3-3. Present Water Use

3-3-1. Surface Water

The Wadi Al Bassierah system consists of the main stream of about 30 km distant and many tributaries such as the Wadi Abadellah, the Wadi Uyaynah and the Wadi Al Fay. The surface runoff occurring in these wadis has two types; one is the flood discharge that takes place once or twice in winter seasons and flows down to the Oman Gulf, and the other is the base flow observed throughout the year. A limited amount of the base flow is lifted by small engine-driven pumps and drawn by pails from shallow wells provided in the midstream area for irrigating date palm and for domestic water supply. The detailed information on the base flow is not available but the following survey data obtained in July, 1980.

Wadis	Total Catchment Area (sq.km)	Catchment Area Commanded at Survey Point (sq.km)	Base Flow (lit/mn)
Abadellah	48.0	20.0	60.0
Uyaynah	18.0	10.0	60.0
Al Fay	26.0	12.0	130.0
Zanhah	20.0	10.0	70.0

3-3-2. Groundwater

The flooding waters caused from winter rainfalls in the eastern mountain areas of the UAE recharge groundwater in the gravel plain characterizing the area, and have long been retained underground as precious water resources. The water demand has increased in the basin as a small fishing village has developed to be a large town area at the extreme downstream of this basin, which requires much more potable water and irrigation water for an increase in agricultural production to support growing population.

The surface runoff water is, however, too instable to meet the above purposes due to depending only on seasonal floodings and a small amount of the base flow in tributaries. Under the circumstances, many wells have been provided to utilize groundwater. Being shallow by some 10 m depth, these wells are equipped with engine-driven pumps for lifting groundwater. Recently, however, only 10 to 30 minutes' operation of pumps have caused most of these wells to be emptied.

In order to cope with the recent sharp increase in water demand by growing population, three modern tube wells instead of shall wells are operated for potable water supply to Dibba. Furthermore, in the basin, several tube wells have been recently provided for supplying irrigation water of the farm lands. In addition, the marble tile factory and the FAO experimental farm provide their own tube wells for respective purposes, and some mountain villages also have wells for domestic use of inhabitants.

The detailed data on lifted water amount of these wells are not available and the recent field investigation has resulted in the following estimation on the water demand.

Description	Irrigation Water (MCM)	Domestic Water Industrial Water (MCM)	Total (MCM)
UAE	1.34	0.55	1.89
Oman	0.96	0.05	1.01
Total	2.30	0.60	2.90

3-4. Present Agriculture

3-4-1. Present Agriculture and Land Use

(1) Present Agriculture

The agriculture of the eastern UAE is characterized by an extensive dates farming in the gravel plain lying between the mountain area and the coastal area. In the vicinity of Fujeirah, the largest municipality in the downstream of the Wadi Ham, the UAE authorities concerned have operated an experimental station, since 1974, for fruit tree plantation and vegetables growing to result in good harvest. For cultivating in the gravel lands in the station, the surface gravel soils were removed for top soil dressing, and gravel removal has been carried out by common bulldozers now although once by special implements which were found inefficient for the purpose. The nursery beds for fruit trees are prepared by digging gravel soils by about 1.0 m deep for being replaced with clayey soils to retain soil moisture contents.

In the downstream portion of the Wadi Al Bassierah basin, an experimental farm has been operated, since 1979, under the cooperation of FAO. In come other areas of the eastern UAE, similar experimental farms are operated for growing fruit trees, vegetables and seedlings of various crops, and the results obtained have drawn attentions to be applied to agricultural development in future.

Under the situations, the plantation farming is very prosperous not only in the eastern UAE but throughout the country. Generally, a plantation covers some 10 ha with wire net or concrete fences provided, and the surface gravel soils are removed to be replaced with suitable soils for farming. Several wells are dug in the plantation area for irrigation, and a plantation management office as well as a living quarters are built in that area. Furthermore, vinyl-covered green-houses are built for growing vegetables with high

commercial values. The plantations of this type have been developed in the UAE, particularly in the eastern coastal area, and indicate the general direction of the future agriculture development of the country.

(2) Present Land Use

In the Wadi Al Bassierah basin, a strip land extending by 1.0 km x 3.0 km in the downstream of the basin is a main farming area. For the land use of the basin, the downstream area of the basin, being developed from small fishing villages, has the residential area along the coastal line and the farming area as its hinterland.

The housing program worked out recently, however, designs the new housing areas in both the upstream of the existing farming area and the eastern portion of the coastal area. Belonging to private ownership, a greater part of the farm lands are cultivated by alien laborers such as Pakistanis, Indians, etc., and the landowners live in Dibba. The private-owned plantations are fenced with barbed wires or wire-nettings with only one entrance provided, but the entrance closes for most of the day. The present land use surveyed as of September, 1980, is shown as follows;

Farm Land and Wells

Country	Farm Land (ha)	No. of Farm Households	No. of Wells
Oman	210	230	-
UAE *	280	870	750
Total	490	1,100	750

Note: * (1) The farm land of 280 ha is obtained from 90 % of registered farm land of 309 ha.

(2) Detailed information is indicated in Table A.2.3-8 of Appendix.

3-4-2. Crops and Irrigation

(1) Crops

Dates are the main crops grown in the Dibba area in the lower Wadi Al Bassierah basin, and some fruit-trees such as citrus, mango, banana, etc. are grown in the dates plantations. Furthermore, under the shade of date palms, there are about 15 kinds of vegetables grown, such as tomato, cucumber, sweet potato, onion, green pepper, cabbage, egg-plant, etc. In the eastern part of the Country, major crops are grown in the rainy season from September to March, while such crops as water melon, broad bean and sunflower are grown in the summer season. The dates, main crops in the area, are harvested in August. The crop calendar in the eastern area is shown in Table A.4.3-1 in Appendix.

(2) Irrigation

Irrigation for major crops like dates has been carried out by the use of rain waters and the Wadis' flooding waters in the winter season. The rain water is used for recharging the groundwater after being stored temporarily in the farm ponds of the fields as well as for irrigation. Since, however, the rainfalls in the area take place only once or twice in January through February, most of the irrigation water is supplied by the groundwater through pumping-up. The water rights are not firmly established in legal terms and the farmers provide their own artestian wells in their farm fields for irrigation purpose. Recently, the Government has provided the tube-wells (ø12") with individual farms as an aid for farmers. In any case, however, no collective use of the wells have been practised in the Country.

The basin irrigation method has been applied for all fruit-tree plantations, and the sizes of basin are variable with the tree-ages. All basins are linked with small irrigation ditches, and the rotational irrigation by pumped-up water is carried out from comparatively high-elevated basins to lowlying basins. Most of these linking facilities are small concrete lined canals or earth canals.

The furrow irrigation method is mainly applied to the vegetable cultivation, although the basin irrigation is carried out for some vegetable cultivation as well. In the furrow irrigation method, crops are planted on one side of the ridges for salinity prevention, and the ridges are formed rather narrow in width and low in height.

The data of irrigation water requirements in the eastern area are available. According the data irrigation water for the major crops like tomato, cucumber, green papper, etc. is supplied triple or quadruple in actual operation throughout the season. Unexpected water losses may cause excessive water supply to be required due to low irrigation efficiency by poor water holding capacity of gravel or sandy soils, even though the data have some problems in accuracy.

The crop water requirements on major 20 crops are prepared for four areas of the UAE (the centre, the east, the north and the south areas) under the cooperation of FAO. These specific crop water requirements were estimated based on Pan-evaporation method according to area-wise meteorological data covering five to eight years, so as to obtain Reference Crop Evaporation (ETo) and Crop Evapo-transpiration (ET crop) by mm/da/10 days. The estimated ETo was 2,070 mm/year in the north, 2053 in the central, 2552 in the east and 2,414 in the south, respectively. Belonging to the east area of the Country, Dibba indicates about 20 percent higher ETo value than those of the central and the north areas. The ET crop of the respective crops and the actual results of irrigation in the central area are tabulated Table A 2.3-7 of Appendix.

3-4-3. Management of Farms

(1) Seeds, seedlings and Mechanized Farming

The seeds or the seedlings of crops, whose varieties are kept steady in cropping throughout the country, are distributed to the farmers by the respective experimental farms under the Government's subsidies. And the staff concerned with the experimental farms give guidance to the farmers about how to sow or plant.

Farm mechanization has been little employed in the Country because of the small scale of the individual farms and particular farming works for the date plantation, but some newly developed farms, providing furrow irrigation systems, have employed farming machines and equipment for preparatory works in cultivation. In the Dibba area, removing the surface gravel and land leveling are made by machines but further cultivation works by man-power. The MAF has arranged a few tractors for the Dibba office, which are operated in free of charge for various preparatory farming works on request from the farmers, and the farmers use only farming implements such as picks, shovels and iron-bars.

(2) Fertilizers

As for fertilizers, small farms where no vegetables are grown are little fertilized although the Government give a 50 percent subsidy for fertilizers purchased, and ordinary fertilizers used locally are goat dungs, dried anchovies, orange peels, etc. Some imported or domestic organic fertilizers are used in the newly developed farms. Besides the above, the following imported chemical fertilizers are used in some farms; urea (Iraqi-made), 46% nitrogen (Iraqi-made), ammonium sulfate (Iraqi-made) and granular compound fertilizer (NPK: 18 + 18 + 5 + 1.5 Netherlands-made).

(3) Production Management

The vegetable production in 1978 in the east area including Dibba comprises tomato (24%), water melon (18%), green pepper (15%), and others. The major tree-fruits produced are dates, representative tree crop of the country, (77%), lemon (12%) and mango (4%).

In field cropping, tobacco and alfalfa are grown, although very small in production. The distribution of the farm products in the Dibba area, having no specific marketing facilities, has been made directly from the farms to the retailers in Dibba, Khol-Fakkan with products in simple box-packing. On the other hand, the purchasers of the farm products can have direct individual dealing with the farm-owners.

3-5. Fisheries

3-5-1. Oman Coastal Area

In the Oman coastal line about 60 km southward from the Dibba, hilly lands branching-off from the Oman mountain range draw near the Oman Gulf. These mountains and hills develop a number of valleys with wadis which extend to many fan-like gravel plains large or small in size along the coastal line. The coastal line for this part presents a very intricated landscape with sand beaches, rocky coast and some isolated small islands off-shore of the coastal line.

The coastal lands provide fishing villages as well as the plantations with date palms as a main crop. Along this coastal area, the largest city is Fujeirah, the capital of the Fujeirah Emirate, developed by agriculture supported by wadi waters and fisheries, and the second largest Khol-Fakkan, and the third Dibba. There are about 20 large and small villages situated in the area. In these villages, all of the traditional palm-leaves huts were replaced by modern concrete houses in neat with asphalt-paved road networks. Every family enjoys modern life with water supply, electricity, telephone, and television. And many modernized towns and villages have been completely built up in this way and some more are under construction.

The population of this area was estimated in 1978 at 35,000 persons in Fujeirah Emirate to the total population of the country, 877,340 persons, and the current figures may exceed further the figures quoted above. With rapid modernization of the area, the road networks linking with the emirates in the west coast of the UAE have been improved and the old coastal roads with one lane are now under broadening works to asphalt-paved two lanes roads.

3-5-2. Fisheries

Most municipalities along the Oman Gulf coast in Fujeirah Emirate provide fishing ports, although different in size, and a new modern port is being constructed near Fujeirah city. The villages have been still fishing by beach seine net fishing.

The catches at Dibba are sold after checking the quantities and controlling by the MAF's officer. These data are reported to the branch office of the MAF in Khol-Fakkan. The catches at the other ports than Dibba and Khor-Fakkan are directly sold by fishing-net owners to buyers coming from Dubai and other places with ice-boxes.

According to the MAF's statistics on fisheries in 1977, the annual catches at Fujeirah came second biggest by 5,140 ton (8%) and the biggest catches was at Ras Al Khaima by 42,130 ton (65%). The market prices of fish per ton are highest in Dubai by DH 12,380, the second in Fujeirah by DH 4,670 and the third in Ras Al Khaima by DH 1,460, respectively.

3-5-3. Others

Dibba town area located in the extreme north of the UAE facing the Oman Gulf has been developed as fishing village. And in the course of such development, the area has essentially required to develop the agriculture for securing self-sufficiency of vegetables and fruits. As the oil-income has increased sharply, the Dibba area and its vicinity have been rapidly consolidated with various facilities of roads, houses, electricity supply system, water supply system; telephone, etc. In relation to this area development, a few concrete block manufacturing factories have been operated in small scale. On the other hand, the local representative factory is the marble tile factory which supplies the floor tiles and walling marble plate for housing project.

CHAPTER IV. THE PROJECT

4-1. Objectives and Components of the Project

4-1-1. Objectives of the Project

Having contemplated to modernize the agriculture and fisheries in the eastern region facing the Oman Gulf, the Government of the UAE has tackled the water resources development projects as the basis for the program. Among various projects relating to the water resources development, the Wadi Al Bassierah Water Resources Development Project is one of the initial water resources development projects including the Wadi Ham development project in the same district and the Wadi Bih development project in the other area of the UAE. The eastern region of the UAE is situated in the northern piedmont area of the Oman mountain range in the eastern part of the Arabian peninsula.

In the Project Area, the annual mean rainfalls, although some taking place in the rainy season, is as small as about 14 percent of the world average (850 mm/year). The purpose of the Wadi Al Bassierah Basin Development is to establish a long-ranged programme for developing the water resources and agriculture based on highly effective and efficient utilization of precious water in the basin.

(1) Water Resources Development and Management

In the basin a population of about 13,200 lives in the modern concrete houses with facilities of water supply and sewerage and their water consumption per capita has reached about 100 ℓ/day. Further population growth and upgrading of their life-style will inevitably require to increase the amount of water consumption per capita to the level in the urban areas. On the other hand, irrigation water has tended to be supplied from tube wells in replacing the shallow wells so as to secure the stable water supply.

Recently, however, the coastal area has been suffering from brackish water caused by sea water intrusion. Taking into consideration these conditions prevailing in the basin, a proper countermeasure of stable water supply shall be established through the development of water resources locally available and the desalination of the sea water.

(2) Agricultural Development

Under stringent water saving, the total study should be made on agriculture including locally proper crops, soils, irrigation method, etc. Through a series of studies and development plan formulation, a strategy of agricultural production increase shall be pursued. A particular attention should be paid to soil improvement of the farm plots, upgrading of the irrigation facilities by introduction of drip irrigation system, the selection of crops and fruits, and the establishment of collective works for assorting the fruit crops, so that the modernized farming can be carried out in the basin.

4-1-2. Project Components

Potential of the water resources to be developed in the basin has been looked through analyzing data hydrology, groundwater, topography, geology, etc. The alternative studies based on the above analyses will allow a variety of necessary facilities to be designed. In taking into account the amount of the water resources available at present and to be developed under the Project, the phased development plan shall be formulated to cope with demands for domestic use and irrigation use on the basis of a long-term forecast.

(1) Water Resources Development Project

A groundwater recharging dam will be constructed in the middle stream of the main flow of the Wadi Al Bassierah. Furthermore, a

pond, will be constructed in the lower Al Fay basin for recharging groundwater. On the other hand, tube wells will be provided along the champion aquifers in the farming areas, according to the aquifer sounding. In order to meet increasing water demands in domestic use by population growth and irrigation use by modernization of farming, a study on additional sea-water desalination plants well be required, while monitoring wells against sea water intrusion will be provided in the coastal area to take a proper measure for water lift control through water quality check.

(2) Agricultural Development Plan

In order to increase the production of vegetables and fruits through the effective use of groundwater of which development has been planned in the Project, the agricultural development plan has been formulated such as soil improvement, farm plot arrangement and the introduction of a pipeline system for water conveyance and drip irrigation method. Needless to say, the acreage of farm lands to be newly developed under the Project will be restricted by the groundwater quantity to be developed. Under the situations, the three alternative plans have been proposed for farm land development as follows:

Plan 1. Vegetable farms of 75 ha (the largest among the three).

Plan 2. Fruits-three plantation of 60 ha.

Plan 3. The combination of vegetable farms of 30 ha and fruits-tree plantations of 40 ha.

4-2. Water Resources Development Plan

4-2-1. Basic Concept

The major water resources in the Wadi Al Bassierah basin are the groundwater stored by rainfalls (infiltrated into ground) taking place annually by 180 mm on an average and the surface runoff waters in small wadis in the mountain valleys in the upperstream and floodings into the Oman Gulf, occurring once or twice in the Wadi Shimal Basin. These water resources have been utilized as domestic water for inhabitants and irrigation water for growing dates, fruits and vegetables. The basic plan for drastic water resources development in the basin is formulated on the concept of storing ineffective surface runoff and underground flow into the Oman Gulf as well as preventing the sea waters from intrusion to the inland areas. A definite development plan is recommended with elaborate study on alternative plans.

(1) Study on Surface Water Development

To store in the basin the ineffective surface runoff to the Oman Gulf is planned by constructing low dam across the Wadi Al Bassierah and its tributaries according to the results of the runoff analysis for the basin. The dam and other facilities shall cooperate in their functions to successfully develop the water resources in the basin.

(2) Study on Groundwater Exploitation

The gravel plain in the basin extends several tens of square kilometers, and gravel layers and bed rocks have been detected by electric prospecting survey and bore hole drillings. The preventive measures for ineffective groundwater runoff to the Oman Gulf will be detailed in the following paragraph on approach to groundwater development, but the basic concept of the approach is that the surface structures to be constructed shall play a role to recharging groundwater by surface water and to prevent ineffective runoff to the sea.

The sea water intrusion to the inland area will be looked into as a part of water balance computation for the whole basin. As for the method on studying, the existing shallow wells are studied on their operation hours and methods. Proposed observation wells in the coastal area are expected to serve to control and prevent the sea water intrusion. The study employs the hydraulic model for groundwater analysis which consists of the secondary dimension plain unsteady percolation by finite element method. The groundwater movement is assumed to depend upon linking condition of groundwater and application of the results of the Darcy's law, and the estimation of groundwater to be recharged by the surface will be made by giving to every element the percolation amount computed in the above tank model analysis.

(3) Approach to Water Resources Development

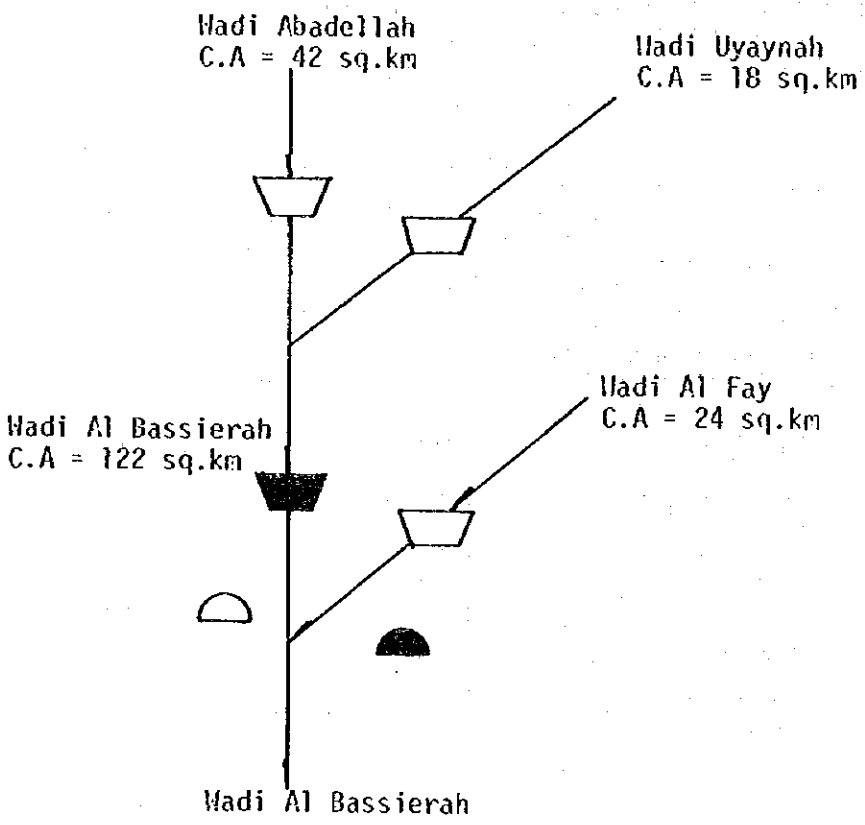
According to the above general concept, the development approach is made from the both viewpoints of surface runoff water and groundwater. Efficient utilization of these water resources requires to construct certain structures across a wadi for storing the water within the Wadi Al Bassierah basin so as to meet the project requirements. The locations of these five proposed facilities are tabulated as follows in arranging from upstream to downstream in the Basin.

