinated with the Akkar Plain Authority. The first priority, following the establishment of the Agricultural Service Center, should be the improvement of the existing roads and construction of new roads. The development of schools and health facilities should be developed gradually and in accordance with the overall government policy. Marketing and processing facilities should be provided in accordance with the schedule of increased production of the Akkar Plain.

Surface Water Development

The surface water development is scheduled for Phase II, Stage 1, and would be the last portion of the Development Plan for which construction would be initiated. The final planning, designing and constructing of this work is contingent upon the results of Rihaniyeh Dam investigation described in the previous section.

The construction of the Phase II, Stage 1, work as envisioned in the Development Plan would consist of the construction of an earth-rock dam having a maximum height of 36 meters and a concrete gravity overflow spillway section. This work would require a contractor with experience in earth dam and concrete dam construction and such a contractor is not native to Syria. This work would therefore require a foreign contractor. The surface irrigation system and the Berge Arab diversion system, however, could be constructed by Syrian contractors.