社会開発協力部報告書

No.-008

THE UNITED ARAB EMIRATES
MINISTRY OF AGRICULTURE AND FISHERIES
WATER AND SOIL DIRECTORATE

AL. BASSIERAH DAM PROJECT

REPORT
ON
FINAL DESIGN

VOL. I

MAIN REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY

NOVEMBER, 1981

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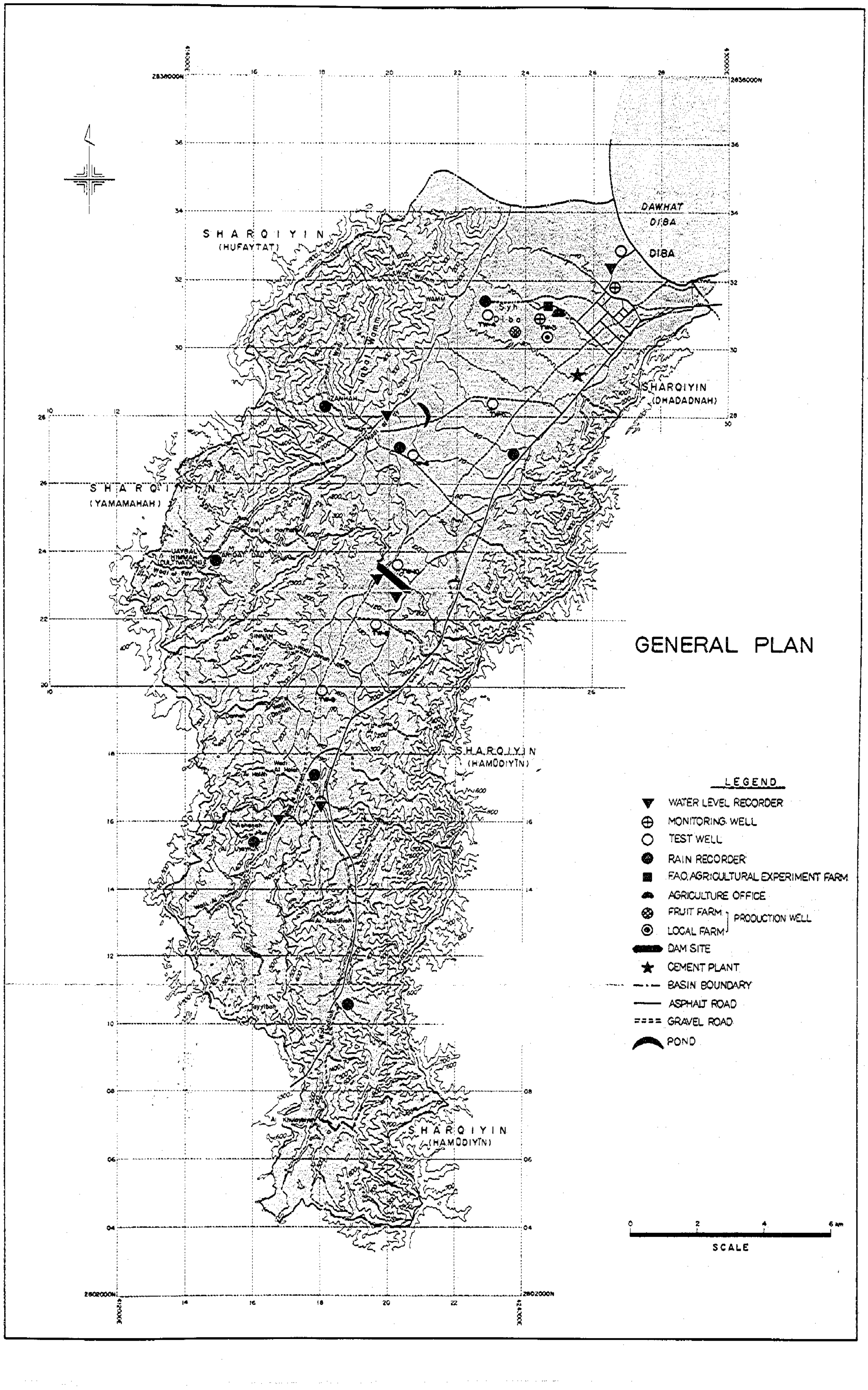
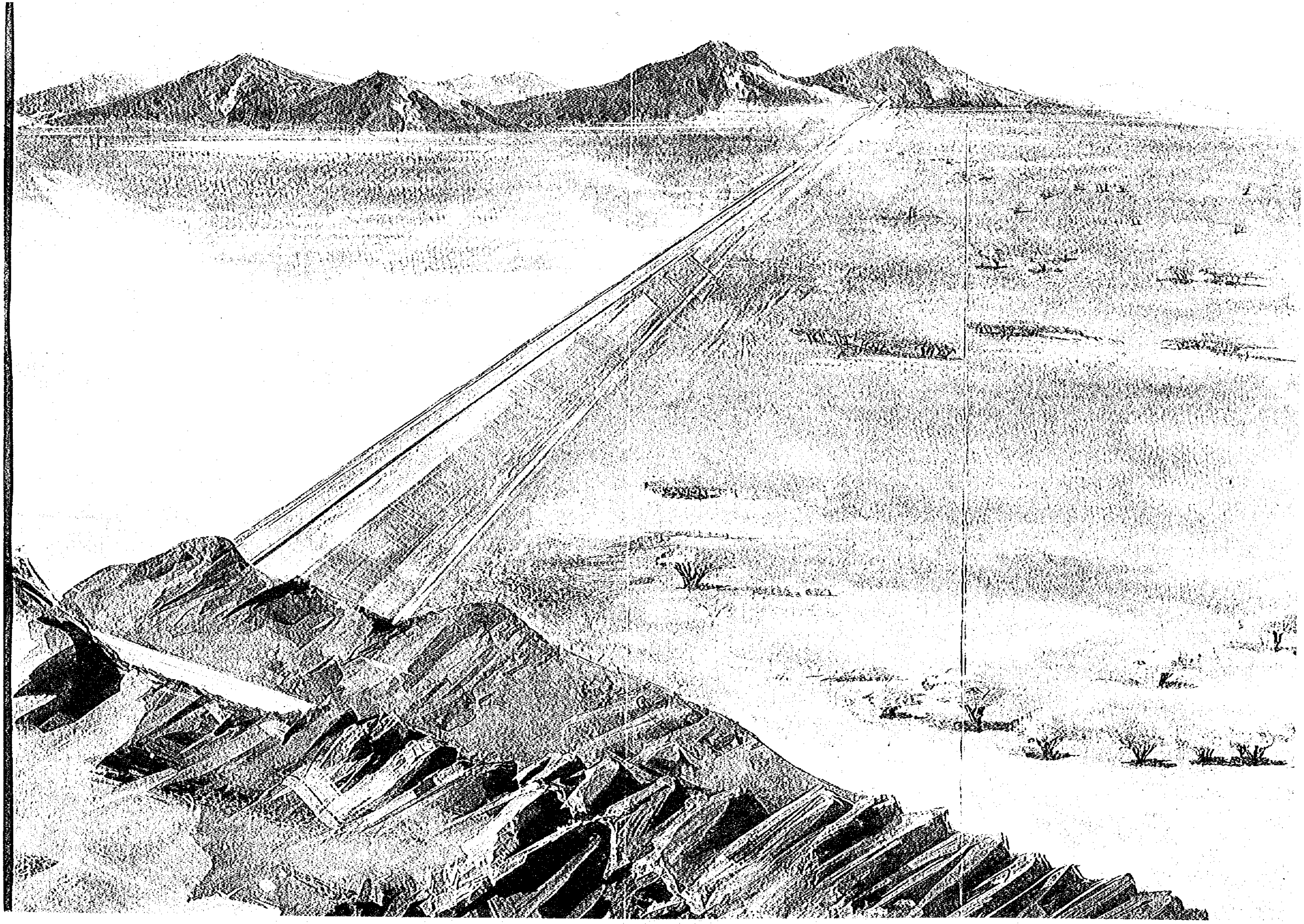
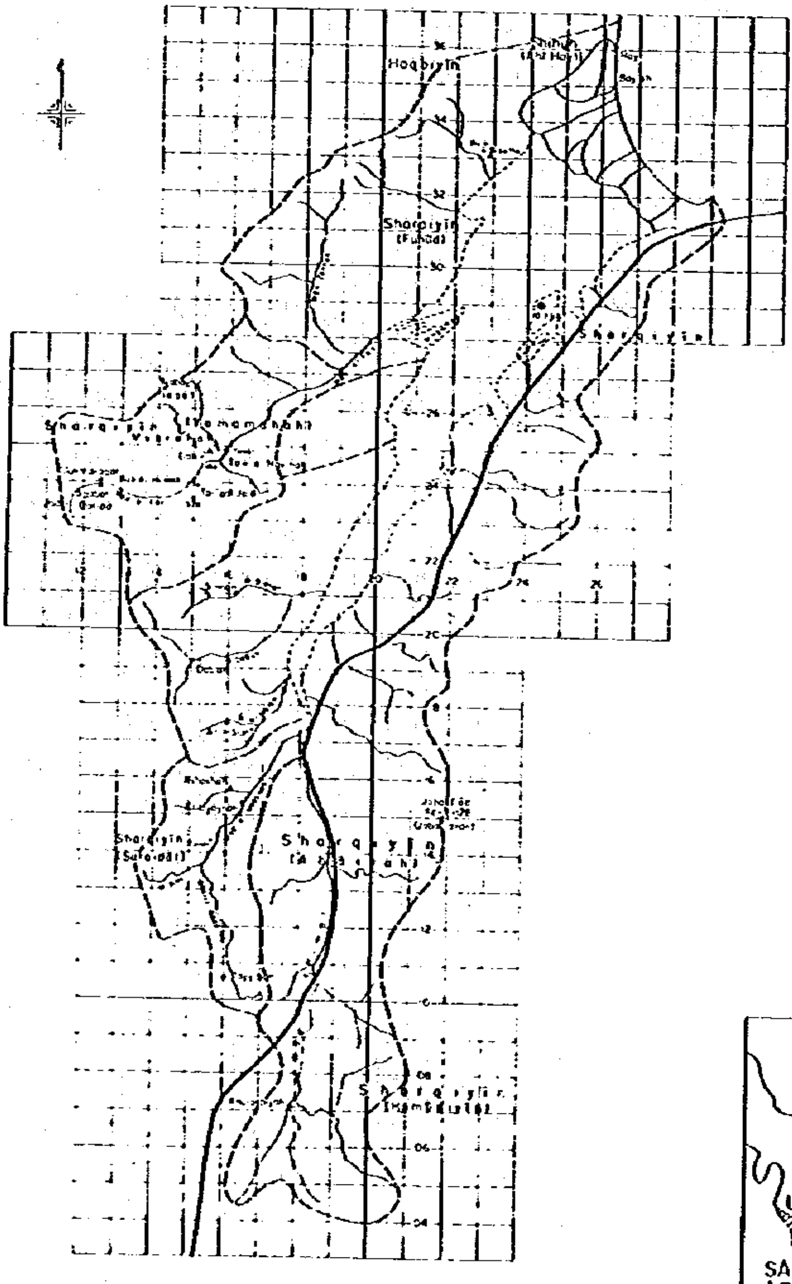
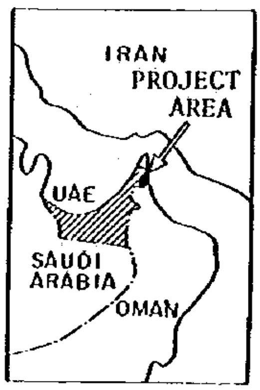
GENERAL PLAN





LOCATION OF THE PROJECT





PREFACE

In response to the request of the Government of the United Arab Emirates, the Japanese Government decided to conduct a detailed design for the Al Bassierah Dam Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to the United Arab Emirates a study team headed by Mr. Fujio Matsumoto from June, 1981 to October, 1981.