Facilities	Wadis	Catchment Area (km^2)	Remarks
Abadellah Dam	Wadi Abadellah	42.0	Low dam
Uyaynah Dam	Wadi Uyaynah	18.0	"
Al Bassierah	Wadi Bassierah	122.0	"
Ghob Dam	Wadi Al Fay	24.0	"
Recharging Facilities	Wadi Al Bassierah (Downstream)		Low dyke

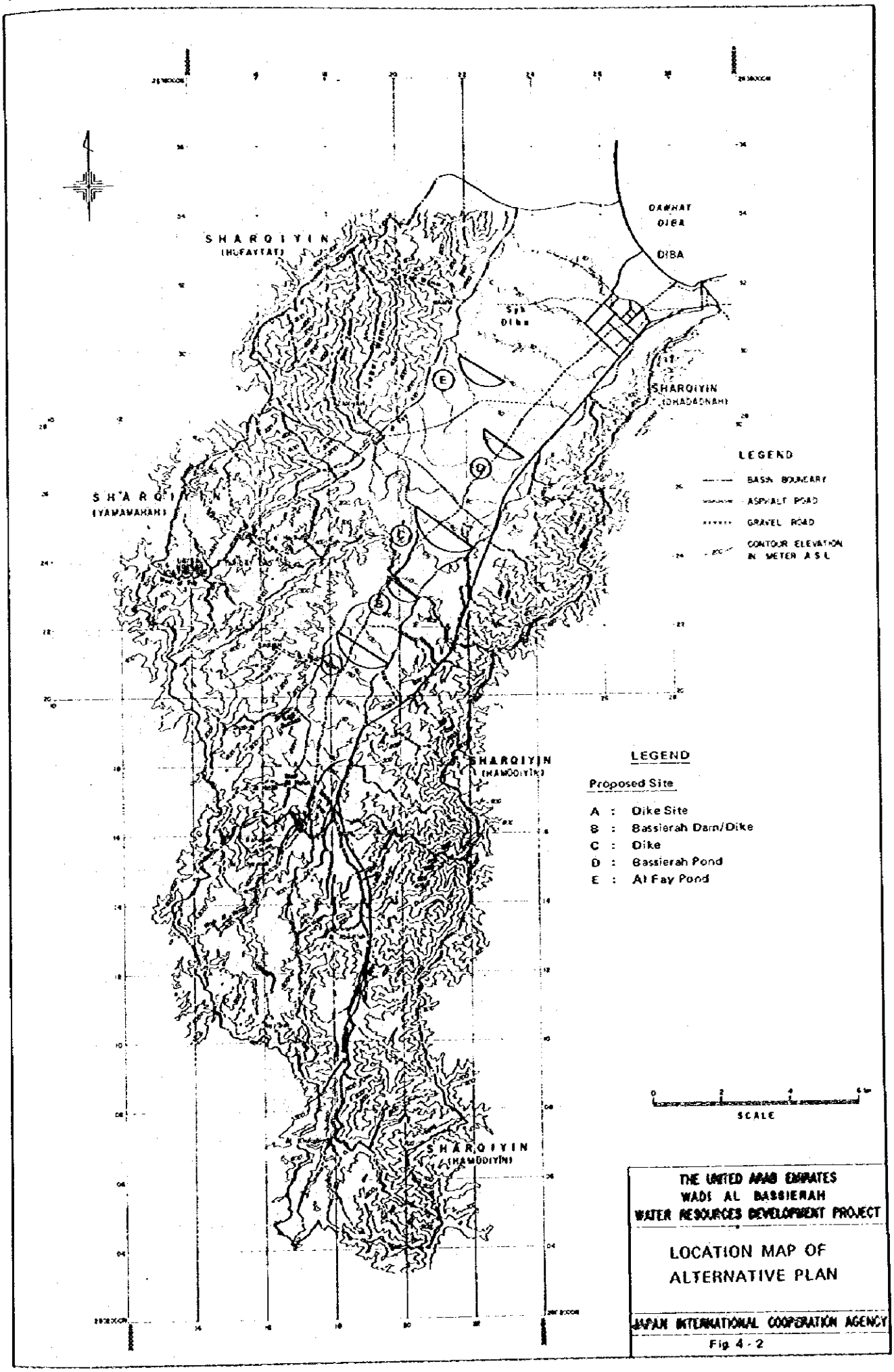
4-2-2. Water Resources Development Plan and Alternatives

Water resources development plans are studied in both terms of surface and groundwater and then, these plans were screened to three alternatives, on which the related construction cost estimation and economic analysis were conducted and boiled down to one recommendable plan. Figure 4-1 indicates the wadi system in the basin which consists of the Wadi Al Bassierah main flow and its major tributaries.

Fig. 4-1 Wadi System in the Basin



Note: C.A = Catchment Area


SHARQIYIN
(HUFAYYAH)
DAWHAT
DIBA
DIBA
SHARQIYIN
(DHADADNAH)
SHARQIYIN
(HAMDDIYIN)
SHARQIYIN
(HAMDDIYIN)
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L
LEGEND
Proposed Site
A : Dike Site
B : Bassierah Dam/Dike
C : Dike
D : Bassierah Pond
E : Al Fay Pond
SCALE
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
LOCATION MAP OF
ALTERNATIVE PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY
Fig 4 - 2

(1) Plan - A

This plan will provide two low dams across the Wadis of Abadellah and Uyaynah in the Wadi Al Bassierah basin. On the other hand, the surface runoff collected from the fields downstream of the dams is expected to naturally recharge groundwater in the gravel plain. The capacity of these dams is restricted to be about 1.0 MCM by the topographic conditions of the dam sites, which is equivalent to the runoff discharge with a probability of once a five-year period. The capacity of three facilities and dam type are shown below:

Wadis	Dam Type	Catchment Area (km^2)	Capacity (MCM)
Abadellah	Disperse	42.0	1.3
Uyaynah	Rock-fill type dam	18.0	0.5
Al Fay	Disperse	24.0	0.7

This plan will require nearly DH 9.3 million of construction of the necessary facilities, and the cost per 1.0 m^3 of the capacity was estimated at DH 3.7. The plan, however, is not deemed so favourable in taking into account the fact that the facilities for groundwater recharging would function to exert an adversely effect to the whole catchment area, which was revealed from the hydrological analysis for 21 years to decrease in the rechargeable amount by 0.2 MCM on an annual average.

(2) Plan B and C: Physical Plan for the Main Stream of the Wadi Al Bassierah

The Plan B contemplates to provide the necessary facilities across the main stream of the Wadi Al Bassierah in its mid-basin, while Plan C will provide the additional groundwater recharging facilities to those contemplated in Plan B so as to establish the more effective water resources development plan. As for Plan C, 12 alternative plans were thoroughly studied from the viewpoint of increase in rechargeable amount and economy of the facilities.

The evaluation of groundwater augment by a storage type of facility is made through simulations by the storage model. The modelling of storage facility in the simulation is carried out adding the storage depth which is equivalent to storage capacity of facility onto the existing depth of the top tank of subbasin where the facility is built in. When a conduit is installed into the storage facility, an orifice with the same coefficient as the conduit is set up to the existing lowest runoff orifice of the top tank.

Taking into consideration about the effect of sedimentation on the storage basin, the coefficient of infiltration orifice of the top tank is deducted to 15% lesser than the original one.

The recharge facility on the gravel plain can be proposed so as to make direct recharge of from the facility by means of temporary storage. The gravel plain in the Basin can be devided into the upper, the lower left bank and the lower right bank. The surface runoff on those three plains at present are 1.3 MCM/a each on an average. To lead the above runoffs into the ground, various facilities with different capacities can be proposed at the said subbasins.

Supposing compinations of facilities in various capacities, 12 cases of simulation were conducted employing the storage model. The results of simulation are concluded in Table A.4.2-1.

An appropriate dam site has been pointed out at the midstream of Wadi Al Bassierah proper, 12 km upstream from the sea coast. The proposed dam site is about one km wide with the bedrock outcrops on the both abutments, having comparatively large catchment area of 122 sq.km. The proposed dam at the site shall be a high fill dam with a spillway and a conduit in respect to the best adopted capacity, the large design flood, to prevent siltation onto storage basin and to control flood discharge.

The proposed storage capacity for the dam is decided by the simulation so as to maxmize the recharge effect and to minimize the size of facility.

As seen in Table A.4.2-1, the facility at this site is deemed to be appropriate with capacity of 2.0 or 2.5 MCM and with a conduit of 1,420 mm showing recharge effect of 0.7 MCM/a.

The lower left bank gravel plain which spread out down ward of Wadi Al Fay and Zanhah is recieving the relatively large runoff from the said wadis, and deemed possible to make an effective facility. Many alternatives in capacities could be considered on this basin, the simulation indicate the appropriate capacity is 2.0 or 1.5 MCM.

The lower right bank gravel plain situates the immediate lower reach of the upper plain, and recieves the remained water from the facility on the upper plain. Therefore, the adequate capacity on the plain depends upon that on the upper. The simulation results show the effects of facility on the plain are only 0.2 to 0.3 MCM/a regardless the capacities.

As the conclusion of simulation, the cases C'-8, C'-9 and C'-10 are finally recommendable as per the alternative plans of water resourse development scheme. The case C'-8 consists of three facilities, on the damsite for 1.5 MCM capacity, on the lower left plain for the same and on the lower right plain for 1.0 MCM capacity, and augments groundwater for 0.9 MCM/a in total. The case C'-9 is composed of two facilities, one on the damsite with 2.5 MCM capacity, another on the lower left plain with 1.5 MCM capacity. Total augment is as same value as in Case C'-8. The case C'-10 has same components as C'-9 but only 2.0 MCM capacity for the facility on damsite the augment of groundwater decreases to 0.8 MCM/a in total.

Table 4-1 Alternative Study for Water Resources Development Plan (12 cases)

Case No.	No.5 Sub-Basin			No.10 Sub-Basin			No.9 Sub-Basin			Whole Basin		
	Storage Capacity (MCM)	G.W. Recharge (MCM/a)	G.W. Augment (MCM/a)	Storage Capacity (MCM)	G.W. Recharge (MCM/a)	G.W. Augment (MCM/a)	Storage Capacity (MCM)	G.W. Recharge (MCM/a)	G.W. Augment (MCM/a)	Storage Capacity (MCM)	G.W. Recharge (MCM/a)	G.W. Augment (MCM/a)
Present	-	1.4	-	-	0.4	-	-	0.9	-	-	2.9	-
C'-1	4.2 2/	2.0	0.6	1.0	0.5	0.1	2.0	1.5	0.6	7.0	3.9	1.0
C'-2	3.0 2/	2.0	0.6	1.0	0.5	0.1	2.0	1.5	0.6	6.0	3.9	1.0
C'-3	2.0 2/	1.9	0.5	1.0	0.5	0.1	1.5	1.4	0.5	4.5	3.8	0.9
C'-4	2.0 1/	2.0	0.6	1.0	0.5	0.1	1.0	1.3	0.4	4.0	3.7	0.8
C'-5	2.5 1/	2.1	0.7	0.5	0.3	-0.1	0.5	1.1	0.2	3.5	3.5	0.6
C'-6	3.0 1/	2.2	0.7	0.0	0.2	-0.2	1.5	1.4	0.5	4.5	3.8	0.9
C'-7	2.0 1/	2.0	0.6	0.5	0.4	0.0	1.5	1.4	0.5	4.0	3.8	0.9
C'-8	1.5 1/	1.9	0.5	1.0	0.5	0.1	1.5	1.4	0.5	4.0	3.8	0.9
C'-9	2.5 1/	2.1	0.7	0.0	0.3	-0.1	1.5	1.4	0.5	4.0	3.8	0.9
C'-10	2.0 1/	2.0	0.6	0.0	0.3	-0.1	1.5	1.4	0.5	3.5	3.7	0.8
C'-11	2.5 1/	2.1	0.7	0.0	0.2	-0.2	0.0	0.9	0.0	2.5	3.4	0.5
C'-12	0.0	1.4	0.0	0.0	0.4	0.0	1.5	1.4	0.5	1.5	3.3	0.4

Notes: 1/ 1 x ø1,420 mm conduit, 2/ 2 x ø1,420 mm conduit

The best adopted plan is decided among those three alternatives from the study on the raw water cost which is described in the following paragraph.

Table 4-2 Alternative Study for Water Resources Development Plan (3 Cases)

Case	Facilities	Rechargeable Amount (MCM/a)
C'-8	BD: 1.5 MCM BP: 1.0 MCM 1.5 MCM AP:	0.9
C'-9	BD: 2.5 MCM 1.5 MCM AP:	0.9
C'-10	BD: 2.0 MCM 1.5 MCM AP:	0.8

The locations of the above facilities are illustrated in Fig. 4-2 and the abbreviations of BD, BP and AP stand for Al Bassierah Dam, Al Bassierah Pond and Al Fay Pond, respectively.

The best plan available in the aforesaid three cases shall be decided as the plan that can minimize the water cost. The type of the facilities and the construction costs were elaborately studied from the viewpoints of engineering and economy as follows.

(3) Selection of the facilities for the Wadi Al Bassierah

In the mid-basin of the Wadi Al Bassierah, the both type of dam and dike can be taken into consideration, while the three sites for these facilities are taken up by Ⓐ, Ⓑ and Ⓒ as shown in Fig. 4-2.

However, in terms of the proposed capacity of the facilities for the water resources development, plan (1): when employing dam type facilities, the proposed site will be limited to site Ⓑ, whereas, plan (2), when employing dike type facilities, the confinantion of the sites Ⓐ and Ⓑ can be one plan and the site Ⓒ only can be another. After studying the alternative study on the dike plan, a thorough study shall be made again on the dam plan at Ⓑ site and the selected dike plan again.

1) Construction cost in plain (2)

First of all, a comparative study was made on the dikes at site Ⓐand Ⓑ with one dike at site Ⓒ in plan (2), and the results is shown in Table 4-3.

Table 4-3 clarifies that the one dike construction at the site Ⓒ is advantageous in any cases.

Table 4-3 Construction Costs of Dikes

Case	Site	Dike Length (Rm)	Overflow Part (m)	Non-overflow Part (m)	Capacity (MCM)	Total Capacity (MCM)	Const. Cost (MDH) Overflow Part	Non-overflow Part	Total
C'-8	A	1.6	3.8	6.8	1.0	1.5	6.8	5.1	19.2
	B	0.9	3.8	6.8	0.5]		6.8]	0.5]	
	C	2.5	3.8	6.8	1.5	1.5	6.8	11.5	18.3
C'-9	A	1.6	5.0	8.0	1.6	2.5	8.9	6.4	26.6
	B	0.9	5.0	8.0	0.9]		8.9]	2.4]	
	C	2.5	5.0	8.0	2.5	2.5	8.9	11.7	20.6
C'-10	A	1.6	4.5	7.5	1.3	2.0	8.1	5.9	24.3
	B	0.9	4.5	7.5	0.7]		8.1	2.2]	
	C	2.5	4.5	7.5	2.0	2.0	8.1	10.7	18.8

Note: Construction costs were obtained based on the monogram shown in Fig. 4-3.

Fin. 4-3 Construction Cost of the Dike per Kilometer

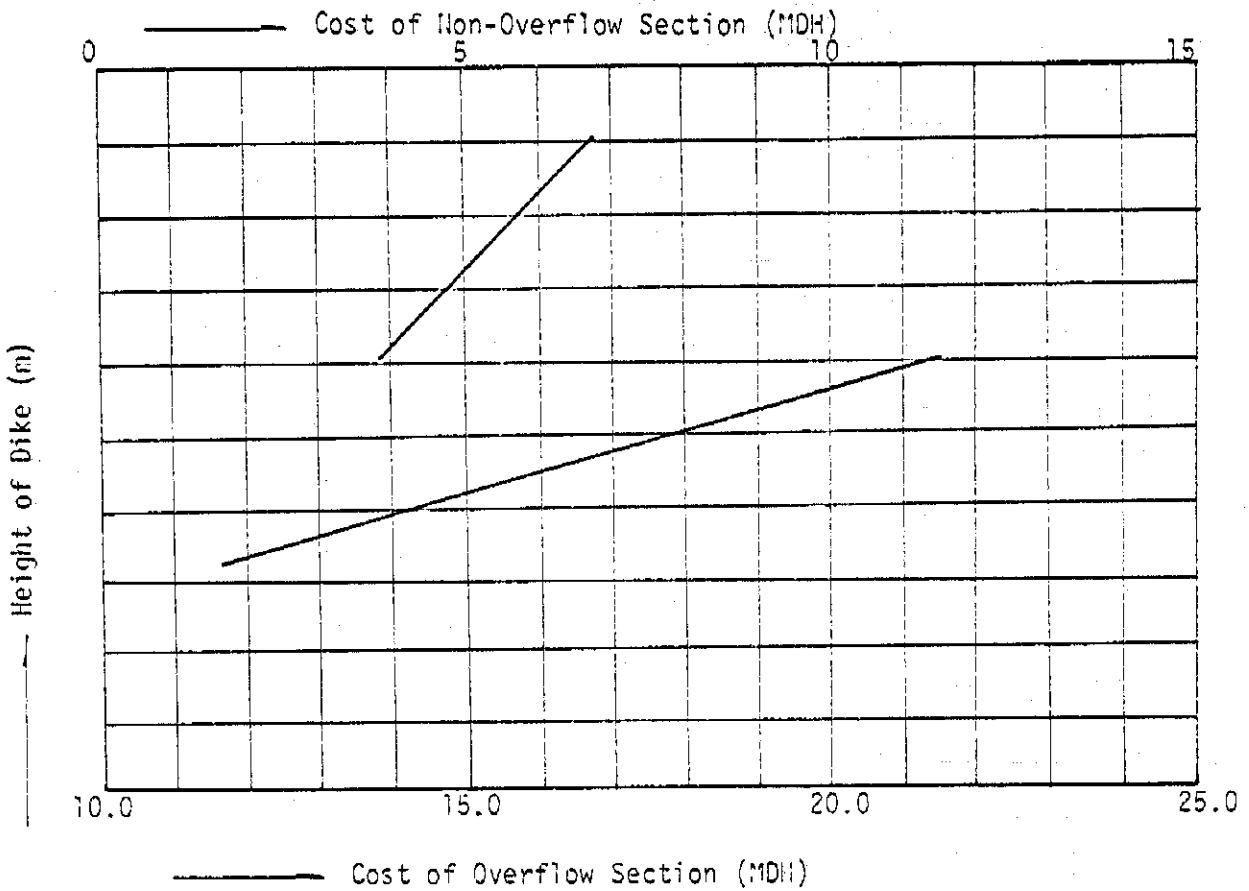


Table 4-4 Construction Cost of Dike per Kilometer

Description	Unit	h = 3.2 m		H = 6.2 m		h = 6.0 m		H = 9.0 m	
		Qua. (1,000)	Amo. (MDH)	Qua. (1,000)	Amo. (MDH)	Qua. (1,000)	Amo. (MDH)	Qua. (1,000)	Amo. (MDH)
Stripping	cu.m	48	254.4	30	159	60	318	39	206.7
Embankment	"	28	285.6	130	1,326	131	1,336	259	2,641.8
Rocks	"	10	200	7	140	21	420	7	140
Riprap (A)	"	14	420	28	840	23	690	45	1,350
Riprap (B)	"	13	2,990	-	-	23	5,290	-	-
Gabion	"	28	3,304	-	-	49	5,782	-	-
Filter	"	13	260	8	160	23	460	8	160
Gravel Paving	"	-	-	1	27.4	-	-	1	27.4
Sub-total			7,714.0		2,652.4		14,296		4,525.9
Total	Sub-total x 1.5		11,570		3,980		21,450		6,790

Note:

h = Overflow Section

H = Non-Overflow Section

2) Construction cost of dam

Secondly, dam construction costs at the site Ⓑ with various capacities were studied and the results are shown in Table 4-5.

Table 4-5 Dam Construction Costs

Case	Capacities of Facilities (MCM)	Ebankment Height (m)	Embankment Volume (MCM)	Costs (MDH) Flood Way	Dam Body	Total
C'-8	1.5	17.0	0.51	3.9	11.7	15.6
C'-9	2.5	19.5	0.67	3.4	16.4	19.8
C'-10	2.0	18.4	0.56	3.4	14.3	18.2

The details of the above are shown in Table 4-7 and Fig. 4-4 illustrates a typical section of the Al Bassierah Dam for references.

3) Determination of the most suitable type of facilities and the proposed damsite.

The sutdy on the Plan (3) at the site Ⓒ , the construction costs for the more advantageous dike plan and the dam plan at the site Ⓑ resulted in as shown in Table 4-6.

Table 4-6. Construction Costs of Dam and Dike

Case	Capacity of Facilities (MCM)	Costs of Dike (MDH)	Costs of Dam (MDH)
C'-8	1.5	18.3	15.6
C'-9	2.5	20.6	19.3
C'-10	2.0	18.8	18.2

Fig. 4-4 Typical Section of Al Bassierah Dam

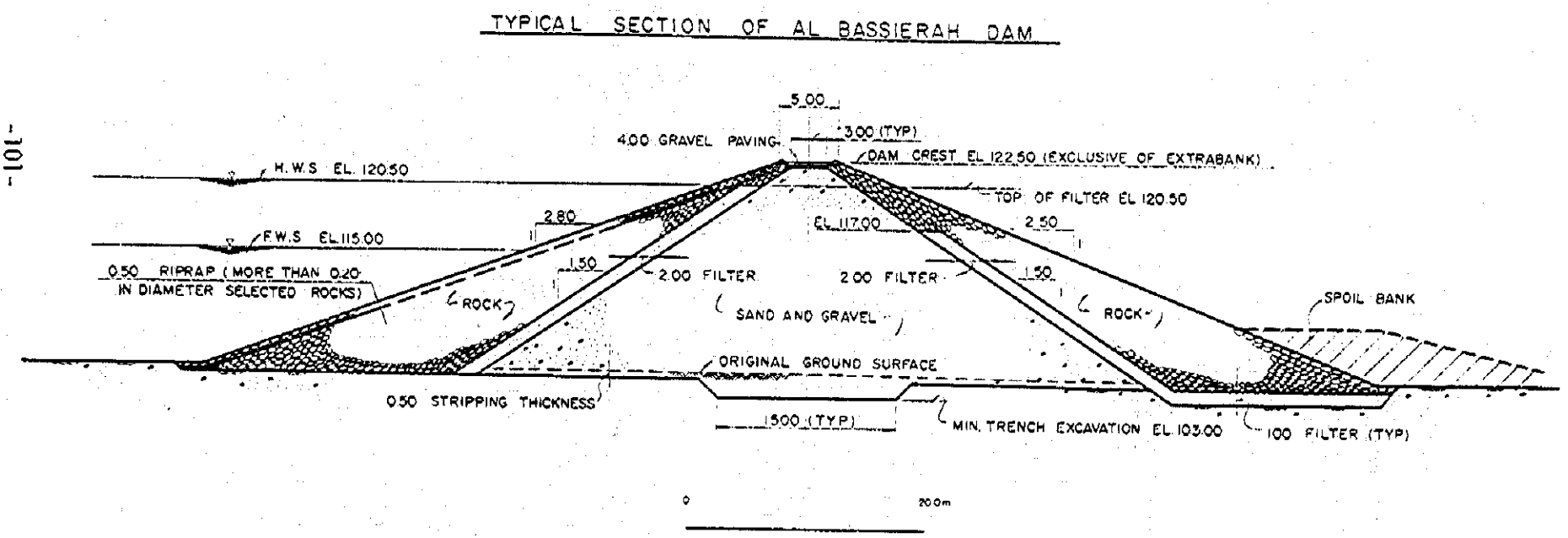


Table 4-7 Construction Costs for Proposed Dam

Description	Items	Unit	C'-9	C'-10	C'-8
MAIN DAM	Capacity	MCM	2.5	2.0	1.5
	Dam Crest EL.	EL	122.5	121.4	120.0
	High Water EL.	EL.	120.5	119.4	118.0
Design Criteria	Full Water EL.	EL.	115.0	113.9	112.5
	Free Board	m	2.0	2.0	2.0
	Low EL. of Dam	EL.	103.0	103.0	103.0
	Dam Height	m	19.5	18.4	17.0
	Width of Dam Crest	m	5.0	5.0	5.0
	Slope of Embankment		1:2.8/1:2.3	1:2.8/1:2.5	1:2.8/1/2.5
	Sand/Gravel	TCM	305	286	267
	Rocks	"	275	203	176
Embankment Volume	Filter	"	64	50	48
	Riprap	"	21	19	18
	Total	"	665	558	509
SPILLWAY					
	Design Flood	m^3/s	2,320(1/10,000)	2,320(1/10,000)	2,320(1/10,000)
Design Criteria	Depth of Overflow	m	5.5	5.5	5.5
	Length of Spillway	m	75.5	75.5	75.5
Rock Excavation Volume		TCM	75	75	90
Conduit		No.	1	1	1
CONSTRUCTION COST	Main Dam	MDH	10.1	9.1	7.1
	Spillway	"	2.3	2.3	2.6
	Conduit	"	0.8	0.7	0.7
	(A) Sub-total	"	13.2	12.1	10.4
Total (A) x 1.5			19.8	18.2	15.6

The dam plan is more advantageous in any cases than the dike plan. Furthermore, the dam is considered more practically advantageous in providing a small reservoir surface which preventy the evaporation losses, and high water head which promotes percolation of water into ground. Therefore, the facilities to be provided in the mid-basin of the Wadi Al Bassierah are proposed as dam type facilities.

4) Pond plan in the gravel plain

In the water resources development plan, either of the three alternative plans contenplates to provide a water sotrage pond in the gravel plain (No.9 sub-basin) in the downstream of the Wadi Al Fay, and C'-8 will provide additionally another storage pond in the gravel plain (No.10 sub-basin) in the downstream of the main stream of the Wadi Al Bassierah.

These proposed storage facilities are to be of dike type. The proposed pond in the downstream of the Wadi Al Fay (hereinafter referred to as Al Fay Pond) and that in the downstream of the Wadi Al Bassierah (hereinafter referred to as Al Bassierah Pond are to be constructed at the proposed site Ⓔ and Ⓓ as shown Fig. 4-2, by one each, respectively. The flood control, which requires a considerably large-scaled facilities, is designed to be carried out by means of overflow parts of the dikes in the plan.

The estimation of the necessary scale of the facilities in each case to provide the required capacity was made in the presumption that the average land slope would be 1/100 because no other detailed data is available than the topo-map at the scale of 1/25,000. However, further detailed study should be made for final design of the facilities, when the elaborate topo-survey is completed.

As for Al Fay Pond, as discribed in Appendix 4.1 (Hydrology), the Case C'-2 with capacity of 2.0 MCM, C'-3 with 1.5 MCM and C'-4 with 1.0 MCM are considered desirable. Table 4-8 shows the construction volumes and costs of the above three cases and the water costs estimated based on the above data. The said table clarifies that the proposed Al Fay Pond should be provided with capacity of 1.5 MCM which is the most effective among the alternatives.

Table 4-8 Capacity and Water Costs at Al Fay Pond

Case	Capacity (MCM)	Length of Dike (km)	Dike Height(m) Overflow Part	Dike Height(m) Non-Overflow Part	Construction Cost(MDH) Overflow Part	Construction Cost(MDH) Non-Overflow part	Construction Cost(MDH) Total	Rechargeable Amount (MCM/a)	Water Cost (DH/m^3)
C'-2	2.0	2.0	5.2	8.2	4.5	12.8	17.3	0.5	3.6
C'-3	1.5	2.0	4.5	7.5	2.6	9.8	12.4	0.4	3.2
C'-4	1.0	1.5	3.7	1.7	1.8	6.7	12.8	0.3	4.2

Note: The water cost was estimated by using the equation shown in (4-1) as below.

As for Al Bassierah Pond, as described in Appendix 4.1. (Hydrology), the study was made on two cases of the ponds with capacity of 1.0 MCM and 0.5 MCM, respectively. The effect for these cases cannot be discussed easily due to the fact that the said pond will function to store the surplus water from the Al Bassierah Dam to be located in the upstream of the pond. When the capacity of the dam is taken larger, it is not expected to have a good effect even by a larger-scaled Al Bassierah Pond to be provided. Therefore, for the cases of C'-8 and C'-9, the case study was made by that the amount of 1.0 MCM out of the proposed dam capacity of 2.5 MCM was allocated to the Al Bassierah Pond, so as to look into whether the facilities should be dispersed or integrated for getting higher effect.

The construction costs of the Ponds in the three alternatives are shown in Table 4-9.

Table 4-9 Construction Costs in the Three Alternatives

Case	Name of Pond	Capacity (MCM)	Length of Dike (km)	Dike Height (m)		Construction Cost (MDH)		
				Overflow part	Non Overflow part	Overflow part	Non-Overflow part	Total
	Al Bassierah	1.0	1.5	3.7	6.7	6.6	6.7	13.3
C'-8	Al Fay	1.5	2.0	4.5	7.5	2.6	9.8	12.4
	Total	2.5	3.5	-	-	9.2	16.5	25.7
C'-9	Al Fay	1.5	2.0	4.5	7.5	2.6	9.8	12.4
C'-10	"	1.5	2.0	4.5	7.5	2.6	9.8	12.4

These construction volumes were estimated based on the monogram shown in Fig. 4-3, and the structures and hydraulical factors are illustrated in Fig. 4-5 and -6, respectively.

Fig. 4-5. Typical Section of Dike

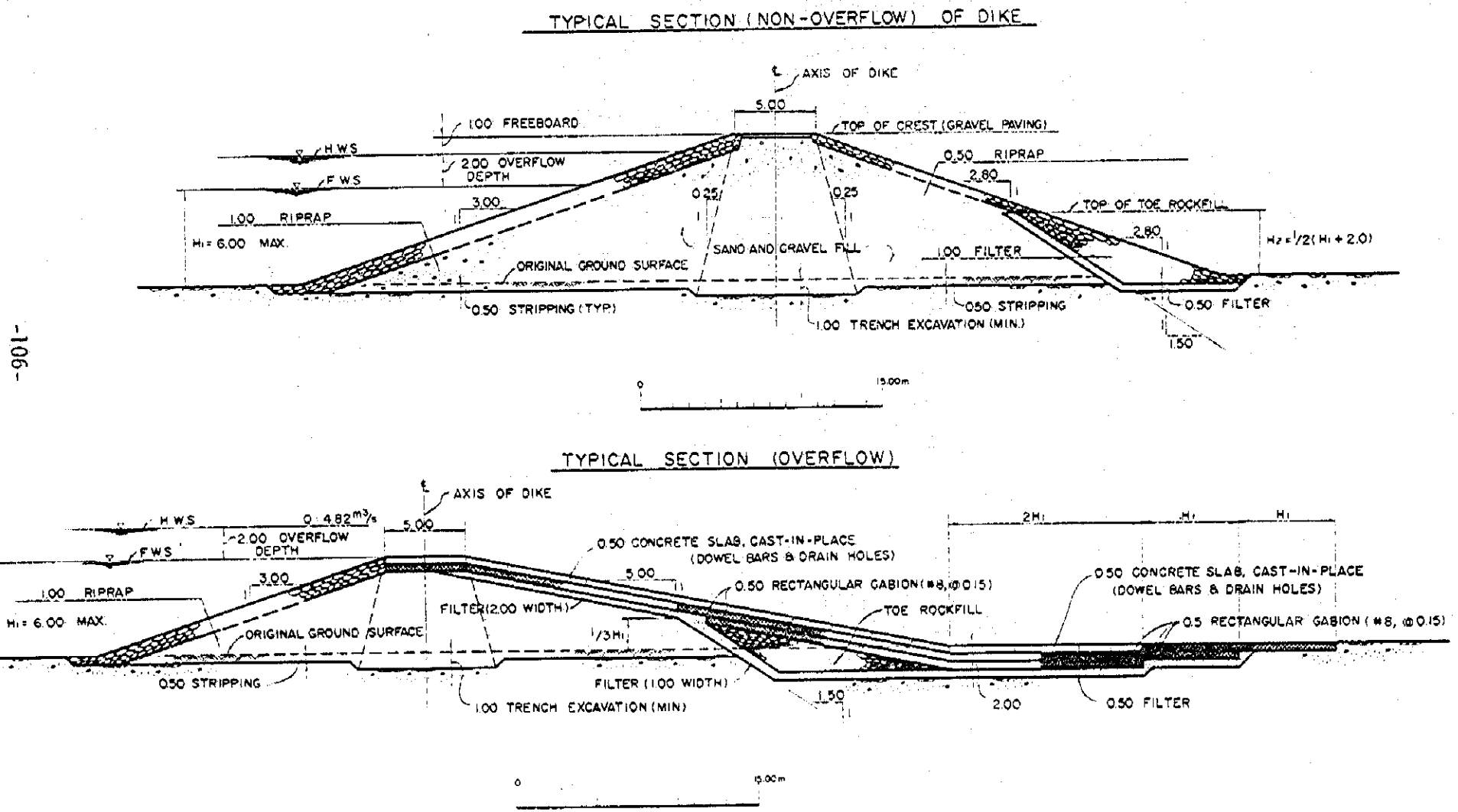
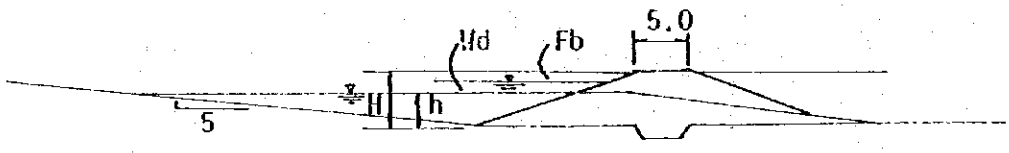


Fig. 4-6 Hydraulical Factors



H:	Embankment Height at non-overflow part:	Max. 9.0 m (H)
b:	Embankment Height at overflow part:	Max. 6.0 m (h)
Fb:	Freeboard :	Max. 1.0 m (Fb)
Hd:	Overflow depth :	Max. 2.0 m (Hd)
q:	Overflow amount per unit length :	Max. 4.8 $m^3/s/m$

Design flood discharge for floodway (Q):

- Catchment Area of Al Bassierah Dam (122 km^2) : 2,320 m^3/sec
- Catchment Area of the Wadi Al Fay (24 km^2) : 780 m^3/sec

Topographical slope of the gravel plain (S):

- Up and downstream of proposed damsite of Bassierah Dam: 1/80
- Topographical slope of gravel plain in the downstream of the Wadi Al Fay.

(4) Determination of the most suitable plan for water resources development

The comparative study of the water resources development was made as follows on the three alternatives so as to determine. The study was made on the basis of the total construction costs of the respective combinations of Al Bassierah Dam, Al Fay Pond and Al Bassierah Pond, and the water costs of the relevant cases.

The water costs were calculated by the following equation.

$$Wc = \frac{Dc\ (1 + 0.4\ I \times T)\ (A + I) + Mo}{Ra} \quad \ldots\ldots\ (4 - 1)$$

Where,

Wc = Water cost per one cubic meter at the facilities sites

Dc = Construction cost of facilities

I = Interest rate (adopted 7%)

T = Construction period (adopted 2 years)

A = Depreciation rate of facilities (adopted 1/50 = 0.02)

Mo = Annual operation & maintenance cost of facilities (adopted 0.5% of the construction cost)

Ra = Annual yield of water (m^3/year)

The result of the above study is shown in Table 4-10, which indicates that the case C'-9 is most advantageous in water cost of DH 3.6/m^3, the lowest cost, and rechargeable water of 0.9 MCM/year. Therefore, the case C'-9 can be proposed as the most suitable case in this study.

Table 4-10 Water Cost for Respective Cases

Case	Facilities	Construction Cost (MDH)	Rechargeable Amount (MCM/a)	Water Cost (DH/m³)
C'-8	BD: 1.5 MCM BP: 1.0 MCM AP: 1.5 MCM	Dam: 15.6 Pond: 12.8 Pond: 12.2 Total: 40.6	0.9	4.5
C'-9	BD: 2.5 MCM AP: 1.5 MCM	Dam: 19.8 Pond: 12.2 Total: 32.0	0.9	3.6
C'-10	BD: 2.0 MCM AP: 1.5 MCM	Dam: 18.2 Pond: 12.2 Total: 30.4	0.8	3.8

Note: BD: Al Bassierah Dam
BP: Al Bassierah Pond
AP: Al Fay Pond

4-2-3. Water Allocation

The groundwater resources available in the basin was estimated at 3.8 MCM per annum to be totaled by 2.9 MCM/year by natural recharging and 0.9 MCM/year by artificial recharging. The proposed water allocation was worked out in maintaining the present allocation for domestic water use and irrigation use as of 1980, which in allocating 0.1 MCM/year for industrial use (cement plant) and others for irrigation use out of 0.9 MCM/year available by artificial recharging. For the above proposed allocation, the irrigation water allocation was thoroughly studied by three alternative plans.

(1) Present water use

The below-mentioned water use of the total 3.1 MCM/year in the basin as of 1980 was confirmed at the meeting with the UAE authorities concerned and recorded in the relevant minutes. The said amount, however, was revised to 2.9 MCM/year as shown below as the average for 21 years with additional hydrological data available in 1981.

Table 4-11 Present Water Use

Descriptions	Area	Water Use
Domestic Use	UAE (15,000 inhabitants and marble plant)	0.55 MCM/year
	Oman (15,000)	0.05
Irrigation Use	UAE (Vegetable cropping 50 ha)	0.30
	UAE (Dates 230 ha)	1.04
	Oman(Dates 210 ha)	0.96
	Total	2.9 (MCM/year)

(2) Allocation of Developed Groundwater

The artificially rechargeable groundwater of 0.9 MCM/year was planned to be allocated by 0.1 MCM/year for industrial use and 0.8

MCM for irrigation use. And the allocation for irrigation use was further studied through the following three alternatives.

Plan A: For proposed upland fields of 75 ha (vegetable farms) and FAO's farm of five hectares

Plan B: For proposed upland fields of 65 ha (fruits plantation) and FAO's farm of five hectares

Plan C: For proposed upland field of 30 ha (vegetable farm), fruits plantation of 40 ha and FAO's farm of five hectares.

The details are tabulated in Table 4-12.

Table 4-12 Allocation of Developed Groundwater

Description	Use		Allocation Plan (MCM/year) A	B	C
Industrial Water	UAE Cement Plant		0.10	0.10	0.10
Irrigation Water	Vegetable farm:	75 ha	0.73	-	-
		30 ha	-	-	0.30
	Fruits farm:	65 ha	-	0.73	-
		40 ha	-	-	0.43
	FAO's farm:	5 ha	0.07	0.07	0.07
Sub-total			0.80	0.80	0.80
Total			0.90	0.90	0.90

The details of total water allocation plan is shown in Table 4-13.