The team exchanged views with the officials concerned of the Government of the United Arab Emirates. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the United Arab Emirates for their close cooperation extended to the team.

December, 1981

Keisuke Arita
President
Japan International Cooperation Agency

C O N T E N T S

MEASURES AND ABBREVIATIONS

MEASURES

mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)
sq.cm, cm^2	:	square centimeter(s)
sq.m, m^2	:	square meter(s)
sq.km, km^2	:	square kilometer(s)
ha	:	hectare
ℓ, lit	:	liter
cu.m. m^3	:	cubic meter
MCM, 10^6m^3	:	million cubic meter
Barrel	:	barrel = 31.5 gallon (U.S.) = 36 gallon (U.K.)
Gallon	:	gallon = 4.546 ℓ(U.K.) = 3.785 ℓ(U.S.)
g	:	gram(s)
kg	:	kilograms(s)
ton, m.t	:	metric ton
Kw	:	kilowatt
Mw	:	megawatt
%	:	percent
°C	:	degree centigrade

ABBREVIATIONS

DAO	Dibba Agriculture Office
ERD	Eastern Regional Department
FAO	Food and Agriculture Organization
MAF	Ministry of Agriculture and Fisheries
MEW	Ministry of Electricity and Water
UNESCO	United Nation Educational, Scientific and Cultural Organization
USBR	United States Department of Interior, Bureau of Reclamation
UAE	United Arab Emirates

OUTLINE OF THE PROJECT

1. The results of the Feasibility Study of the Wadi Al Bassierah Basin Water Resources Development Project allowed to decide the Plan C'-9 as the most suitable c-se among several alternatives. The Plan C'-9 comprises the construction of the Al Bassierah Dam in the mid-stream of the main flow of the Wadi Al Bassierah and the related facilities so as to recharge the groundwater for securing the irrigation water through highly effective and efficient water utilization.

2. The proposed Al Bassierah Dam, which is located in the middle of the Basin, will provide the dimensions as follows:

° Location:	On the mid-stream of Wadi Al Bassierah (approximately 10 km upstream of Dibba)
° Dam Type:	Fill type with sand & gravel and rock
° Dam Length and Height:	Height: 19.5m, Length: 900 m
° Dam Volume:	0.64 MCM
° Capacity:	2.5 MCM

3. The construction of the Al Bassierah Dam is composed of those works of dam body, spillway, conduit, access roads, and replacement of the existing power line, and construction cost of the works are shown as follows:

Unit: 1,000 DH

Description	Construction Cost
° Dam Body	14,890
° Spillway	3,580
° Conduit	1,310
° Administrative Expense	2,960
° Contingency	2,960
Total	25,700

4. Implementation of the Project is scheduled for 16 months. How to construct economically the dam body of about 0.64 MCM is the most significant consideration for scheduling the implementation of the Project. On the other hand, the embankment is divided into three zones; an inner zone, an outer zone and a filter zone. The inner zone consists of about 0.37 MCM of sand and gravel deposited in the river bed, while the outer zone consists of about 0.21 MCM of rock materials which could be economically obtained from the excavated materials 0.072 MCM in the construction of the spillway on the right bank of the Wadi and the rest volume at the quarry site of the left bank of the wadi and about 0.059 MCM of filter materials.

The embankment of the dam body takes about 12 months of construction period. Furthermore, the multiple-stage diversion system has been proposed to keep the discharge route of the floods, which is expected to have a winter season during the construction period.

CHAPTER I. INTRODUCTION

In July, 1980, in the course of the feasibility study on the water resources development project in the Wadi Al Bassierah basin under a technical cooperation of Japan, the Government of the United Arab Emirates requested the Government of Japan for the technical cooperation, following the feasibility study, the implementation of project selected among the alternative plans formulated in the said feasibility study. In reply to the request, in March, 1981, the Government of Japan dispatched a mission to the UAE, through the Japan International Cooperation Agency (JICA), to prepare the scope of works for the technical cooperation, one of three alternative plans proposed by the feasibility study team in December, 1980, and exchanged the Record of Discussion on the Technical Co-operation for Final Design and Construction Supervision of the Al Bassierah Dam Project with the Ministry of Agriculture and Fisheries of the UAE. The Report is prepared on the basis of the Basic concept of Revised Feasibility Study, October, 1981.

The Al Bassierah Dam Project will be implemented in two phases, the Phase I - final design and preparation of tender documents inclusive of Conditions of Contract, Specifications and Bills of Quantities, and the Phase II - tender evaluation and construction supervision. The Phase - I works for the above have been made in Japan and compiled into this report.

Hereinafter listed are members of the advisory group, the study team and the UAE counter parts personnel concerned, all of whom have been engaged in the relevant study.