Table 4-13 Proposed Water Use

Area	Classification	Use	Acreage (ha)	Present Use	Proposed Water Allocation A	B	C
UAE	Domestic Water			0.48	0.48	0.48	0.48
	Industrial Water	Marble Plant		0.07	0.07	0.07	0.07
		Sub-total (1)		(0.55)	(0.55)	(0.55)	(0.55)
		Cement Plant		-	0.10*	0.10*	0.10*
		Sub-total (2)		-	(0.10)	(0.10)	(0.10)
	Total (1)	(1) + (2)		((0.55))	((0.65))	((0.65))	((0.65))
	Irrigation Water	Existing vegetable farm	50	0.30	0.30	0.30	0.30
		Existing dates Palm Plantation	230	1.04	1.04	0.04	1.04
		Sub-total (3)		(1.34)	(1.34)	(1.34)	(1.34)
		Supplement to Exist. Dates Palm Plantation		-	-	-	-
		FAO's Farm	5	-	0.07*	0.07*	0.07*
		Proposed vegetable farm	30	-	-	-	0.30*
		-ditto-	50	-	-	-	-
		-ditto-	75	-	0.73*	-	-
		Proposed fruits farm	40	-	-	-	0.43*
		-ditto-	60	-	-	-	-
		-ditto-	65	-	-	0.73*	-
		Sub-total (4)		-	(0.80)	(0.80)	(0.80)*
	Total (2)	(3) + (4)		((1.34))	((2.14))	((2.14))	((2.14))
	Total [1]			[1.89]	[2.79]	[2.79]	[2.79]
Oman	Domestic Water			0.05	0.05	0.05	0.05
	Irrigation Water	Existing dates Palm plantation	210	0.96	0.96	0.96	0.96
		Sub-total (5)		((1.01))	((1.01))	((1.01))	((1.01))

Area	Classification	Use	Acreage (ha)	Present Use	Proposed Water Allocation A	B	C
		Supplement to Exist. Dates Palm Plantation		-	-	-	
	Total (II)			[1.01]	[1.01]	[1.01]	[1.01]
	Grand Total	(I) + (II)		2.90 (2.9)	3.80 (3.8)	3.80 (3.8)	3.80 (3.8)

Note: Aesterisks indicate the proposed water allocation by newly developed groundwater at the unit of MCM/year

4-2-4. Future Prospect of Water Use

The water allocation priority after development of the water resources in the Wadi Al Bassierah Basin were determined as domestic use, irrigation use for the existing farms and proposed new water use in the order. The domestic water allocation was worked out based on the total population of 14,700 (13,200 for the UAE and 15,000 for Oman) in 1980. The water demand, however, will increase year by year with population growth accompanying production increase of vegetables for self-sufficiency in future. In order to cope with such situation, the plan was formulated to convert the existing date palm plantation into vegetable farms, to establish new vegetable farms and to provide sea-water desalination plants to meet the forecasted population growth in the year of 2000. The forecasted water demand in 1990 and 2000 is shown in the following table.

Forecasted Water Demand (1980 - 2000)

Year	Doemstic Use	Industrial Use	Irrigation Use			Total (MCM)
			UAE	Oman	Proposed	
1980	14,700 persons					
	(100 ℓ/caput/day)		280 ha	210 ha	75 ha	
	0.53	0.17	1.34	0.96	0.80	3.80
1990	19,800 persons					
	(150 ℓ/caput/day)		160 ha	210 ha	200 ha	
	1.10	0.27	1.03	0.96	1.91	5.30
2000	26,600 persons					
	(200 ℓ/caput/day)		70 ha	210 ha	300 ha	
	1.94	0.35	0.61	0.96	2.86	6.70

Note: (1) Population growth rate is assumed to be by three (3) percent per annum and the water consumption increase per capita by 50 ℓ per day for every ten years.

(2) The forecasted water industrial water demand will cover the demand by cement plant now under construction and the peak water demand in 2000 was designed as 250,000 tons per annum.

(3) The forecasted irrigation demand was estimated in taking into account the plan that the existing date palm plantation would be decreased to 70 percent in 1990 and 30 percent in 2000.

4-2-5. Water-use Simulation

The hydrologic balance in the present condition and the augmented groundwater recharges are clarified to some extent through the simulation by the storage model. However to utilize these groundwater resource to a full scale, it is necessary to grasp the groundwater bahavier in the aquifers besides the hydrologic balance.

The groundwater flows are, in general, very slow comparing with the surface flow. Therefore, in a water use planning, it is indespensable to understand the response between recharge and draft.

Moreover, since the groundwater demands in the Basin concentrates into the coastal strip, it is also needed to pay careful consideration to the sea water intrusion into the coastal aquifers.

The said view points introduce the necessity of groundwater basin management. And it is also needed to establish manners of control for the management.

In case to clarify such matters, it is more convenient and practical to construct a mathematical model for groundwater system, groundwater hydraulic model, and to make simulation on various water use alternatives applying the model.

The mathematical hydraulic model is constructed basing upon the two-dimensional finite element model for an unsteady seepage.

The divisionning of groundwater basin of the Basin is made for 176 finite elements and 113 nodes.

The groundwater in the Basin is under unconfined condition, and the permeability matrix is made multiplying the permeability coefficient of an element by the water depth.

The aquifers in the Basin are composed of three layers different in permeability and incline gently toward the sea. The relationship between the height of each aquifer at the representative spots and their permeability is shown in Fig. A. 4.2-3. This relationship means the average permeability of an element changes in accordance with the groundwater head.

The storage coefficients estimated through aquifer tests shows 0.01 or less. However the specific yield of the Basin is deemed feasible through the result of simulation being 0.03 to 0.06.

The simulation of sea-water intrusion is made not in the strict solution but in an approximation by the Ghyben-Herzberg principle. The difference of specific gravities of fresh and salt waters is deemed to be 25 basing upon the depth of fresh and salt water interface observed at TW-3 well. Adopting this value, the phenomenon of sea water intrusion is simulated.

The simulation is made at each calender month for the past 20 years.

Every boundaries except sea coast are deemed to be impervious walls.

Fig. A.4.2-9 and A.4.2-10 shows the groundwater flow regime on 1st August 1980 and hydrographs of groundwater head and salt water interface at the representative spots for 20 years which are simulated by the identified hydraulic model through trial runs.

Table A.4.2-51 gives the groundwater balance under the present condition by the model simulation. The groundwater storage in the Basin is approximate by around 120 MCM and fluctuates from 150 MCM in a wet year to 70 MCM in a dry year. So far the groundwater storage of the Basin is concerned, the recent extreme dry and wet years are 1967/68 and 1976/77 respectively.

Simulation for the proposed water-use allocation after the groundwater recharge is augmented is made for three cases. The breakdown of the case are shown in Table A.4.2-10.

The major priorities of groundwater management of the Basin shall be put at the prevention of sea water intrusion and conservation

of groundwater resource. As the natural phenomenon, the sea water wedge is formed and intruded deeply into the coastal aquifers of the Basin. In a part of the coast, the salt water interface is floated upward due to the overdraft, and alkalination of farm land takes place already.

To prevent these phenomenon, it is only necessary to keep salt water interface down the bottom of production wells. It is clear in the Ghyben-Herzberg principle that the position of interface can be controlled by the level of fresh water head.

Therefore, as per the Basin, a control height of fresh water head at an appropriate location shall be established to manage the depth of interface. In this manner the groundwater resource will be conserved at a level in the same time.

The location and the height of water head are determined at Node 66 (TW-3) and 1.5 m above sea level respectively in the simulation. When the groundwater head at the node reaches this level or less, the all drafts except the domestic water supplies in both UAE and Oman are stopped until the head recovers to the level.

The location of production wells both existing and under planning is desirous to be at as far as possible from the sea taking into consideration of the said condition. In the simulation the production wells under the Project are supposed to be at three km or more far from the sea.

Table A.4.2-52 to A.4.2-54 show the simulation results in each case. Since the total water demands for each case are the same amounting 3.8 MCM/a, about same results are obtained. Due to the draft stop before satisfaction of water demand, shortages take place on seven years of 1966/67, 1967/68, 1968/69, 1972/73, 1975/76 and 1976/77. The extreme shortage takes place on 1967/68 for 2.7 MCM/a and this is continued from the drought of 2.1 MCM/a in the previous

year. The shortages on other years are deemed to be not so severe amounting 1.2 MCM/a or less.

RELATIONSHIP BETWEEN WATER HEAD AND PERMEABILITY
Fig. 4-7
NODE 66
NODE 48
NODE 16 & 36
ELM ELM ELM
90 70 10
1ST AQUIFER
50 30 -30
2ND AQUIFER
20 0 -60
3RD AQ.
ADOPTED
AQUIFER TEST RESULT
0.16
0.03
0.10
0.05
0.015
0.007
10⁻¹
10⁻²
10⁻³
K (cm/sec)
SEKIREI A4 NO.407C

Fig. 4-8

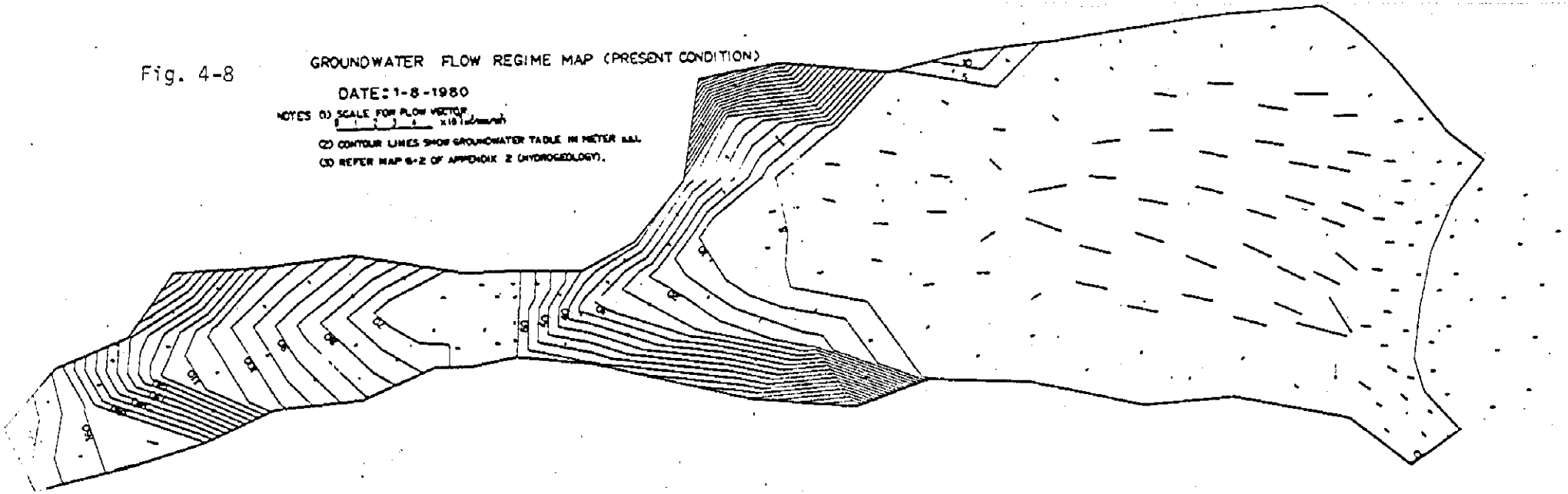
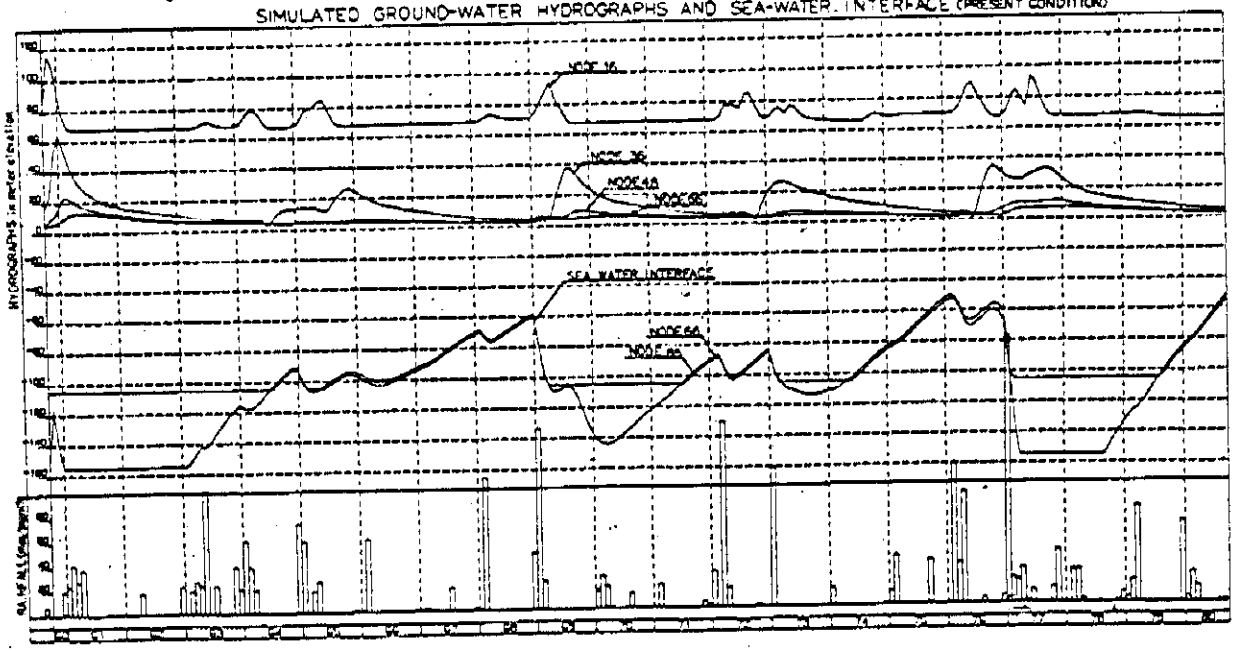

GROUNDWATER FLOW REGIME MAP (PRESENT CONDITION)
DATE: 1-8-1980
NOTES (1) SCALE FOR FLOW VECTOR
(2) CONTOUR LINES SHOW GROUNDWATER TABLE IN METER S.S.L.
(3) REFER MAP 6-2 OF APPENDIX 2 (HYDROGEOLOGY).

Fig. 4-9


SIMULATED GROUND-WATER HYDROGRAPHS AND SEA-WATER INTERFACE (PRESENT CONDITION)
NODE 16
NODE 36
NODE 48
NODE 80
SEA WATER INTERFACE
NODE 64
NODE 88

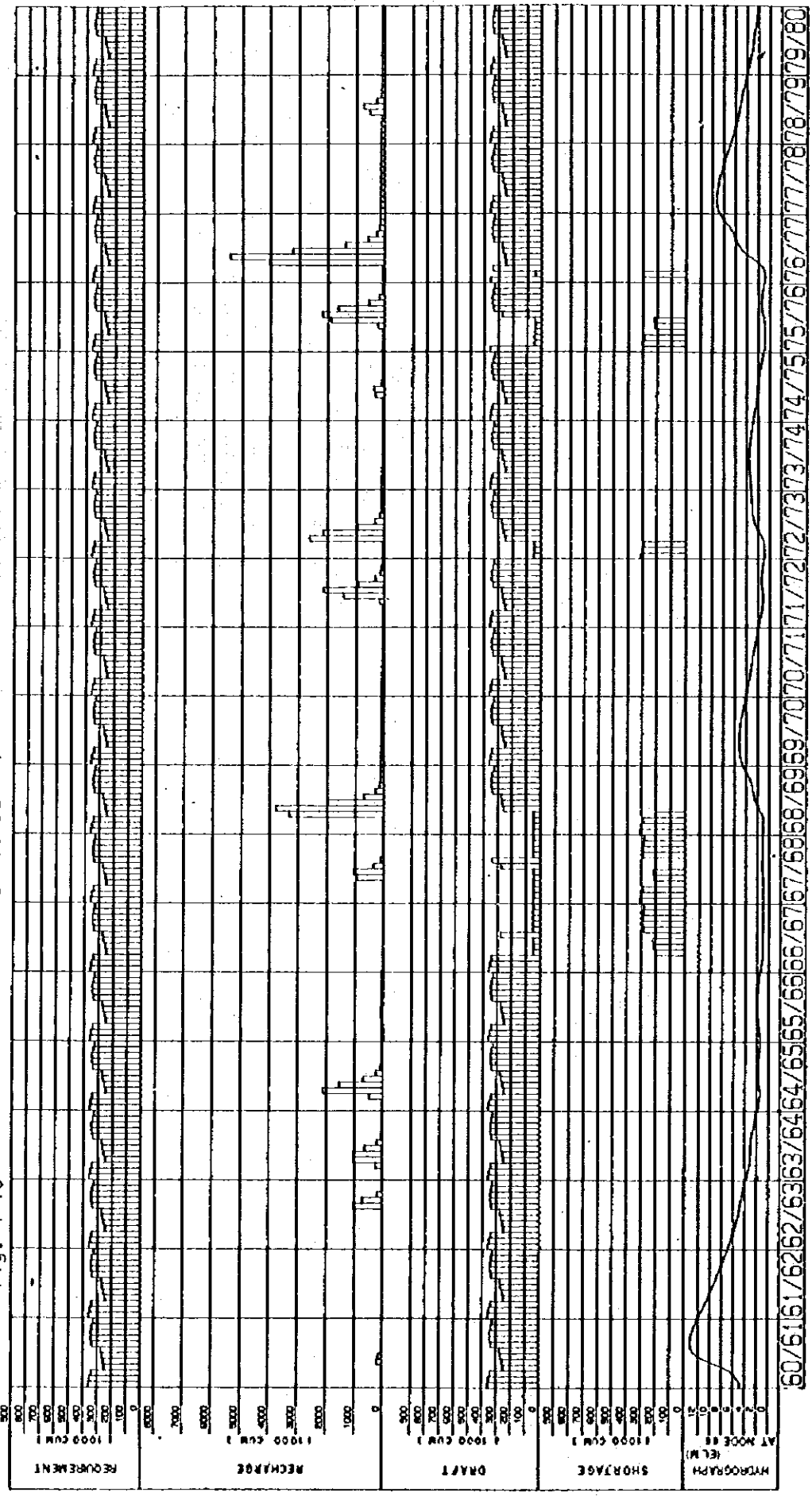


Fig. 4-10 GROUNDWATER BALANCE (CASE A)

Fig. 4-11 GROUNDWATER BALANCE (CASE B)

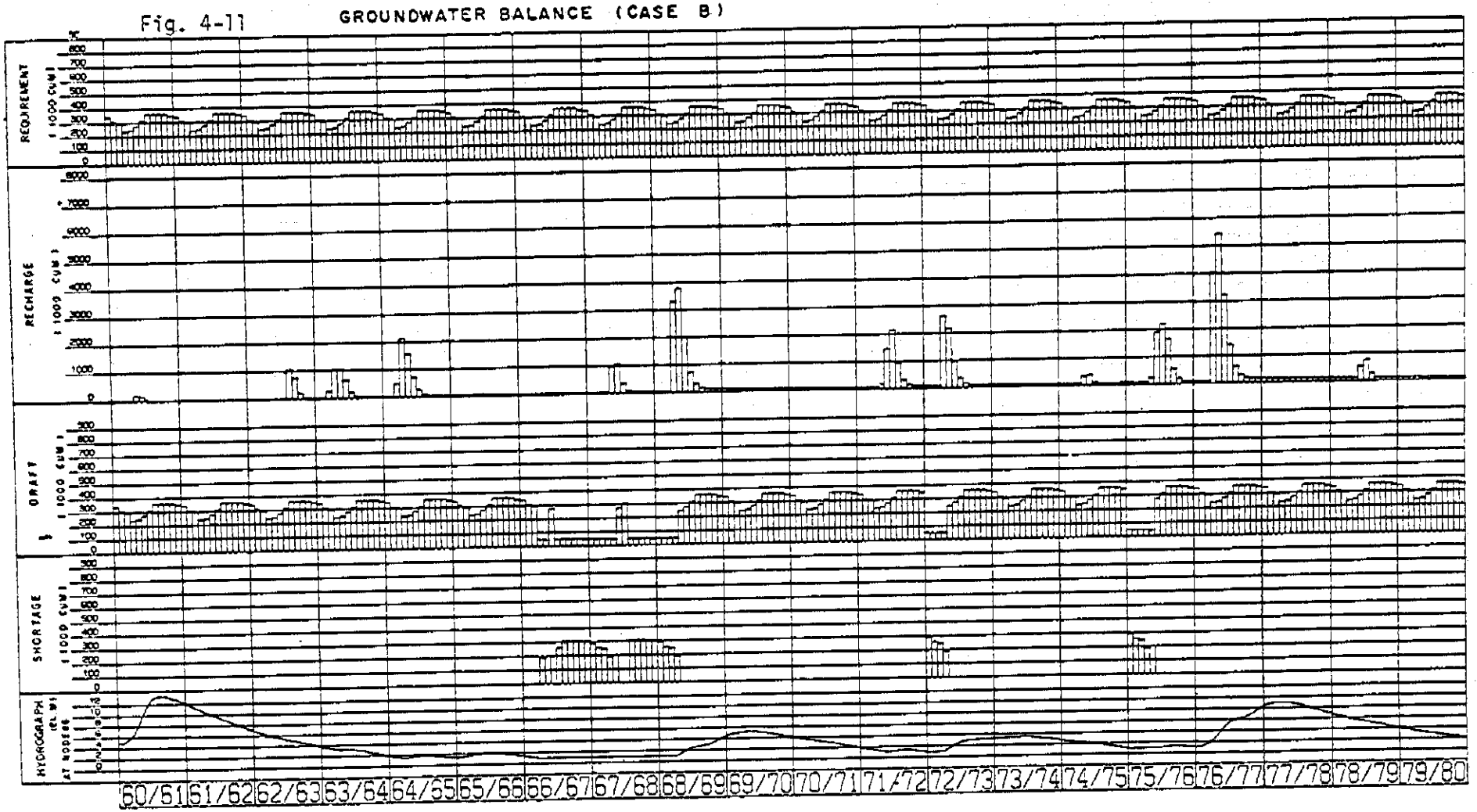
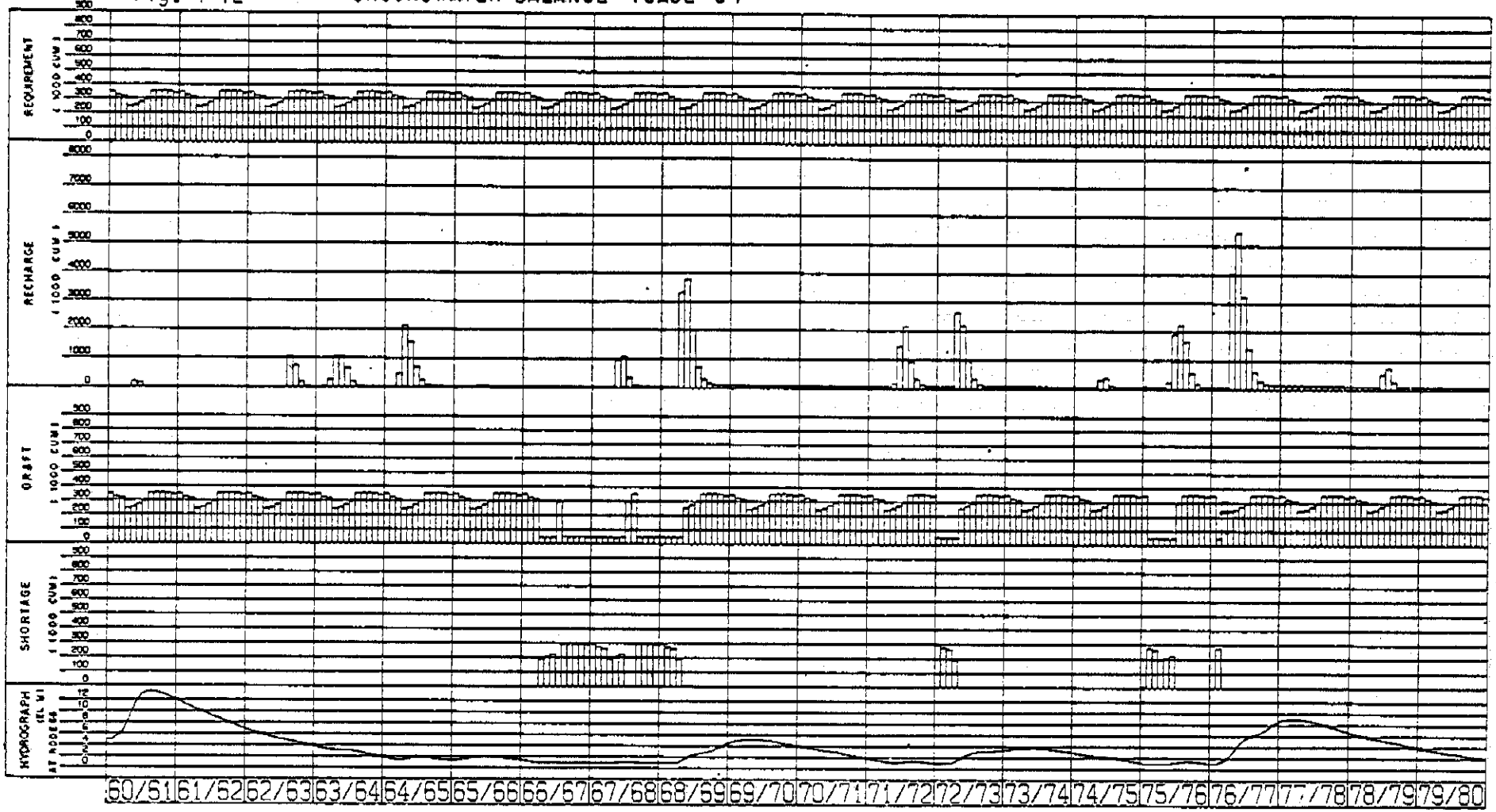


Fig. 4-12 GROUNDWATER BALANCE (CASE C)



4.3. Agricultural Development Plan

As mentioned in the section on Present Agriculture, the existing farm lands around Dibba in the Wadi Al Bassierah Basin in the UAE are about 280 ha. The agricultural development plan involved in the Water Resources Development in the basin comprises three alternative plans; Plan A - 75 ha for the vegetable farms only, Plan B - 65 ha for the fruits farms only and Plan C - combination of 30 ha for the vegetable farms and 40 ha for the fruit farms.

The UAE authorities concerned have taken up 120 ha of the fruits farm and the Fujeirah emirate 100 ha of the vegetable farms as objectives of the agricultural development; however, these objective areas should be decreased to any of the above three alternative plans due to restriction in the water availability in the water resources development plan. The basic problems in the agricultural development are as follows:

(1) Vegetable farms (75 ha or 30 ha)

The proposed two farm lands by the Fujairah authorities concerned are located near the FAO's experimental farm. The unit farm plot was designed by 0.5 ha which is the average acreage of farm land cultivated per farmer in the Dibba area.

° Unit farm plant	0.5 ha
° Cropping pattern	Vegetable cropping in winter and summer
° Water conveyance and Irrigation system	Pipeline and drip irrigation
° Farming practices	Semi-mechanized farming by small-scale machines
° Farm management	Collective farming

(2) Fruit farms (65 ha or 40 ha)

The proposed fruits farms are located in the same area as the above vegetable farms near the FAO's experimental farm.

And also, the proposed scale of farms should be reduced in view of the water balance. For the originally proposed plan, the feasibility study, detailed design and construction works of some facilities have been carried out since September, 1980 under the supervision by Jeuzy and Partners, to Consultants in UAE. Therefore, this section discusses the water balance and the economy on the specific vegetable and fruit production.

° Existing farm lands

The existing farm extends in the both countries of the UAE and Oman, and water balance computation and farm production evaluation will be carried for these farm lands.

Description	Area	Remarks
Farm lands in Oman:	210 ha	Dates
Farm lands in the UAE:	280 ha	Dates: 230 ha Vegetables: 50 ha
Total	490 ha	

4-3-1. Land Use and Its Improvement

(1) Soil improvement in the Wadi Fan

The future farm land development in the Basin will be possible only in the Wadi Fan which can spare some more acreages for farming; however, these lands are classified into grade 6, unsuitable for farming by the standard of land classification of the USBR. The ground surface is covered with cobbles which extremely hinder the lands from being formed into farming fields and will reduce farming efficiency even if converted into farm lands. And the gravel layer appearing in a range about one meter deep from the ground surface will prevent the plant roots from growing. The spaces among gravels are filled up with coarse or fine sands. Therefore, the soils are considered to provide very poor holding capacity of water and nutrient with extremely high permeability.

The lands exposed to such natural conditions will be unsuitable for farming. However, the information obtained from FAO experimental station at Wadi Fan in the Basin and other stations allow to judge that such lands may be converted to fruit-tree plantations or farming areas in intensively protected agriculture by improving the following points.

Removal of gravels larger than 5.0 cm dia from the surface and top soil dressing to the minimum depth will allow to secure the necessary farming and increase holding capacity of water.

For fruit-tree plantations, planting base (3 x 3 x 0.6 m) should be excavated after removing gravels, and top soil dressing should be practised with clayey soils in the amount equal to removed gravels for improving the soils to provide compactness below 20 mm, bulk density in a range from 1.3 to 1.5 and solidity between 40 percent and 55 percent. Furthermore, organic matters like compost and peat moss should be put in the soils, which shall be disturbed for mixing with organic matters, when the soil improvement is carried out.

For field crops lands, top soil dressing should be made after removing gravels larger than 2.0 - 3.0 cm dia, and the soils with much clayey contents should be put in the amount equal to the removed gravels. Then, the organic matters should be mixed up with soils at the rate of one percent of the soils.

(2) Soils in the coastal lands

Total soil improvement for the plantations in the coastal lands will be impossible because most of these lands have long been utilized as tree plantations mainly with dates. For soil improvement of the plantations, stress in the study is placed on the improvement in physiochemical properties of sub-surface soils. Under the situation, the land formation should be made by soil disturbance, deep plowing, etc. together with increasing organic contents in the soils by organic matters input so that the root zone soils can provide

adequate water and air holding capacities for stable supply of water and nutrient to the roots. The following points should be prudently considered for the soil improvement of the existing lands.

(3) Soil Improvement in physical properties

As mentioned already, the soils in this area have small porosity with high solidity, although having sufficient thickness of effective top soils, and furthermore, the soils, having a considerably high hardness, seem to be unfavourable in physical properties for sound growing of the plant roots.

For these soils with negative properties, the soil improvement should be made to reach soil solidity with about 50 percent and hardness with about 20 mm. And the development of fruit-tree plantations will require careful attention to be paid according to a variety of notices mentioned previously.

(4) Soil Improvement in chemical properties

The soils in the area show in general a high reaction with pH ranging from 8.0 to 9.0, which causes lack of such elements in citrus as zinc, manganese, iron, etc. Chelate spraying has been practised as a remedial measure in some plantations. However, the soil improvement with sulfur, gypsum, etc. is essential as thorough mitigation of soil reaction for increasing productivity, and well-managed fertilization including micro elements and organic matters will also be required for increasing soil fertility.

(5) Experiment and researches for soil improvement

As mentioned previously, the comparison of the alkaline contents in the soils of irrigated lands with non-irrigated lands revealed that long-lasting irrigation practices have much affected the accumulation of alkaline contents in the soils in depending upon the salinity in the irrigation water. It is urgently required, therefore, to establish a practical countermeasure against soil salinity con-

centration through carrying out a variety of experiments and researches on relationship among irrigation methods, soil improvement methods, salinity elimination and crops fruits to be introduced. It is recommended to make the better use of the existing FAO experimental station for this purpose.

4-3-2. Proposed crops and cropping calendar

The proposed crops for agricultural production are mainly classified into two; vegetables and fruits, which have been long grown in the UAE. The vegetables and fruits are selected among many according to their market values and demands. The following table shows the itemaized market prices in Dibba in June, 1980.

Vegetables		Fruits	
Item	Price	Item	Price
* Tomato	1,379 DH/t	Citrus fruits	3,455 DH/t
* Cucumber	3,255	Mango	2,571
* Egg-plant	1,493		
Green Pepper	3,283		
* Cabbage	1,929		
* Melon	2,080		
Water Melon	1,148		

The items marked with asterisks have been objectives to study in the Project and taken up in the experimental farms in Fujeirah and Ras Al Khaima.

In taking into account the fact that the vegetable production is considerably small in Dibba, the proposed local farm (50 ha) is planned to grow vegetables for stably supplying fresh farm products to the local markets under the due consideration of possibly effective utilization of land and water resources as well as stabilization of labour powers in the area.

The cropping calendar is applied in referring to the calendar for the eastern part of the UAE in the report on Crop Water Requirements in the UAE prepared by Dr. C. R. I. Prasher. The proposed crops and crop calendar for the local farms of 50 ha are referred to in 4B, Fig. A.4.3-1 in Appendix.

(1) Cropping acreage and rotational cropping

The actual cropping acreages for vegetables and fruits are shown as follows, and in principle, vegetables will be grown in both winter and summer, although melon should not be grown in summer in the dry year. Rotational cropping of vegetables should be made by tomatos, cucumbers, egg-plants and cabbages in the order in every four year. The fruit farm should be cropped with those cropps designated by MAF. The cropping acreages and crops to be adopted in this plan are shown as follows.

1) Plan A: Vegetable Farm (75 ha)

Crops	Acreage (ha)	Remarks
Tomatos	16.0	Winter crops
Cucumbers	16.0	"
Egg-plants	16.0	"
Cabbages	16.0	"
Melon	(25.0)	Summer crops
Others	11.0	Others
Total	75	

2) Plan B: Fruit Farm (65 ha)

Crops	Acreage (ha)	Remarks (%)
Dates Palm	10.0	15
Citrus Fruits	19.5	30
Mangoes	10.0	15
Decidius tree-crops	17.0	26
Others	8.5	14
Total	65	100

4-3-3. Irrigation

(1) Existing farms

The water resources in the Basin, being in the critical situation, would have to be utilized for irrigating the existing farms of 50 ha under the stringent control to save water. A greater part of existing water conveyance facilities from the farm wells to the individual farm lots or planted trees is gravel or earth canals. The proposed new farm should be provided with pipelines for water conveyance to reduce the water losses. On the other hand, the present dates plantations which need to be supplied with much irrigation water should be converted to vegetable farms or fruit-tree plantations in order to meet the critical conditions in expected shortage in water supply.

For the proposed farms, the irrigation system that can minimize the water conveyance losses should be provided, and at the same time, the soil improvement including gravel removal and top soil dressing should be carried out to consolidate the basic onditions in the farms to be newly developed farms in the gravel plain. For reducing losses, the water conveyance from the wells to each farm lot or tree should be made through pipeline systems, and irrigation should be made by drip irrigation systems as a general rule in the Project.

Determination of crop water requirements for planning the irrigation scheme was made based on the Pan-Evaporation Method which was adopted in the report of Crop Water Requirements in the UAE by Dr. C.R.K. Prasher (May, 1978), and the necessary data for estimation are supplied by those records observed in the Dibba Meteorological Station. The crop water requirements and irrigation efficiency used for irrigation planning are detailed in Table A.4.3-15 in Appendix.

4-3-4. Farm Management

The proposed new farms include three plans, all of which cover the area ranging from 65 ha to 75 ha, respectively. The plans for management of these farms should be conducted under the organization of the cooperatives, which shall plan and control the annual farming works, cropping, labour supply and operation and maintenance of the farming machinery so as to carry out modernized farming. Staffing and labour supply for Plan A (75 ha/cooperative) requires 49 permanent employees per month and temporary farmers of 14 to 51 heads per month for six months according to the aforesaid cropping plan, and the temporary farmers should be employed for the winter cropping period from September to February or March. The following building should be provided for the successful operation of the farms.

Buildings	Floor Area (sq.m)	Remarks
Office Buildings	70	Rest room for labourers
Warehouse for materials	30	Fertilizers, chemicals, seeds, etc.
Warehouse for farming machinery and equipment	70	
Fruits-sorting plant	70	Fruits and vegetables
Total	240	

4-3-5. Farm Economy

The farm economy analysis was made on the farms of total about 370 ha, including 280 ha of existing farms, 65-75 ha of proposed new farms. The annual gross income from these farms was estimated at OH 18.1 millions, which is brokendown as follows.

(1) Income

Items	Acreage (ha)	Production (ton)			Gross Income (1,000 DH)		
Dates (existing)	230	2,300			12,226		
Vegetable (existing)	50	1,000			2,080		
		A	B	C	A	B	C
Plan A (vegetable)	75	3,290			6,157		
Plan B (fruits)	65		160			2,755	
Plan C (vegetable & fruits)	70			1,870			3,964
Present & proposed	345-355	6,590	3,960	5,200	20,463	17,061	18,270

In the UAE, the highest economic effect is given to cucumbers, in the farming, being followed by dates, sweet melons, cabbages, decidious tree-crops, citrus fruits, and mangoes come last. The gross income was estimated at DH 6.1 million from vegetable cropping, while the managerial costs was estimated at DH 2.4 million. For fruit cropping, the economic merits of date palm cropping and other fruit-tree cropping rank first and mango cropping and citrus fruit cropping follow in the order. The gross income of the fruit farming was estimated at DH 2.7 million, while the managerial cost at DH 1.5 million. In this estimation, the existing farms, mainly occupied by the data palm plantations, were represented in the production by dates, and the gross income of dates production was estimated at DH 12.2 million, while the managerial costs at DH 1.1 million. All of these estimation was made based on the following yield estimate.

(2) Yield (Fruit cropping)

Although the yields of the winter crops in the country, fluctuating year by year as shown in Appendix A.4.3-2, these yields were taken up as references for working out the target yields as follows:

Fruit Crops	Spaces between Trees	No. of Trees (plant/ha)	Target Yield (kg/plant)	Production (ton/ha)
Dates	6 m x 6 m	278	60	16.6
Citrus fruits	7 m x 7 m	204	50	10.2
Mangoes	7 m x 7 m	204	55	11.2

The above target yields were estimated for the trees more than 16 years of age for dates/citrus and 11-15 years for mango, which are defined in the guideline of fruit cultivation in the UAE. However, the yield in the existing date palm plantations was estimated by 60 percent of the above target yield due to having had poor fertilization and farming works.

(3) Yield (Vegetables)

In referring to the average yields of the statistics covering a period from 1977 to 1979 and the data obtained in the Agricultural Research Station, Sulymat Al Ain, the following target yields of vegetable croppings are prepared by taking 70 percent of the values resulting from the Al Ain station in due consideration that the Project will employ the drip irrigation system; however, the target of melon is set at the average of the result in the Al Ain station.

Yield per Hectare

Vegetables	Statistics (ton/ha)	Results in Al Ain Station (ton/ha)	Target Yields (ton/ha)
Melon	21	20 - 30	25
Tomato	31	90	63
Egg-plant	39	55	39
Cabbage	24	55	39
Cucumber	21	20 - 30	25

(4) Agricultural Production

° Vegetable Farm (75 ha and 30 ha)

Crops	Acreage (ha)	Unit Production (ton/ha)	Total Production (ton)
Melons	25.0 (9.6)	25	625 (240)
Tomatos	16.0 (6.3)	63	1,008 (397)
Cucumbers	16.0 (6.3)	25	400 (158)
Egg-plants	16.0 (6.3)	39	624 (246)
Cabbages	16.0 (6.3)	39	624 (246)
Total	64.0 (25.2)		2,656 (1,047)

Note: Figures in parenthesis indicate the production per 30 ha.

° Fruit Farm (65 ha and 40 ha)

Tree-crops	Acreage (ha)	Proposed Unit Yield (ton/ha)	Total Production (ton)
Date	10.0 (6.0)	16.6	166 (100)
Citrus-fruits	19.5 (12.0)	10.2	199 (122)
Mangoes	10.0 (16.0)	11.2	112 (67)
Decidious tree-crops	17.0 (10.0)	10.7	182 (101)
Total	56.5 (34.0)		659 (390)

Note: Figures in parenthesis indicate the values per 40 ha.

° The production of the existing vegetable farm of 50 ha was estimated at 70 percent of that of the proposed new vegetable farm.

° Existing date palm plantation (230 ha)

Crop	Proposed Unit Yield (ton/ha)	Total Production (ton)
Date palms	10.0	2,300

The detailed information can be referred to in Appendix A.4.3-14.

(5) Water management

In the Project, the water management should be exercised for the total area of 115 to 125 ha including 50 ha of the existing vegetable farms and 65 to 75 ha of the proposed farms.

Irrigation for farms has been carried out under the water management of the employee farmers by their own judgement. Such individually different way of water management, however, should be improved to the rationalized way so that irrigation can be made properly to each farm. To realize the rational water management, an adequate water requirement for each farm should be estimated first in reference to the records of the farm registration to the Dibba agricultural office, and then, the adequate water amount should be allocated to the plantations by pumping hours computed from the pump capacities. Upgrading of the existing earth-lined ditches should be made by replacing with pipeline systems for efficient water conveyance.

For the proposed vegetable farms and fruit farm, the watchman in charge of water management, which is to be organized in each farm, should control the water amount to meet the designed irrigation requirements. In each farm, the proposed pumping facilities and storage tanks should be operated functionally to supply the waters to each irrigation block. At the irrigation plot, the drip irrigation system should be monitored with tensiometers equipped with at irrigation block to secure adequate water supply through reasonable water management.