A. Advisory Group

Title	Name	Position
1. Leader	Mr. Noboru Kano	Director, River Administration Division, Hokkaido Development Agency, Prime Minister's Office
2. Hydrology	Mr. Katsuyoshi Ishizaki	Chief, Hydrology Division Public Works Research Institute Ministry of Construction
3. Dam	Mr. Tokuhisa Matsumoto	Chief, Fill Dam Division, Public Works Research Institute Ministry of Construction
4. Coordinator	Mr. Toshio Nakamura	Japan International Cooperation Agency

B. Study Team

Title	Name	Assignment Period
1. Team Leader	Mr. Fujio Matsumoto	Apr.23,1981 - Apr.30,1981 Jun. 1,1981 - Jun.15,1981
2. Design (Hydraulic)	Mr. Hiroshige Tomiyama	Apr.23,1981 - Jun.15,1981
3. Design (Structures)	Mr. Munehisa Murayama	Apr.23,1981 - May 19,1981
4. Construction planning, cost Estimation	Mr. Osamu Suzuki	Apr.23,1981 - Jun.15,1981
5. Condition of Contract	Mr. Tsutomu Tokumaru	Apr.23,1981 - Jun.15,1981
6. Specification (General)	Mr. Yasumi Kinoshita	Apr.23,1981 - Jun.15,1981
7. Specification (Particular)	Mr. Shizuo Sato	Apr.23,1981 - Jun.15,1981
8. Bill of Quantities	Mr. Toshio Shima	Jun. 1,1981 - Jun.15,1981

C. Counterparts Personnel of the Ministry of Agriculture and Fisheries, UAE

Name	Position
1. Mr. Obaid M. Karki	Assistant Deputy Minister for Water & Soil Resources Affairs
2. Mr. Khalil Ataya	Assistant Director
3. Mr. Taissir Adlbi	Main Counterpart
4. Mr. K. Kurian	Counterpart
5. Mr. Ali Badawi	General Manager of Eastern Coast Department
6. Mr. Khalfan	General Manager of Dibba

CHAPTER. II. BACKGROUND

2-1. Wadi Al Bassierah Basin

(1) General

The Wadi Al Bassierah Basin is situated in lat. 25°30'N and long. 56°20'E, extending in the region about 300 km north-east from the crown (EL 3,018 m) of the Oman mountain range which runs from east to west in the extreme eastern part of the Arabian Peninsula, and the most downstream portion of the Basin faces the Oman Gulf. The Basin has about 260 km^2 in its land acreage, and road networks in the basin are a coastal highway between Dubai and Fujeira on the Oman Gulf and a ring road running through the Basin to Masafi and to link with the above Dubai - Fujeira highway.

The meteorological conditions of the Basin are the annual mean temperature by 27.6°C, the relative humidity by 68 percent and the annual rainfalls by 130 mm an average. Major town is Dibba in the Basin, and about ten villages and settlements are dotted in the mid- through upper basins. The population as of September, 1980, was about 13,200 of which some 3,700, equivalent to 28 percent of the total, are resident aliens. Approximately 1,240 people are engaging in farming and fishing out of whom 870 are farmers and 370 are fishermen. The number of households in the Basin counts 1,340. The total farm land are is 490 ha, most of which extends in the lower basin.

(2) Topography, geology and soils

The Basin can be specified into three in terms of characteristics in topography and geology; (a) north-western mountain area (b) central mountain area and (c) gravel plains and coastal area. The Wadi Al Bassierah basin itself consists of a wide flood plain thickly covered with gravels. The highest elevation in the flood plain is EL 175 m and the slope is 1/85 on an average in the upper basin while 1/105 in the lower basin. The gravel plains provide no clear river courses; however, the diluvial sand and gravel layers are eroded by three wadis, the Abadellah, the Uyaynah and the Al Fay that are flowing into the gravel plain, and form corridors.

Geology of the Basin consists of (a) igneous rocks related to the submarine volcanic product of the Permian Palaeozoic to the Lower Cretaceous periods, (b) marine sediment of the Triassic Mesozoic to the Cretaceous periods (c) terrace sand and gravel deposited in Tertiary to Quaternary Overlaying the older rocks (a) and (b), and (d) alluvial rocks forming the present wadi beds, etc.

Soils are composed of desert sand and gravels and the mixture of the above with schist soils. The surface layers is underlain by desert pavement consisting of 1 - 20 cm dia. gravels. The layers under the desert pavement are observed as less-gravel-containing sand and silt layers which become thicker from 5 cm to 15 cm as coming down to the lower basin. In the coastal area the sandy loam or loamy sand is observed at the surface layers, while the sand layer in the subsurface layers. Higher salinity concentration is observed, in general, in the deeper layers.

(3) Supply of water and power

The domestic water supply to Dibba depends upon three tube wells provided in the office lot of the Ministry of Electricity and Water, which is in the upperstream of the new residential area proposed by housing projects.

The pumped-up water is chrolinated and pressurized to be raised to the 30 m elevated water tank (200,000 gl ≒ 900 m³), and the stored water is conveyed 30 km to the residential areas through asbestos pipelines with 16" to 4" in diameter. Besides, two artesian wells equipped with pumps are secured as emergency water sources. Currently water supply is made at the rate of 100 ℓ/day per capita.

Electricity is supplied from the thermal power station with capacity of 11 MW, and further 2 MW is suppliable by the Kidofa power station (24 MW) about 40 km south of Dibba. For such power supply, the demand of Dibba is 5.7 MW in summer while 1.8 MW in winter. The largest power consumer is the marble and tile factory with demand of 300 KW.

2-2. Water Resources Development Plan

(1) General

In the United Arab Emirates which has the total population of 877,340 and the total farm land of 21,556 ha, the water resources development strategy appears to take two major directions; one is the sea-water desalination to supply fresh water to cities and towns located along the Arabian Gulf and the other is the most effective use of wadi floodings by rain water of some 130 mm per annum, which take place in the eastern mountain areas and gravel plains in the UAE, so as to supply irrigation water and domestic water.

The Wadi Al Bassierah Basin Water Resources Development Project has taken up as part of the water resources development program for the eastern UAE. Substantially, the Project has been thoroughly studied through alternative studies conducted in the feasibility study and resulted in taking up the plan for constructing the Al Bassierah Dam and related structures in the midstream of the main flow of the Wadi Al Bassierah so as to recharge the groundwater (Plan C'-9). In this connection, the minutes of discussion were exchanged for confirmation between the Ministry of Agriculture and fisheries and the Feasibility Study Team in December, 1980 and June, 1981, and agreed in October, 1981.