On top of the above, water quality analysis and groundwater table measurement should be made for several wells in each farm and plantation to provide reference data for planning the annual water use.

4-4. Preliminary Design of Facilities and Cost Estimation

4-4-1. Recharging Facilities of Groundwater

(1) Dams

The Project aims to retain within the wadi basins the flood discharge presently flowing into the Oman Gulf ineffectively once or twice a year, and simultaneously to infiltrate the flood was into gravel plains for recharging groundwater. Therefore, the proposed facilities will be given the functions to control floods and to recharge groundwater. The dam sites have been selected on the four major wadis taking into consideration the following general requirements of a dam site;

- The wadi bed between the both abutments is narrow, and so, a small dam body can avail;
- The both abutments are well consolidated, and have favorable geologic conditions;
- In general, the lower reach of a wadi is more advantageous that the upstream reaches in the aspect of groundwater recharge and flood control; and,
- Terrace deposit layers should be avoided in dam construction where possible.

In general, the Wadi Al Bassierah basin is divided into the following four geological zones;

- Limestone zone on the left bank of lower reaches of the Wadi Al Bassierah basin;
- Serpentinite zone on the right bank of the Wadi Al Bassierah basin;
- Schist zone on the left bank of upper reaches of the wadi Al Bassierah basin; and,

° Terrace deposit layers, i.e., wadi deposit of gravels.

Under the circumstances, the proposed dam sites are underlain by one of the above-mentioned rocks or terrace deposits.

The proposed dam sites have the following conditions;

(2) Abadellah dam site

The dam site is located on the lower reach of the Wadi Abadellah, a tributary of the Wadi Al Bassierah. The terrace deposit of gravels accumulated on the wadi bed in old time has been down-cut, and the down-cut portion forms the present wadi bed. The both abutments have vertical sections.

The right abutment of Abadellah dam site is geologically composed of clastic serpentinite whereas the left abutment is of green schists. The terrace deposit of gravels once formed on the wadi bed has been partially down-cut, and the down-cut portion froms the present wadi bed. Under the situations, the both abutments at this dam site are actually composed of the terrace gravel layers.

(3) Uyaynah dam site

The proposed dam site is located about 1.5 km upstream of the end of the Wadi Uyaynah. The both abutments of this dam site have the gradient of 1/2.5. The right abutment is composed of green schist, whereas the left crystalline schist.

(4) Al Bassierah dam site

The proposed dam site is located about 12 km inland of the Dibba coast along the Wadi Al Bassierah main course. The topography at the dam site is constrictive. The wadi bed is about 900 m wide at the dam site. The right abutment has the gradient of 1/1.0, whereas

the left 1/2.8. The right abutment is composed of siliceous serpentinite, whereas the left calcuceous schist which crops out on the mountain foot slopes. The bed rock is detective at a depth of about 50 m below the wadi bed. The bed rock is overlain by cemented gravels.

(5) Al Fay dam site

The proposed dam site is located about 1.5 km upstream of the lower most of the Wadi Al Fay. The wadi bed is about 150 m wide a the dam site. The left abutment has the gradient of 1/1.6 whereas the right 1/1.5. The left abutment is composed of metamorphic limestone, whereas the right abutment green schist. Gravels lying on the wadi bed have been cemented to a certain degree.

(6) Proposed dam type

Dams to meet the above-mentioned requirements are roughtly classified into the concrete and rockfill dams as described below;

1) Concrete dam

The most advantageous dam site has been selected on each wadi in consideration of the above-mentioned general requirements of such dams. However, dam sites so selected have wide wadi beds, and are overlain by thick wadi deposits. Furthermore, abutments of these dam sites have been weathered to a great extent. Under the circumstances, these dam sites are not considered advantageous in construction of a concrete dam.

2) Rockfill dam

Wadis of various shapes have been formed in the mountainous zone of the eastern UAE. In general, these wadis have formed so-called "gravel plain" on their lower reaches. Aparting from it, all the proposed dam sites are located near the gravel plain along the Wadi

proposed dam sites are located near the gravel plain along the Wadi Al Bassierah main course. Therefore, it is economically advantageous to utilize gravels for construction of dams. Taking into consideration the required functions of these dams to retain flood discharge and filtrate the flood water into the gravel plain as well as the economic construction, the following dam types have been proposed;

Type	Descriptions
A. Storage-type	A great volume of the dam water would evaporate in case of a dam of this type, resulting in a big loss of the dam water. The growth of aquatic plants and outbreak of bacteria would cause a poor water quality.
B. Overflow-type	The dam body filled with gravel would have a problem in its stability when a flood overflows the dam even if a short time.
C. Non-overflow type	In order to release discharge inclusive of floods from the upstream wadi, a dam of this type will be constructed with a spillway and pipe outlets.
D. Dispersion type	A dam body filled with relatively large gravels and rocks will well function to disperse to the downstream basin discharge concentrated at the dam.
E. Diversion type	A dam of this type functions to divert the water into a gravel plain and contributes to artificial recharge.

Among the above-mentioned dam types, the types C and D have been proposed for the Project.

In the basin, the above C type and D type of the dam facilities will be considered adoptable to the proposed site, in taking into account the study on the specific characters of various dam types. As mentioned already in the paragraph on Development Plan, however, the sporadical provision of the facilities on the tributary wadis is not expected to exert the favourable effect for groundwater recharging as a whole, but the dam construction (type C) across the Wadi Al Bassierah in the mid-basin and the dike type pond construction (Plan C'-9) will be most suitable. Therefore, the proposed dam will be of type C.

(7) Dam's design criteria

1) The facilities which are to augment recharge of groundwater are dam for storing flood temporarily and dike of low height. The design criteria for the dam are applied in principle in accordance with structural standard for River Administration Facilities etc. by cabinet order Concerning and Enforcement of Structural Standard for River Administration Facilities etc. and Ministry of Construction Ordinance in Japan.

At the design of spillway, the probable flood of once in 10,000 years is applied as design flood considering unexpected flood characteristics due to shortage of long term hydrological data and some examples applied for Wadi Bih and Wadi Ham projects in UAE. Accordingly, the expected flood at dam site on main stream of Wadi Al Bassierah is 2,320 cu.m/sec per 122 sq.km of catchment area, and that for Al Fay pond is 780 cu.m/sec per 26 sq.km.

2) The dam which is to be constructed on the main stream of Wadi Al Bassierah is planned as a zone type fill dam embanking the center zone with river bed material to save the construction cost. The upper and lower stream zones of the dam body are filled with rock material from viewpoint of stability of structure.

3) The center zone is embanked with sand and gravel material borrowed from river bed which consists of less than 200 mm diameter, and the expected permeability of zone if below 10^{-4} cm/sec after compaction. The filter drain of 2.0 m horizontal thickness with secreened sand and gravel material is to be provided between the center zone of sand and gravel and the rockfill zones of upper and lower stream sides to prevent the piping phenomenon of sand and gravel material and to decrease pore water pressure. At the bottom portion of down stream of the rockfill zone, a horizontal filter drain is to be provided with vertical thickness of 1.0 m for the same purpose as mentioned above.

4) The upper and downstream slopes of dam are to be riprapped in 0.5 m thickness with selected rock material of larger than 200 mm diameter considering wave erosion and weathering because the rock material available at the site contains the altered surpentinite.

(8) Dam body and spillway

1) Dam body

The proposed Al Bassierah dam has a purpose to control and store the flood waters taking place in the commanding catchment area (122 km^2) and simultaneously to recharge the groundwater with the stored water infiltrating through reservoir area and an outlets to be provided.

The dam size should be determined to meet the above requirements. As mentioned previously in the paragraph on alternative study on

three cases of the water resources development plan, according to the direction set up therein, the proposed dam should have capacity of 2.5 MCM in temporal storage with outlet with 1,420 mm in diameter. Hence, the dam dimensions were determined as follows in taking into account the topographical conditions of the dam site.

Full water surface level	115.00 m
Overflood depth of spillway	5.50 m
Design flood water level	120.50 m
Freeboard	2.00 m
Crest elevation	122.50 m
Height of Dam	19.50 m

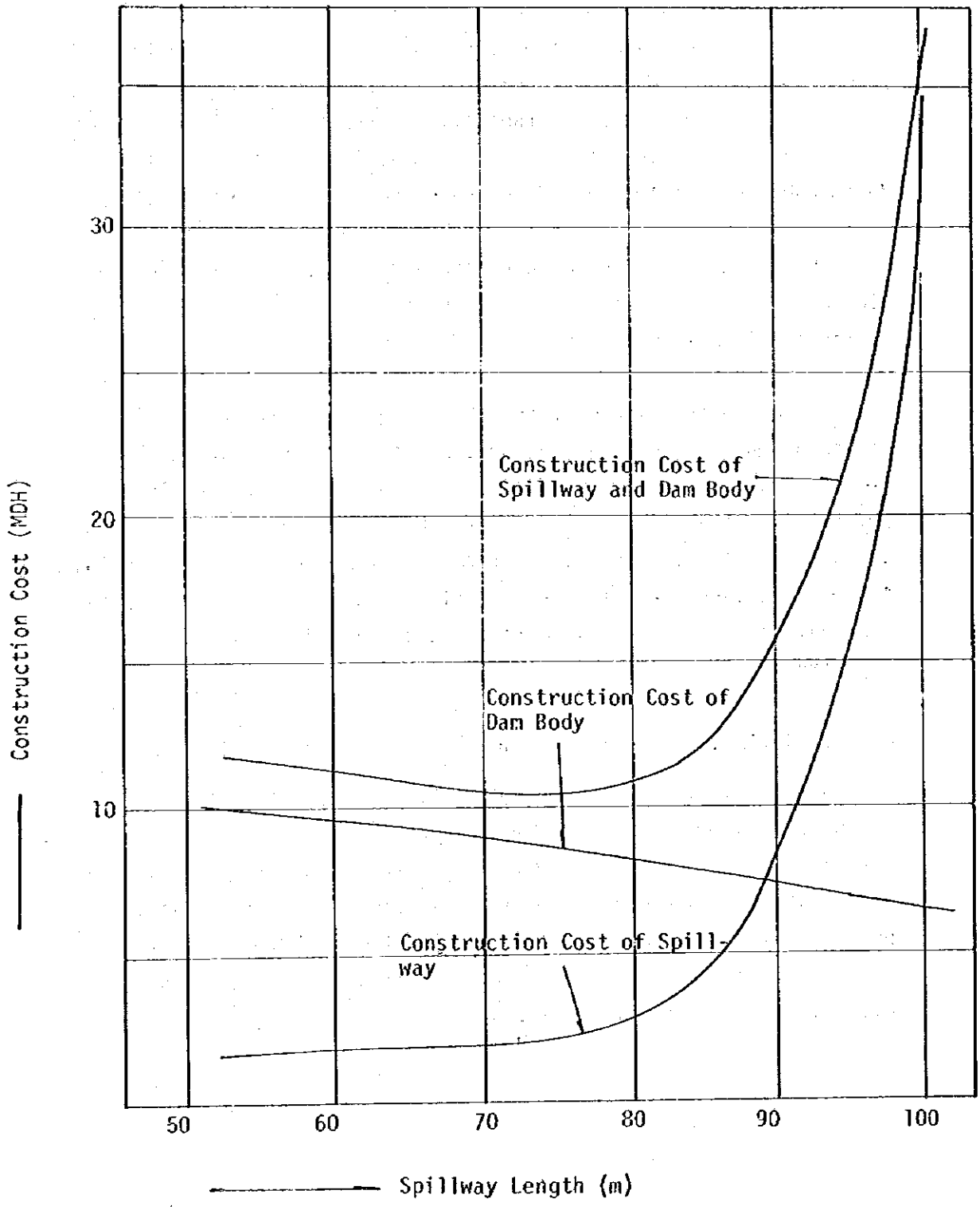
The hydraulic factors and the typical dam section are shown in Fig. 4-6 and 4-4.

The sediments deposited in the reservoir are to be removed every year, but for first 19 years, it will be no need to do sediment removal because the embankment materials shall be borrowed from the reservoir area. The sediment to be deposited in the reservoir was estimated at 20,000 m^3/year in due consideration of the conditions topography, geology and rainfall in the basin. The details are illustrated in the Appendix A.4.4-1.

2) Spillway

The spillway of the Al Bassierah dam, whose dam body consists of river-bed gravel materials and rock materials as filt-type dam, should be provided independently from the dam site with overflow type. The spillway site was proposed at the right bank saddle portion, where the overflow type embankment with 75.5 m length is to be constructed as a result of comparative study made on construction costs for several cases. The results of comparative study is shown in Fig. 4-13.

Fig. 4-13 Relation between Spillway Crest Length and Dam Body, and Construction Cost of Spillway



(9) Pond

At the design of dike of low height, the central section of dike is designed as overflow type considering that the dike is to be embanked with river bed material mainly. The overflow section is to have at the maximum dike height of 6.0 m, overflow depth of 2.0 m and overflow discharge per unit length of 4.8 cu.m/sec to pass flood smoothly keeping stability of structures. The maximum height of non-overflow section is 9.0 m adding 2.0 m of overflow depth and 1.0 m of free board to the height of overflow section.

The typical sections of overflow and non-overflow sections of dike based on such design criteria are shown in Fig. 4-5 and other hydraulic dimensions are shown in Fig. 4-6.

Since the overflow portion, which requires further stability if the height exceeds 6.0 m, should be concrete structure. The concrete-overflow type dam of this kind, being costly, should be omitted from the objectives in this study. Accordingly, the dimensions of the Al Fay Pond were determined as 2.0 km for dike length, 4.5 m for embankment height at overflow portion, 7.5 m for embankment height of non-overflow portion, and 1.5 MCM in the storage capacity.

4-4-2. Wells and Pumping Stations

Geological surveys conducted to find the water sources for the proposed farms revealed that the favourable aquifers would exist within an area at the elevation ranging from 40 m to 100 m in the gravel plain downstream of the Al Bassierah dam. Hence, the proposed wells should be drilled at the locations within that extent as shown in the figure. The expected well depth and the water available for lifting were determined as follows:

- Well depth: 40 m
- Groundwater table: 25 m from GL (in case of 1.0 m drawdown of the ordinary table)
- Water available for lifting: 3,000 m^3/day (possible in continuous pumping)

These data allow to determine the dimensions of the pumping facilities as follows:

- Amount pumped-up: 2.10 m^3/min
- Lift: 40 m
- Type of pump: Submerged pump (ø125 mm)
- Power output: 22 KW
- Well diameter: 300 mm

The typical drawing of the pump is illustrated in A.4.4-7, 4.4-8, Appendix. The 10 m-elevated delivery tanks will be provided at the points close to the farms in taking into account the head loss for conveyance to the terminal facilities and the irrigation method. Number of the wells are shown as under and in addition to the said wells, one spare well will be provided in considering operation and maintenance of the facilities.

Alternative Plan	Objective Area (ha)	Water Requirement (m^3/day)	Lift Amount (m^3/day)	No. of Wells
Plan - A	75	2,250	3,000	3
Plan - B	65	2,250	3,000	3
Plan - C	70	2,250	3,000	3

The total cost required for providing these wells was estimated at MDH 0.57 on the basis of the cost per well by MDH 0.19, which can be brokendown to DH 37 thousands for well facilities and DH 153 thousands for pump facilities.

4-4-3. New Farm and Irrigation Facilities

The proposed sites of farms are currently the gravel plain that requires the land improvement for growing crops. Gravel removal and top soil dressing by fertile soils taken at the mountain foot or in the Basin will be essentially required for land improvement. The unit farm plot is designed by 0.5 ha, equivalent to the average acreage of the present land holdings per farm household, which will allow mechanized farming to be introduced. Pipeline systems will be employed for irrigating these farms so as to minimize the conveyance loss to the terminal fields for the possibly efficient use of precious water resources.

The details of the facilities are illustrated in Fig. A.4.4-5, to 4.4-7, Appendix. The necessary construction cost of the farms was estimated at DH 30 thousands per 0.5 ha, and the breakdown is made as follows:

Description	Amounts (1,000 Dirhams)
Irrigation facilities	10
Gravel removal, top soil dressing and roads	15
Fence, others	5

Consequently, the total construction cost for the farm is estimated at MDH 3.9 to MDH 4.5 within Plan A, B and C. On the other hand, the inprovement existing vegetable farm of 50 ha is estimated at MDH 5.3, and the breakdown is DH 46 thousands per ha for pump and DH 60 thousands per ha for irrigation facilities, if required in future.

4-4-4. Observation Equipment

In addition to appropriating the existing rain gauges and water level meters in the wadis and the wells, the water level meters at the proposed dam site for gauging the flood discharges and gauging groundwater level should be relocated to the adequate points and new staff gauges should be provided for gauging the water level in the reservoir, a tube well with 100 mm dia pipe will be installed to m downstream of the dam site for monitoring the profile of the groundwater, and furthermore, the existing wells of BH-1 and TW-3 will be used for monitoring wells against sea-water intrusion providing 150 m in depth and PVC pipes of ϕ100 mm x 60 m for water table observation and ϕ450 mm x 120 m for monitoring sea-water intrusion. The sea-water observation will be made by electric conductivity indication.

Number of locations of these equipment is shown as follows:

Rain gauges:	8 places
Water level meters:	7 places
Water table gauges:	8 places (one proposed)
Monitoring wells:	2 places

4-4-5. Project Cost

The implementation schedule of the water resources development plan and water allocation plan is discribed as follows by specifying the work volumes, construction cost and implementation program.

(1) Work volumes

The proposed facilities and the related dimension are shown as follows:

° Al Bassierah Dam:	Dam height	19.5 m	Length	900 m
	Storage capacity	2.5 MCM	Dam volume	0.64 MCM
° Pond:	Embankment Height	7.5 m	Length	2.0 km
	Storage capacity	1.5 MCM	Dam volume	0.55 MCM

° Irrigation Facilities and Farms

Plan A: (a) Vegetable farms: 75 ha to be developed

Plan B: (a) Fruit farm: 65 ha to be developed

Plan C: (a) Vegetable farm: 30 ha to be developed (b) Fruit farm: 40 ha to be developed

(2) Project cost

The Project cost consists of the construction cost and administrative cost (managerial cost + engineering fee), and the construction cost comprises the direct construction cost, overhead cost, and temporary works' cost. The direct construction cost was estimated by applying the unit costs used by Ministry of Public Works and Housing in 1980. And the overhead costs and costs for temporary works were estimated at 50 percent of the direct construction cost. The breakdown of the Project cost is shown below.

(Unit: Million Dirham)

° Cost for groundwater recharging facilities

Al Bassierah Dam:		25.7
Al Fay Pond	:	15.9
Sub-total	:	41.6

° Cost for irrigation facilities and farms

Plan A	:	6.6
Plan B	:	5.8
Plan C	:	6.2

The plan-wise total costs are shown as follows:

Cost for Plan A: 48.2
Plan B: 47.4
Plan C: 47.8

Details of these project costs are shown in Table 4-14.

Table 4-14 Details of the Project Cost

(Unit: Million Dirham)

Item	Cost for groundwater recharging facilities			Cost for irrigation facilities and form			Total		
	Al Bassieran Dam	Al Fay Pond	Sub-total	A	B	C	A	B	C
(1) Direct Const. Cost.	19,755	12,238	31,993	5,070	4,470	4,770	37,063	36,463	36,763
(2) Administration Cost									
Adm.[5% of (1)]	988	612	1,600	254	223	239	1,854	1,823	1,839
Engineering fee [10% of (1)]	1,976	1,224	3,200	507	447	477	3,707	3,647	3,677
Sub-total	2,964	1,836	4,800	761	670	716	5,561	5,470	5,516
(3) Preparation Cost [15% of (1)]	2,964	1,836	4,800	761	670	716	5,561	5,470	5,516
Total	25,683	15,910	41,593	6,592	5,810	6,202	48,185	47,403	47,795

The costs for the respective facilities are brokendown to be shown in Appendix Table A.4.4-7 to 4.4-9.

CHAPTER V. PROJECT IMPLEMENTATION, OPERATION AND MAINTENANCE

5-1. Implementation Programme and Construction Schedule

5-1-1. Implementation Programme

The Wadi Al Bassierah Basin Water Resources Development Project was built up as a 3.5-year project by initiating the related feasibility study in December, 1979. The project cost has been estimated at 47.8 MDH on the basis of the unit prices as of October, 1980 in the UAE to cover the development plans for both water resources and agriculture. Among many project components, the Al Bassierah dam construction will start in 1981 in response to the strong request of the UAE authorities concerned for early implementation of the works.

(1) Al Bassierah Dam

Studies on some water resources development plans in the eastern UAE have already been completed and are about to entire into the implementation stage. As for the water resources development in the Wadi Al Bassierah as well, the minutes for technical cooperation in the construction of Al Bassierah dam which is part of the comprehensive water resources development program in region inclusive of the Wadi Bih and the Wadi Ham development plans were prepared by the MAF and a survey team dispatched by the JICA in March 1981.

As regard the work schedule for Al Bassierah dam, the detailed design and the preparation of tender documents were compled in October 1981, based on the selected alternative plan, for starting the construction in the early part of the year 1982 and for completing it in the middle of 1983.

(2) Al Fay Pond, Irrigation Facilities and Farms

The construction of Al Fay pond, improvement of vegetable farms and construction of irrigation facilities and new farms are scheduled to follow the construction of Al Bassierah dam. The execution schedule is shown in Figure 5-1.

5-1-2. Construction Schedule

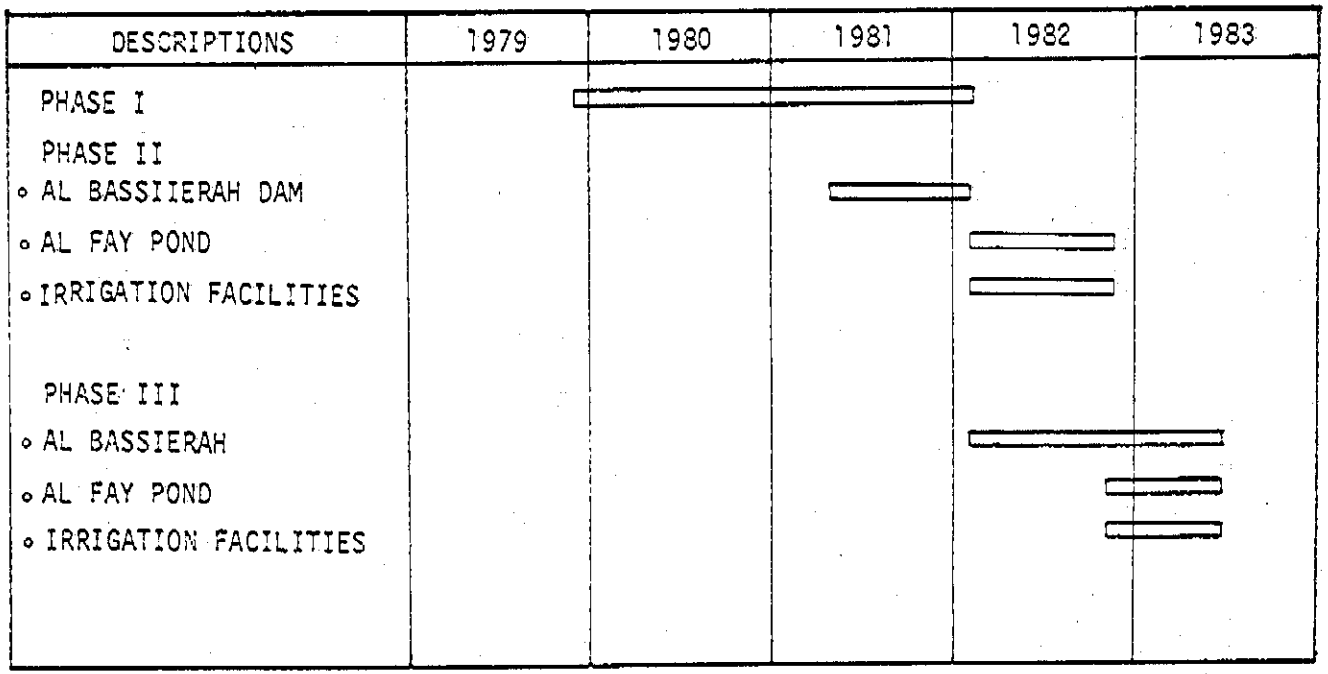
(1) Constructoin of Al Bassierah Dam

The construction works of Al Bassierah dam (Length: 890 m, Height: 19.5 m, Volume: 0.64 MCM) will involve the dam body construction, provision of access road, relocation of electric poles, etc. The dam body construction, judging from its embankment volume of 0.64 MCM, will require more than one year of the construction period, and thereby, the construction will inevitably face floodings in winter. In due consideration of such conditions, the construction shall be executed by employing two-staged method that embankment is to be constructed for a part to cross the halfway of the flow in width so as to keep the rest halfway of the flow for discharging the flood waters, and then, after the part is constructed, the remaining part of embankment is to be constructed.

It is scheduled to complete in a four-month period the preparatory works such as the preparation of survey and construction drawings, obtaining approval on these drawings, establishment of offices, warehouses and stock yards of construction materials, and carrying construction machines for temporary works into the construction site. And the construction of the dam body and floodway is scheduled to be completed in about 12-month period.

As mentioned already, the partial construction will be adopted for embankment in keeping the necessary flow course for the flood waters to be discharged so as to be completed by the end of the first winter season. The remaining part will be constructed by the following flood season. The sand and gravel materials, occupying

Fig. 5-1 PROJECT SCHEDULE FOR WADI AL BASSIERAH WATER RESOURCES DEVELOPMENT



about 58 percent of the total embankment materials needed, compose the semi-pervious zone of the embankment. These materials are obtained in the river bed excavation at the immediate upstream of the damsite and hauled to the site to be compacted. On the other hand, the rock materials, the remaining about 32 percent, are obtainable through spillway construction works at the right bank as excavated rocks, and the shortage will be hauled from the quarry site on the left bank. Furthermore, the river bed materials will be screened to obtain filter materials of the remaining 10 percent.

(2) Al Fay Pond and Irrigation Facilities

The water resources development in the basin involves Al Fay pond for recharging groundwater besides the above dam construction. This is a storage pond which will be provided in the low-lying land in the gravel plain along with the topography. The storage pond will be constructed by comparatively simple works of gravel excavation, hauling and embankment.

The construction of Al Fay pond is comprised of the provision of new wells, pumping facilities, pipelines, farm lands by top soil dressing, etc., and also improvement of the existing pumping facilities and pipelines system. The construction will be completed within about one year.

5-2. Operation and Maintenance of the Project

5-2-1. Organization

(1) Water Utilization Committee (WUC)

Completion of the Wadi Al Bassierah Basin Water Resources Development Project will essentially require the UAE authorities concerned to perform the operation and maintenance of those facilities for recharging groundwater, pumping, rainfall observation, water level observation in the related wadis and water table observation wells. Currently, the water resources development projects and agricultural development projects in the UAE have been administered by the MAF,

while the domestic water supply projects by the Ministry of Electricity and Water (MEW). Consequently, the operation of the projects in the Basin will have to be under control of the said two Ministries. In this connection, it is proposed to establish a committee in charge of water utilization, temporarily named Water Utilization Committee (WUC), which will consist of the members to be assigned by the both Ministries of MAF and MEW, respectively and the WUC shall be responsible for controlling the water utilization in the whole Basin. The most effective and efficient water utilization is to make a reasonable.

(2) Organization for Water Management

The water management office, sub-organization of the WUC will be stationed at the existing Dibba Agricultural Office. As its organization chart is shown in Figure 5.1.2 this office will have two sections for management, operation and maintenance of facilities and for agricultural services. This organization will play an important role in the comprehensive operation and management of water in the basin. Specially, the operation and maintenance of Al Bassierah dam and the other facilities will be under the direct control of the MAF. However, the priorities in water use and the comprehensive operation, etc., will be made based on the decision of the WUC.

5-2-2. Operation and Maintenance Cost

Effective operation and maintenance of the facilities and equipment is inevitably required as the Project is completed with dam, recharging ponds and other various observation equipment.

The operation and maintenance will be carried out in the method mentioned above, and the necessary O/M cost is estimated as follows on the annual basis. In the estimation, however, the cost for office building and vehicles for the O/M was excluded because the Dibba Agricultural Office (MAF) opened in 1980 can spare the room spaces

for the purpose as well as the said office vehicles can be concurrently used.

The salaries of the staff are estimated as the present staff available in the Dibba Agricultural Office can be appropriated, and furthermore, the salaries of those staff who give guidance to the farmers of the local farms and new fruit farms were added in estimation premising that the personnels of Dibba Agricultural Office, the MAF, will be responsible for such works. The necessary number of personnels are allocated to the four types of occupation as follow.

Staff	Existing Farm: 280ha 230ha+50ha	Proposed Farm: 110ha 60ha+50ha	Al Bassierah Dam/others	Hydrological Meteorological Facilities	Total
Engineer	-	1	-	-	1
Technician	1	2	-	1	4
Driver	-	1	-	1	2
Laborer	-	-	2	1	3
Total	1	4	2	3	10

The total O/M cost was estimated at MDH 0.33, being brokendown into DH 0.27 for the salaries of the staff and employes, and DH 0.06 M for the O/M of the facilities and equipment. Such amount of the O/M cost can be allotted to four major facilities by DH 0.08 M each.

In addition, the costs of DH 100 thousands and DH 60 thousands will be required for removing sediment materials accumulated in Al Bassierah dam and Al Fay pond, respectively although such cost for Al Bassierah dam is not required during 19-year period since the wadi bed materials of 370,000 cu.m is excavated in the reservoir area of the dam to secure the embankment materials for the dam construction whereas the annual sediment accumulation is estimated at 20,000 cu.m.

CHAPTER VI. PROJECT EVALUATION

6-1. Outline

The Project as well as the wadi Bhi and wadi Ham project are the first water resources development works in the UAE, and attentions of the Oman gulf countries are focussed on these project with expectations of their success since these projects are going to be implemented under severe natural conditions peculiar to the Mid and Near East countries with dry climate and unfavorable soils where limited agricultural crops can be raised. Prior to the implementation of these projects, the UAE has, however, already made efforts for agricultural development through operation of agricultural experimental farms and extension of results of experimentations to farmers. The Project have the two targets of water resources development and agricultural development, and characterized by the preservation and management of water resources through strengthening the recharge of groundwater in consideration of the behaviors of surface runoff and groundwater peculiar to the Middle and Near East countries. With such background, the Project aiming to actively develop indispensable water for the life of inhabitants could be evaluated to bring about great social impacts to the basin. This kind of development projects will be taken up actively in future, however, it should be noted that water resources in a basin is not infinite. The Project evaluation is described hereinafter.

6-2. Economic Evaluation

(1) Project Cost

The direct cost employed for the cost-benefit evaluation consists of the construction cost, administration cost and engineering fee. The major construction works are made for Al Bassierah dam, Al Fay pond, proposed farms of 65 to 75 ha and irrigation facilities. The Project cost is estimated at DH 47.8 millions as its yearly breakdown is shown in Table 6-1.

Table 6-1 Breakdown of the Project Cost by Years

(Unit: DH 1,000)

Descriptions	1982	1983	Total
Al Bassierah dam	13,900	5,900	19,800
Al Fay pond	3,700	8,500	12,200
Irrigation facilities	1,400	3,400	4,800
Administration cost/ Engineering fee	4,800	700	5,500
Contingency	3,000	2,500	5,500
Total	26,800	21,000	47,800

(2) Unit Cost of Raw Water

The unit cost of raw water to be developed under the Project has been estimated taking into account the construction cost, interest rate, construction cost, depreciation rate, O/M cost and some other factors as mentioned above, the unit cost of raw water, with the construction cost of DH 32.0 millions, is DH 3.6 which is within the production cost of fresh water at the desalination plants presently under construction which ranges from DH 1.3 to 6.4 per cubic meters. Based on the current unit price of water supplied to Dibba amounting to DH 3.3 per cubic meter (1.5 fils/gallon), the rechargeable groundwater of 0.9 MCM/annum under the Project is evaluated to bring about the benefit of DH 3.0 millions. In addition since the Project strengtheus the recharge of groundwater in the basin through the operation of the dam and pond, it will play the role to preserve the water resources and to control water quality, however, the benefit derived from them is not evaluated in this report.

6-3. Financial Evaluation

The benefit of agriculture in this Project will accrue from an increase in production realized by stabilized water supply to farm lands in the downstream area through recharging groundwater as for the beneficially areas, three alternative plans have been

formulated, that is, vegetable farms plan of 75 ha, fruit-tree plantations plan of 65 ha and the combination plan of vegetable farms of 36 ha and fruit-tree plantations of 40 ha (totally 70 ha).

(1) Price of Agricultural Products and Labor Cost

The full yield of fruits can be expected in the 11th years after their transplanting, therefore, the full benefit in the entire fruit-tree plantations will be attained in the 12th year after construction of the plantations. As regards the vegetable farms, the full benefit is attained in the first year after the completion of the construction. The agricultural production by years is shown in Table A.4.3-4 of Appendix.

The cost of farm products is taken by the farm gate price at Dibba in 1980. The conversion rate of the foreign exchange is US$ 1.00 = DH 3.6 (Day Work, July, 1980, by Ministry of Public Works and Housing). The shadow prices were not taken into account in this study.

° Labour

In the UAE, there exists a difference in quality evidently observed between family labour and hired labour. As family labour in most cases, only a family head engages himself in managerial works and not in physical works, whereas the alien labourers are employed for farming works. Female members of the farm family are never engaged in the farming works. Because the hired labour is regarded as an investment in the Country, the farm labour cost will not be deducted from the waged-labour cost. The waged-labour cost, however, should be deducted from the total production.

The completion of this Project will evidently increase labour demand for the newly developed farms, and a part of such labour to meet the demand can be appropriated from the labour to have been employed for the Project construction works. Since the farm labour evaluation is made by the labour contract on the yearly basis, the

estimation of the opportunity cost has not been carried out in this study. The labor demand in the three alternative plans is computed as follows:

Plan A:	Vegetable farms (75 ha)	590	man-months/year
Plan B:	Fruit-tree plantations (65 ha)	410	-do-
Plan C:	Vegetable farm (30 ha) and Fruit-tree plantations (40 ha)	470	-do-

(2) Agricultural Production

The facilities will allow to recharge the groundwater of about 0.9 MCM per annum, on the basis of which the water charge for irrigation per hectare can be estimated at DH 37,600 , DH 72,200 and DH 53,900 in the above-mentioned plans A, B and C, respectively. On the other hand, the net income per hectare from the new farms or plantations or the both is computed at DH 4,800 in Plan A, ΔDH 38,100 in Plan B and Δ DH 21,900 in Plan C. The details can be refered to Tables 4.3-15 and 4.3-16 of Appendix. Under the situation, the new fruit farm, the water cost for which shall be subsidized by the Government, should be operated as the pilot farm on farm management farming techniques extension in anticipation of its social impact.

In summary, the existing date palm plantation will produce some benefit in taking into account the water cost, while the vegetable farms will gain the benefit of more than DH 4,800/ha, and the new fruit farms (Plan B, C) are not expected to produce benefit due to reduction of the benefit rate by long-term investment for full production after planting new seedlings.

6-4. Social and Economic Impacts of the Project

The Project, together with the Wadi Bhi water resources development project facing the Arabian gulf and the Wadi Ham water resources

development project facing the Oman gulf, is the focus of attentions, with the expectation of its success, of the neighboring Middle and Near East countries where the water resources are limited. These three projects are foremost in the UAE, therefore, expected to take the lead of future water resources development in the UAE. With such background, the Project will enable to stabilize the domestic and irrigation water supply to inhabitants as evaluated above, and simultaneously bring about various social and economic impacts. In addition to the stabilization of the peoples livelihood, the following impacts are expected;

(1) Increase in Self-sufficiency Rate of Food

The present agricultural lands are near to a wilderness though some improvements have been made. Irrigation water partially depends on the flood discharge. The flood discharge is diverted to farms both for irrigation and for recharging groundwater. However, most irrigation depends on groundwater which is lifted through small shallow wells. The agriculture is extensive, resulting in a low productivity. However, Al Bassierah dam and Al Fay pond that will be constructed under the Project will increase the groundwater available, and the scheduled water supply and the control of groundwater use by designated aquifers from which groundwater is lift will be realized. In 1978 the UAE imported agricultural products of 688,000 tons (DH 1,690 millions) inclusive of fruits and vegetables of 292,000 tons (DH 496 millions). The Project will decrease such import of farm products by about 16% in quantity and by about DH 6.1 millions from the above amount. Therefore, the Project will be able to contribute to increase in the self-sufficiency rate of foods and will result in improvement of the international balance of trade.

Furthermore, the irrigation water supply under the Project will stabilize the agricultural production specially of vegetables. The present shallow wells cannot supply sufficient irrigation water in dry seasons, resulting in the unstabilized production of vegetables.

The stabilized water supply that is materialized under the Project will stabilize the production of vegetables and result in an increase of self-sufficiency rate of them.

(2) Disaster Prevention

Al Bassierah dam and Al Fay pond will play a role of disaster prevention for farm lands and housing areas in addition to their major functions to recharge groundwaer. Every flood changes the courses of wadis, resulting in a great hinderance of land use as well as in the necessity to make disaster prevention investments such as to the construction of dikes around farms. However commanding a half of the total catchment area of the Wadi Al Bassierah amounting to 260 sq.km, Al Bassierah dam to be constructed in the midstream of the Wadi Al Bassierah and Al Fay pond to be located in the Wadi Al Fay lower basin will contribute to the flood control to a great extent.

(3) Water Management

The augment of groundwater and the comprehensive and rationalized groundwater management will protect the groundwater in the basin from sea water intrusion, and preserve water in high quality. In addition to the effects in the aspects of soil management and conservation, the Project will be effective to preserve healthy living environment for inhabitants.