(2) Plan c'-9

The Plan C'-9 comprises construction of the Al Bassierah Dam in the midstream of the Wadi Al Bassierah to command some 122 km², equivalent to 47 percent of the total catchment area of the Wadi

Al Bassierah and, furthermore, provision of a pond in the downstream of the Wadi Al Fay, so that the water resources development in the Basin can be powerfully promoted through recharging groundwater in combined operation of these facilities. The basic values concerning the Plan C'-9 are determined as follows on the basis of the feasibility study.

Water Resources Development

Plan	Project Cost (MDH)	Rechargeable Amount (MCM/year)	Natural Rechargeable Amount (MCM/year)	Total Rechargeable Amount (MCM/year)
C'-9	41.6	0.9	2.9	3.8

Allocation of Water for Domestic Use and Irrigation Use

(Unit: MCM/year)

Plan	Domestic Water	Irrigation Water	Total
A	0.7	3.1 (570 ha)	3.8
B	0.7	3.1 (560 ha)	3.8
C	0.7	3.1 (565 ha)	3.8

Note: (a) Total rechargeable amount of 3.8 MCM/year consists of 0.9 MCM/year recharged by dam and pond plus 2.9 MCM/year by natural recharging.

(b) Total amount of domestic water 0.70 MCM/year consists of 0.48 MCM/year supply to UAE of 13,200 people, 0.05 MCM/year to Oman of 1,500 people, 0.07 MCM/year for marble factory and 0.10 MCM/year for cement factory respectively.

(c) The study on domestic water demand is made on the basis of the population of the UAE as of 1980.

(d) The irrigation water of 3.1 MCM/year is allocated to the following:

Items	Acreage (ha)	Irrigation Water (MCM/year) Plan A	Plan B	Plan C
Existing Vegetable Fields in UAE	50	0.30	0.30	0.30
Existing Date Palm Plantation in UAE	230	1.04	1.04	1.04
Existing Date Palm Plantation in Oman	210	0.96	0.96	0.96
Proposed Fruit Farm	-	-	0.73 (65 ha)	0.43 (40 ha)
Proposed Local Farm	-	0.73 (75 ha)	-	0.30 (30 ha)
FAO Farm	5	0.07	0.07	0.07
Total	495	3.1	3.1	3.1

2-3. Agricultural Development Plan

For the effective utilization of new groundwater created by the construction of Al Bassierah dam and related facilities, an allocation of irrigation water is studied through an integrated water use program; that is to say, the agricultural development plan is formulated for irrigating 570 ha of fields in total including the present farm land of 490 ha, new development of 75 ha of fruit farms and local farms in terms of acreage to be developed and FAO of 5 ha.

The production of fruits and vegetables, and the gross income anticipated therefrom are tabulated below:

Items	Production (ton)	Prices (1,000 DH)
Vegetables	4,290	8,237
Fruits	2,300	12,226
Total	6,590	20,463

The gross production of vegetable in the UAE in 1978 is 71,860 ton or 220 grm/day per capita, which is almost equal to a level of the world average vegetable consumption. Imported vegetables abound in the market, however, it seems that the demand exceed the domestic supply to a considerable extent. Hence, the vegetables to be grown under the Project have been selected by five high preferential crops such as tomato, cucumber, egg-plant, cabbage and melon, all of which have high marketability. And furthermore, it is planned to grow two crops, at maximum, per unit lot in order to avoid mixed growing of many various crops.

2-4. Implementation Programme of the Wadi Al Bassierah Basin Water Resources Development Project

The implementation programme of the Wadi Al Bassierah Water Resources Development Project has been built up as 3.5-year plan since the feasibility study was started in December, 1979. The cost required for the Project was estimated at total 47.8 MDH for both water resources component and agricultural component on the basis of the unit prices quoted in the UAE in July, 1980. Among many water resources development plans, the Government of the UAE has a strong wish, to commence the construction of Al Bassierah Dam at the possible earliest time, perhaps at the early 1982.

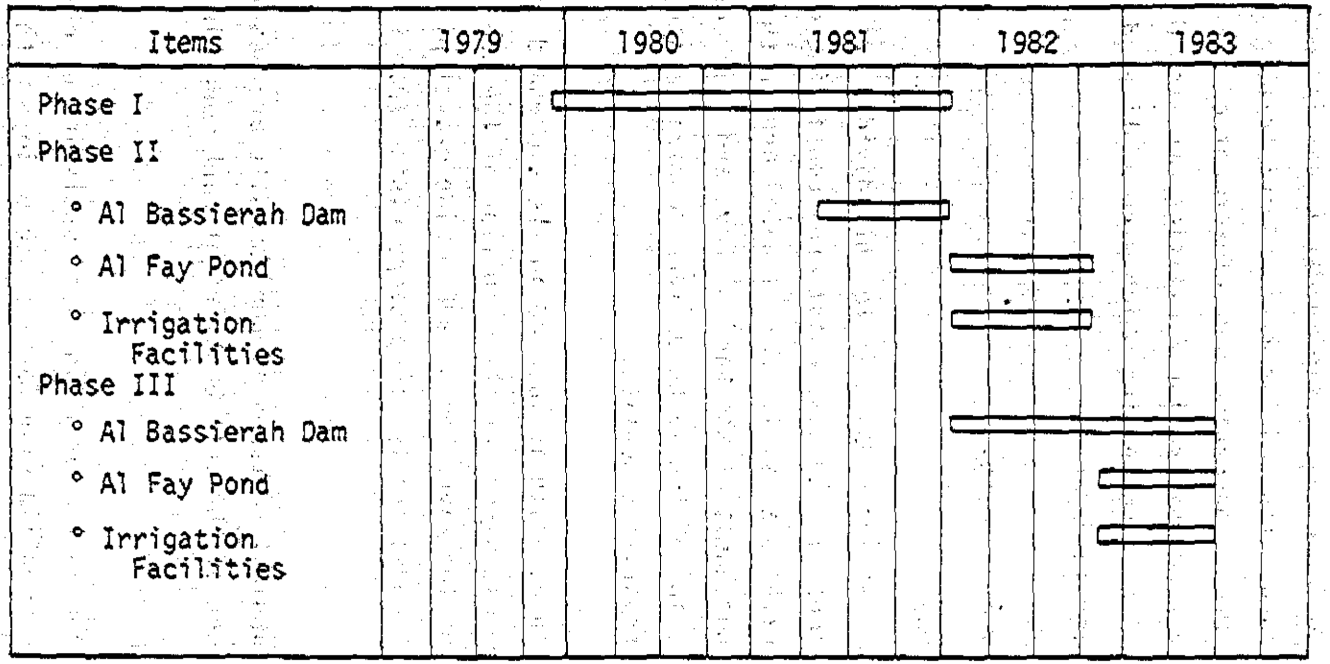
(1) Implementation Programme of Al Bassierah Dam Construction

The development of wadi water and groundwater by rainfall in the eastern UAE is coming to a stage of implementation after some years of survey and study for the Wadi Bhi and Ham. The implementation programme for the Al Bassierah Dam construction was discussed in March and June, 1981, and agreed in October, 1981, at the UAE between the MAF and the mission dispatched by the JICA.

The said implementation programme is that the final design of the dam and related facilities and the tender documents including Conditions of Contract, Specifications and Bill of Quantities would be completed by the end of 1-81, according to the water resources development plan provided in the feasibility study made in December 1980 and the selected alternative plan of construction of Al Bassierah Dam with rechargeable groundwater development concluded in October 1981. Following the necessary steps for bidding and contract procedures, the construction works would be commenced in early 1982 and completed in middle 1983.

The relevant implementation schedule is shown in Fig. 2-1.

Fig. 2-1 Implementation Programme for Wadi Al Bassierah Basin Water Resources Development Project



Notes: (1) The Phase I consists of feasibility study on water resources development in the Wadi Al Bâssierah basin.

(2) The Phase II consists of final design and tender documents including conditions of contract, specifications and Bill of Quantities.

(3) The Phase III consists of implementation works for the project.

CHAPTER III. FINAL DESIGN OF AL BASSIERAH DAM

3-1. Application of Design Criteria

The final design of Al Bassierah Dam is carried out 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 concerning which were applicated for design the dam prevailing in Japan.

3-2. Topography and Geology

3-2-1. Topography

The Wadi Al Bassierah Basin is roughly divided into three topographical divisions; i) the east coast area consisting of a group of fan lands and gravel plains, ii) Ras Al Jahal area with limestone mass extending northwest of the Wadi Al Fay, and iii) central mountain area consisting of the south eastern mountain masses of serpentinite and chrystaline schists.

The proposed dam-site is located in the aforesaid central mountain area in the mid-stream of the main flow of the Wadi Al Bassierah being composed of the river bed of 900 m wide gravel plain and mountain mass with a considerably steep slope rising from the said gravel plain.

The topographical features of the dam-site are described hereunder in the order of the left bank, right bank mountain mass and the river beds.

The left bank is the mountain mass consisting of chrystaline schists, and the mountain side forms a steep slope with about 40 degree gradient rising from the plain. The mountain crests, however, present rather flat at an elevation ranging from EL 400 m to EL

500 m, running NE to SW. The ravines down-cut by the Wadis Sinnah, Wadi Donhah and Wadi Harah have been well dissected to branch off few tributaries and to form dendritic shape. The topographical lineament of the directions of the ravines, mountain ridges, continuous ravines or ridges or bending points and their branching points run S to N or NS to SE.

The mountain mass on the right bank, consisting of serpentinite rocks, rises on the dam axis with slope of about 20°. The mountain side forming a right abutment presents a bulge by continous mountain crests over EL 1,000 m with several cols formed. Such topographical features are recognized not only amount the damsite but also in the whole mountain masses on the right bank, and the topography around the boundary between the mountain areas and the Wadi plain is very intricated. Many ravines down-cut as well have been dissected considerably to form typical dendritic shape ravines with well-developed branches. Such topographical lineaments observed at the mountain foot area as cols, ravines, and ridges run NE to SW: particularly, the lineation has been well developed around the boundary between the mountains and the Wadi plains.

The present river bed of the Wadi Al Bassierah, formed with flood plain deposits, grows abruptly wider around the confluence with the Wadi Uyaynah and reaches to be about 5.0 km wide or more in the coastal area. In the mid and upperstream portions, the river bed width varies with bulges of the mountain mass; 2.0 km wide around the Wadi Sinnah and 0.9 km narrow wide at the proposed dam axis. The flow course of the Wadi Al Bassierah can be clearly observed in its mid and upperstream; especially around the damsite, two flow courses can be evidently tracted near the mountain feet of the both banks. The river bed slope does not show a large fluctuation in the areas where the wadi deposits are recognized, and the slope is about 1/85 in the mid and upperstream including the damsite while it is about 1/105 in the downstream of the Basin.

3-2-2. Geology

Geology of the Wadi Al Bassierah Basin is composed of the Hawasina Series of sedimentary rocks and metamorphic rocks which were deposited and formed in the period between Paleozoic Permian or earlier era and the Mesozoic Cretaceous, of the Semial Series of the Mafic Igneous rocks, and of the younger clastic deposits forming the Wadi plain in covering unconformingly the aforesaid older rock formation. The stratigraphy and faces of these members are showin in Table 3-1.