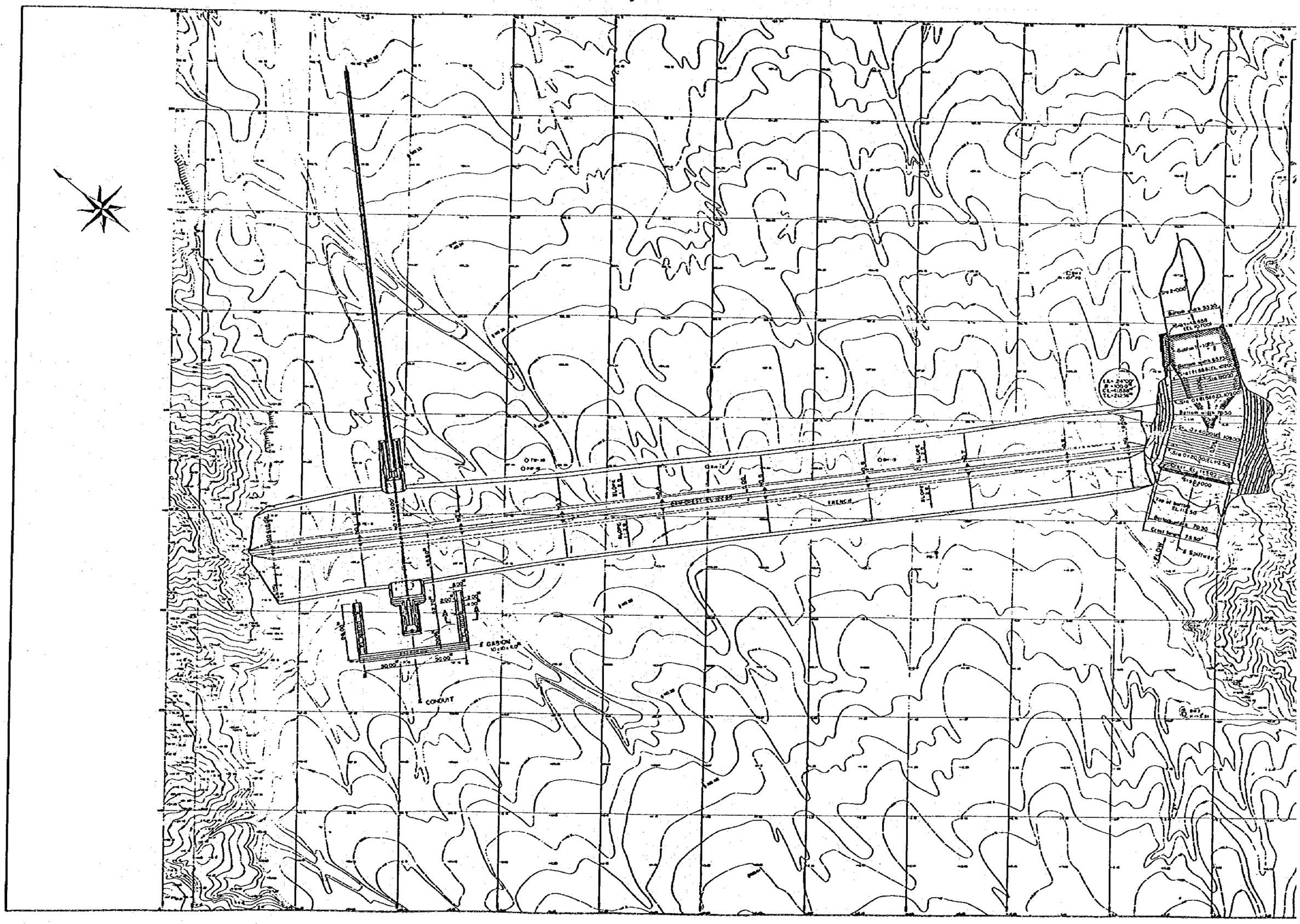
(4) Prevention of Soil Salination

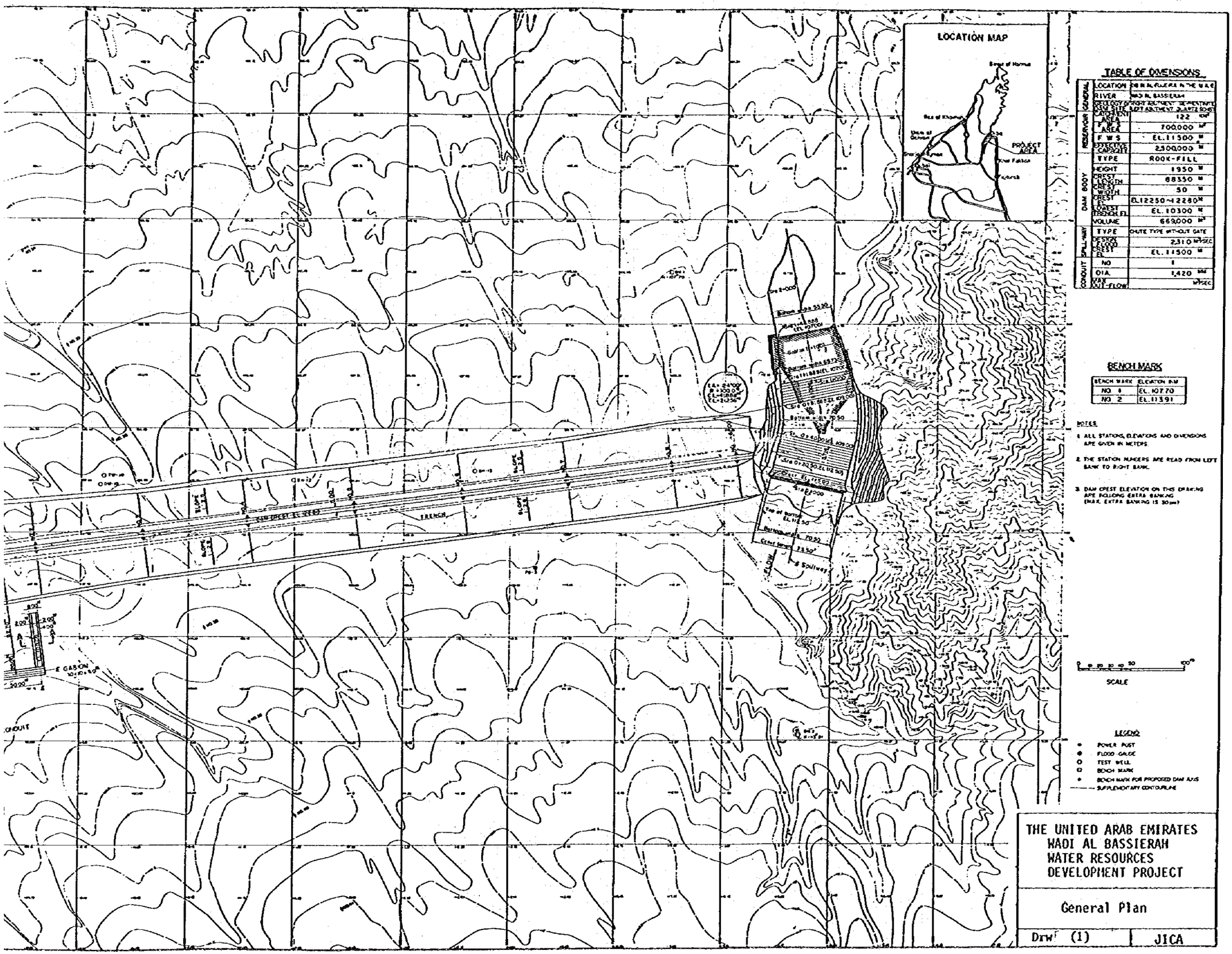
The present over-lifting of groundwater has caused soil salination in some parts of the lower basin near the coastal line. It is anticipated that the situation will get more serious if no groundwater management as mentioned above is made in the basin. The augment of groundwater under the Project will prevent the sea water intrusion, and the irrigation water in high quality will contribute to prevent soil salination and to maintain farm lands.

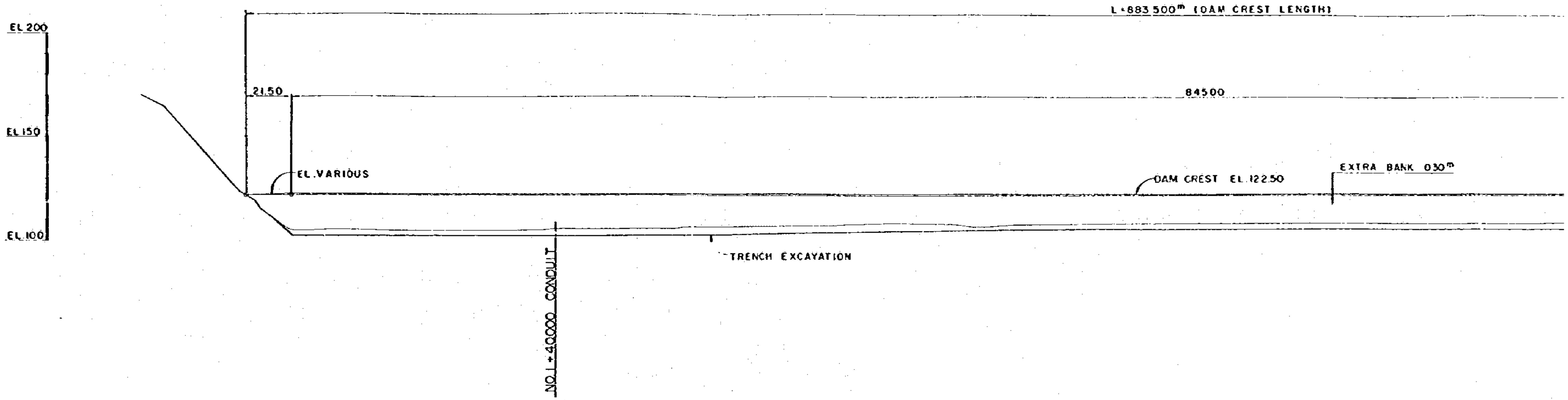
5) Increase in Employment Opportunities

The water resources development and stabilized water supply ealized in the Project will increase farm lands as a direct effect, nd contribute to the stabilization of the people's livelihood hrough supply of domestic and industrial water and to the building- p of foundation for industrial development as indirect effects, and n parallel with the growth of production/circulation and consump- ion industries, the Project will, no doubt, allow to expand the mployment opportunities.

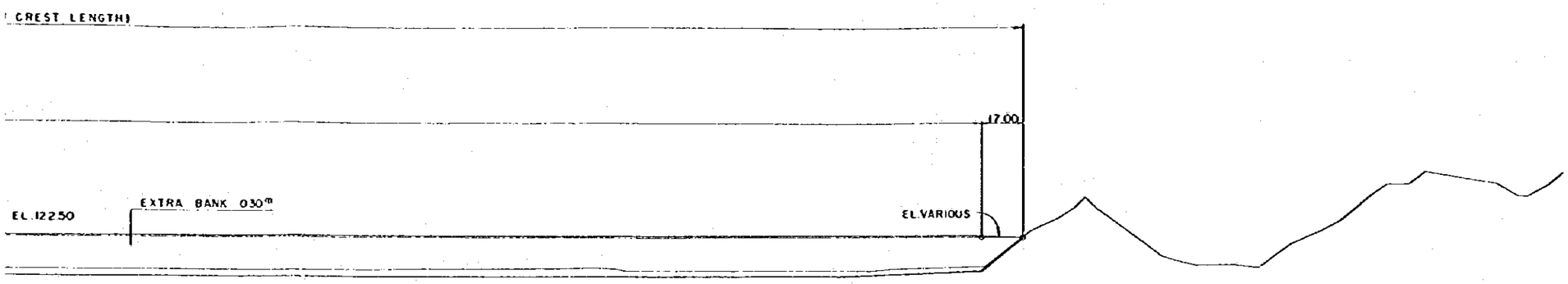
In consideration of the above-mentioned effects, the Project is udged to be justifiable.


CONDUIT


LOCATION MAP
PROJECT AREA
TABLE OF DIMENSIONS
GENERAL
RESERVOIR
DAM BODY
SPILL-WAY
CONDUIT
LOCATION
RIVER
CATCHMENT AREA
F.S.L. AREA
F.W.S
EFFECTIVE CAPACITY
TYPE
HEIGHT
CREST LENGTH
CREST WIDTH
CREST EL.
LOWEST TRENCH EL.
VOLUME
TYPE
DESIGN FLOOD
CREST EL.
NO
DIA.
MAX OUT-FLOW
BENCH MARK
BENCH MARK ELEVATION (m)
NO 1
EL. 10770
NO 2
EL. 11391
NOTES
1. ALL STATIONS, ELEVATIONS AND DIMENSIONS ARE GIVEN IN METERS.
2. THE STATION NUMBERS ARE READ FROM LEFT BANK TO RIGHT BANK.
3. DAM CREST ELEVATION ON THIS DRAWING ARE FOLLOING EXTRA BANKING (MAX. EXTRA BANKING IS 30cm)
SCALE
LEGEND
POWER POST
FLOOD GAUGE
TEST WELL
BENCH MARK
BENCH MARK FOR PROPOSED DAM AXIS
SUPPLEMENTARY CONTOURLINE
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES
DEVELOPMENT PROJECT
General Plan
Drw (1)
JICA



DAM CREST ELEVATION	122.500	122.590	122.800	122.800	122.800	122.800	122.800	122.800	122.800	122.800
TRENCH EXCAVATION ELEVATION	–	–	103.000	103.000	103.000	103.000	105.000	106.000	106.000	106.000
GROUND ELEVATION	122.500	115.500	105.000	105.000	106.000	106.000	108.500	108.500	108.500	108.500
TOTAL DISTANCE	0.000	10.000	25.000	110.000	150.000	210.000	310.000	410.000	510.000	610.000
DISTANCE	0.000	10.000	15.000	85.000	40.000	100.000	100.000	100.000	100.000	100.000
STATION	-6.500	NO. 0	+15.000	NO. 1	+40.000	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6



122.800	122.800	122.800	122.800	122.800	122.500				
106.000	106.000	106.000	106.000	108.000	123.500				
108.500	108.500	109.500	108.000	110.000	122.500	137.000		125.700	
510.000	610.000	710.000	810.000	870.000	887.000	910.000		1010.000	
100.000	100.000	100.000	100.000	60.000	17.000	20.000		100.000	
NO. 5	NO. 6	NO. 7	NO. 8	+60.000	+77.000	NO. 9		NO. 10	

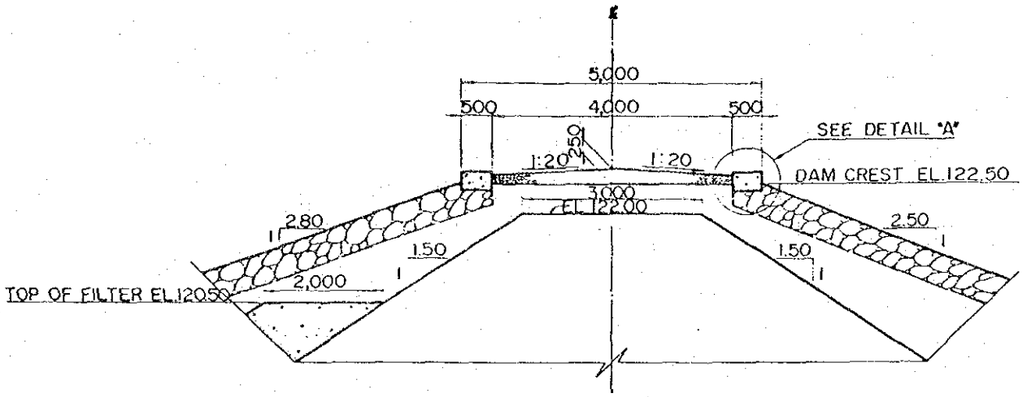
NOTE : ALL DIMENSIONS ARE GIVEN IN METER

0 50 100M
SCALE 1:1000

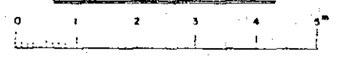
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES
DEVELOPMENT PROJECT

Longitudinal Profile of Dam Axis

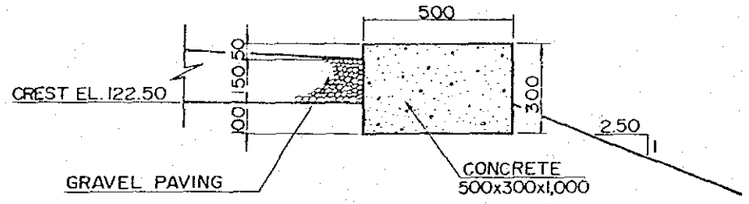
Drw (2) | JICA

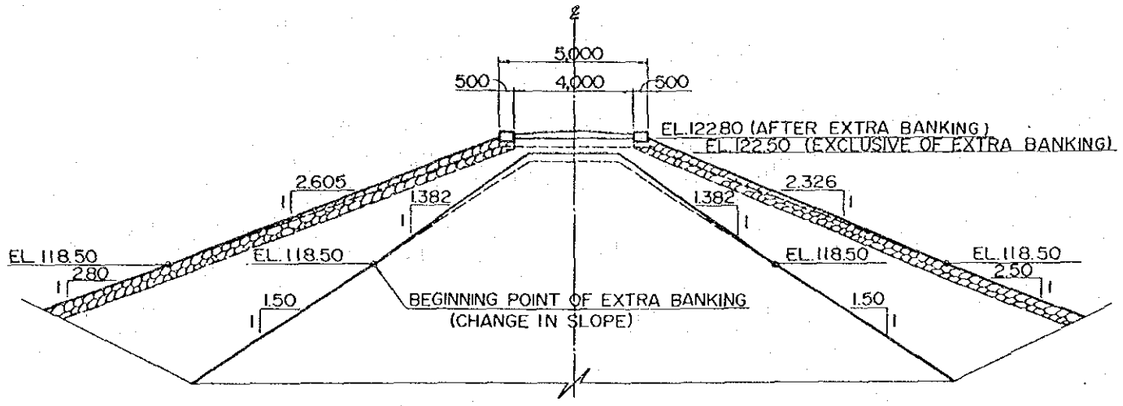


DETAIL OF CREST

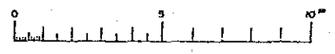


SCALE



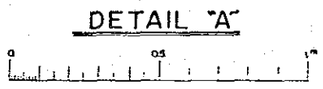


DETAIL OF EXTRA BANK



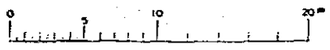
SCALE

DETAIL "A"



SCALE

TYPICAL SECTION



SCALE

NOTES:

(1) DIMENSIONS OF DETAIL DRAWINGS ARE GIVEN IN MILLIMETER.

(2) DIMENSIONS OF TYPICAL SECTION ARE GIVEN IN METER.

(3) EXTRA BANKING IS MAX. 30cm

THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES
DEVELOPMENT PROJECT

Typical Section

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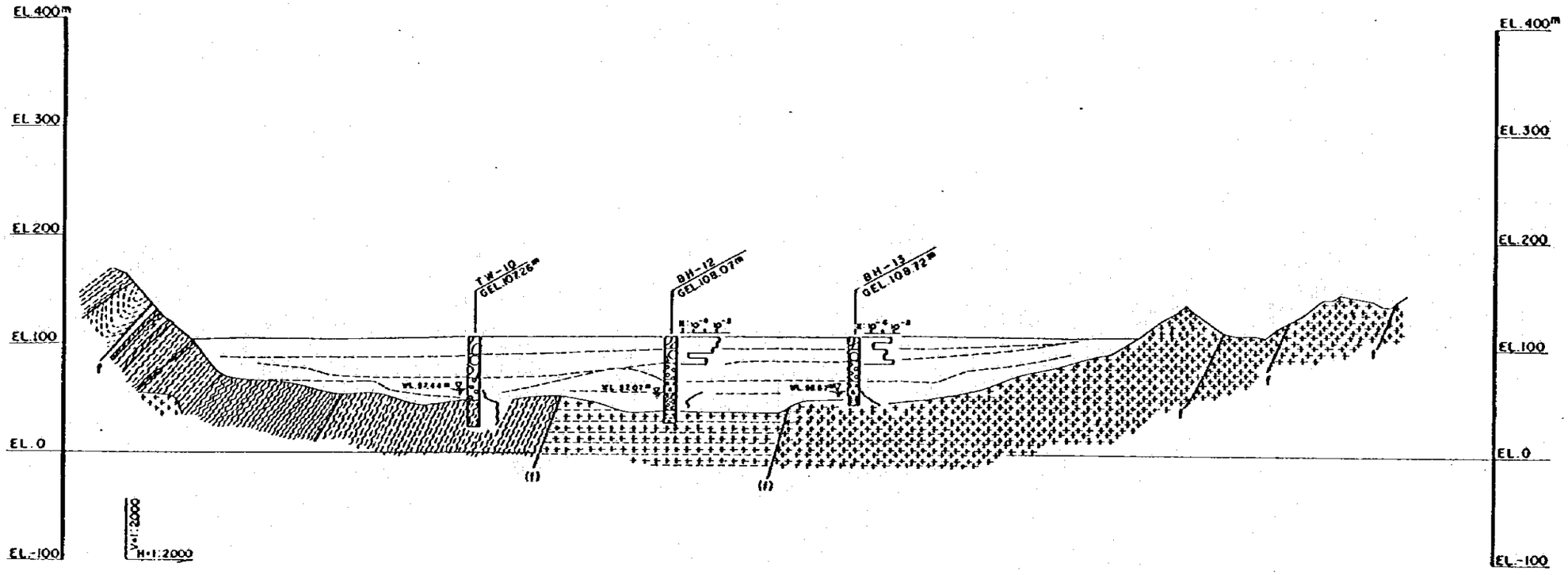
GEOLOGICAL PROFILE ALONG THE DAM AXIS



LEGEND

- RECENT WADIBED DEPOSIT
- LOWER TERRACE DEPOSIT
- UPPER TERRACE DEPOSIT
- TALUS DEPOSIT
- OLD TERRACE DEPOSIT (CONGLOMERATE FORMATION)
- SERPENTINITE
- SERPENTINITE/CLAY
- QUARTZ SCHIST/OTHER SCHISTS
- GREEN SCHIST
- QUARTZ SCHIST
- FAULT
- FAULT (ASSUMED)
- GEOLOGICAL BOUNDARY

TW TEST WELL
BH BORE HOLE

0 100 200M
SCALE 1:2000

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Geological Profile
along the Dam Axis

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