Table 3-1 Stratigraphy and Facies of the Members

Age	Stratigraphy	Rock Facies	Descriptions
Quaterary to Neogene	Younger clastic deposit	Recent Wadi bed deposits Fan deposit/talus deposit Lower terrace deposit Upper terrace deposit	The facies of the dam site river bed consists mainly of gravels. The recent wadi deposits can be regarded as the alluvium deposits, while the terrace deposits as diluvium to neogene.
Mesozoic cretaceous to Palazoic permian	Hawasina series	Limestone/marly limestone metamorphosed limestone Marbel/crystalline limestone Calcareous schist Green schist Quartz schist Quartz schist and other schist Piedmontite schist	Limestones and chrystaline limestones compose the left bank of the downstream portion, and other schist formations compose the mountain mass on the left bank. Around and damsite, quartz schists and green schists outcrop at the left abutment. As a whole, the facies abound with cracks in the well-developed lineation and bedging.
	Semail ophiolote series	Silicified serpentinite Fractured serpentinite Magnesite and chysotile veins Banded serpentinite	The mountain mass on the right bank is composed of these rocks. The mountain crests are composed of the serpentinite containing much magnesite and chrysotile, while the mountain foot areas of cilified sepentinite with many crack developed.

The left abutment of the proposed damsite is composed of quartz schists and green schists belonging to the Hawasina Series, while the right abutment is composed of serpenticite belonging to the Semial Series. The facies observed at the mountain side of the both banks are jointed in the river bed portion under the younger deposits where the fault is detected. The geological section covering the dam axis indicates that the bed rock composed of these facies can be evenly traced 60 - 70 m deep under the river bed. The geology around the damsite is discussed as follows in the order of the left bank, the right bank and the river bed.

The left abutment is composed of quartz schists and green schists with bedding and schistosily showing N5-15 W/45W stribes and quartz schists with remarkable disturbance and folding. These rocks are separated by fault running westward which is observed at the point of EL 135 m on the dam axis. As a whole, the rocks have many cracks; particularly, the schistosity has been remarkably developed in the green schists in layers which are found in quartz schists and collapsion has observed therein.

The right abutment is composed of weathered serpentinites which have developed many cracks. The stribe runs N36E and a fault develops with dip of 75 - 80 degree in the north along the down-cut ravine on the mountain side. Geological section covering the dam axis indicates that faults exist at elevation of EL 120 m, 155 m and 170 m and faces of the faults are relatively clear. Crashed zones consisting of fault clay have not been developed.

The younger deposits consisting of the river bed can be classified in the order of the recent wadi deposits, lower terrace deposits, higher terrace deposits, and talus deposits from the horizon. The materials prevailing in these deposits are sand and gravels in assuming the facies poorly sorted. The recent wadi deposits are formed with uncongIomerated layers containing many rounded gravels and subrounded gravels, and these layers are developed evidently independent from the conglomerated lower formation which abounds with lime. The geological section of the dam axis indicates that the thickness of these layers, tending to grow large toward the left bank, reach 20 m at maximum. The permeability test conducted within an extent of the horizon resulted in the permeability coefficients ranging from $K = 10^{-2}$ to 10^{-4} cm/sec.

The horizon below the recent wadi deposits is composed mainly of the gravels ranging from round to angular, although having facies with variety of the horizons prevailing in well-sorted sand and pelitic materials. The permeability coefficient for the lower terrace deposits ranges from $K = 10^{-3}$ to 10^{-4} cm/sec. These lower horizons have been well developed in conglomeration; particularly, the conglomerates with calcareous matrix of upper terrace deposits and talus can be found in the whole horizons.

The bed rocks, as mentioned previously, are observed 60 m - 70 m below the younger deposits. The deepest point is around the center of the river bed, although becoming more shallow near the both abutments. The facies are composed of schists and serpentinites outcropping on the both banks. These rocks, being in fault contact with each other, have crusted green fault clay in their contact parts. A shear zone is expected along the wadi course in the center of the river bed.

3-3. Dam Type

In general, dams are mainly classified into two types, that is, the concrete dam and the fill dam. A zone type of fill dam is recommendable for the Al Bassierah damsite in consideration of the following items as described in the Feasibility Study Report.

- A relatively large quantity of seepage water is allowed to flow out through the dam body since Al Bassierah dam only functions to store temporarily flood discharge by means of cutting the peak of floods which flow down uselessly into the sea in a short time and to recharge groundwater through infiltration of the stored water by the dam into aquifers.

° River bed deposits and rocks, embankment materials for a fill dam, are easily obtained at the damsite;

° Most part of the dam foundation consists of sand and gravel deposits where no require to construct the barriered structure;

° The cord-height ratio (dam length/dam height ≑ 45) at the dam axis is extremely large; and,

° The construction of fill dam is economical in comprison with the concrete dam.

The inner shell and outer shell of the dam body are planned in considering the resistance against piping, erosion, protection, structural stability and economic execution of the construction works. The inner shell located central part of the dam body will be constructed as semi-pervious zone which consist of river deposits of not more than 1×10^{-4} cm/sec in permeability coefficient.

The outer shell composes of up and downstream slope of the dam body, and is constructed of escavated rock materials at the spillway site and quarry site. At the contact surfaces of the inner shell and the outer shell and the base of downstream outer shell and river deposit, the filter zones should be located in order to prevent washing-out of fines contained in the zones, and to safely permit seepage water to flow out the zones.

Along the axis of dam, a trench should be provided in order to obtain a good bond between the inner shell and the dam foundation, to reduce the hydraulic gradient of seepage water through the foundation, and thereby to increase the safety against piping.

The typical section of the Al Bassierah dam is shown in the Drawing D.4 in Appendix.

3-4. Embankment Materials

Embankment materials of the Al Bassierah dam will be mainly obtained from river deposits at the damsite and from excavated rocks at the spillway and the quarry site as described below:

3-4-1. River Deposits (Sand and Gravel Zone)

River-bed deposits are widely distributed all over the river course at the damsite. The results of three bore hole drillings executed on the river bed along the dam axis have revealed that the thickness of deposits is 61 m on an average though fairly different in places.

River-bed deposits mainly consist of sand and gravel belonging to recent wadi-bed and terrace deposits with a small quantity of boulders, and these materials can be easily borrowed from any places nearby the damsite; moreover, the borrow area can be enlarged to any extent and to any depth, if necessary.

An outline of soil mechanics properties for the coarse materials of sand and gravel can be assumed from the gradation analysis curve.

Judging from results of the gradation analysis test of river deposits at the damsite, the coefficient of uniformity of these materials is about 27, which indicates that they are the well-grade semi-pervious materials, although they contain about four percent of fine materials to be classified into GW under the Unified Soil Classification System.

The data of similar-natured soil tests conducted in the past suggest that these materials are suitable for embankment with a dense compacted weight and a high schearing strength except those being impermeable.

From the above-mentioned soil mechanics properties of the river deposits, it is desirable that these materials shall be used as embankment materials of Al Bassierah dam as much as possible from the view points of abundant distribution, borrowing condition, physical and dynamic properties, purpose of dam construction and economical embankment.

Since the Al Bassierah dam aims to store temporarily flood discharge and to recharge groundwater by infiltrating a stored water into aquifers, a relatively large quantity of seepage water can be permitted to flow-out through the dam body. However, the inner shell of sand and gravel fill should be constructed as a semi-pervious zone of less than 1×10^{-4} cm/sec in permeability coefficient in order to ensure the temporary storage of flood discharge and the stability of the dam body.

Prior to filling river deposits in the dam embankment, these materials should be controlled in gradation distribution of less than 20 cm in maximum diameter at the borrow area. As for the embankment of river deposits, these materials are generally spread out in thickness of 40 cm with moisture control and compacted by comparatively heavy vibratory roller with about eight passes.

In order to obtain the above-mentioned permeability coefficient, it is desirable to execute in-situ embankment test to determine the allowable range of gradation distribution of embankment materials, spreading thickness, number of passes and specifications of compacting equipment.

3-4-2. Rock Materials (Rock Zone)

Rock materials obtained from the excavation of spillway will be used for embankment as the outer shell of rock fill. Such materials consist of only serpentinite rocks with many joints, cracks and fissured, however, the rocks near the ground surface are much disintegrated by weathering. Therefore, the excavated rocks may be turned to fine-grained by breakdown in compacting fill.

Since the excavated rock materials from the spillway are not sufficient to the required quantity of the outer shell embankment of the rockfill, the rock materials located at the left bank of the damsite should be excavated as a quarry site which consists of schiste rocks with comparatively well lithologic character, and these materials will be placed at the surface portions of the dam slope.

3-4-3. Filter Materials

The materials to be used for the filter zone are obtained from the sand and gravel materials deposited at the river-bed with the arrangement in gradation distribution. These materials should be satisfied with the filter criteria described in the 3-6-4, Chapter III of this Report.

3-4-4. Riprap Materials

Since the surfaces of dam body may be affected by the variation of meteorological conditions and repeated drying-wetting effecgs, the up and downstream surfaces of the slopes should be protected by the hand-placed riprap zone. Ripra- materials must be hard and sound having enough durability and will be obtained from the quarry site of schiste rocks. The thickness and grain size of filter zone refer to 3-6-5, Chapter III of this Report.

3-5. Dam Dimensions

3-5-1. Dimensions of Reservoir

According to the Feasibility Study Report, the dimensions of the reservoir are determined as follows:

Catchment area	122 km^2
Detension capacity	2,500,000 m^3
Specific sediment volume	20,000 m^3/year

Full water surface (F.W.S.)	EL 115.00 m
Reservoir water surface area at full water level	700,000 m^2
Design flood discharge	2,320 m^3/sec
Design flood water level (H.W.S.)	EL 120.50 m

3-5-2. Dam Crest Elevation

The crest elevation of the non-over flow section of dam shall be applied the larger value of either following formulas obtained.

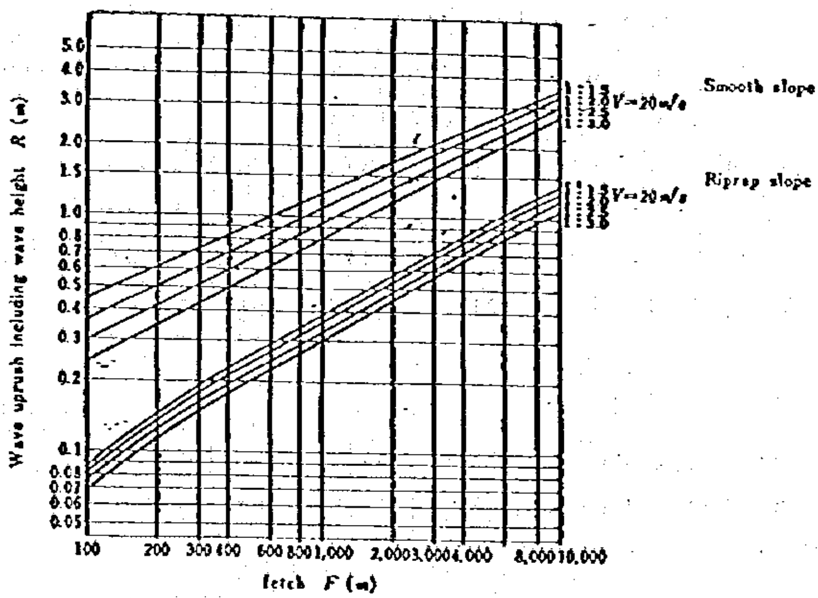
Hf + hw + he + 1 (in case of hw + he <1 adopted by Hf + 2.0 m)
Hd + hw + 1 (in case of hw <1 adopted by Hd + 2.0 m)

where, Hf; full water level
hw; height of wave due to wind
he; height of wave due to earthquake
Hd; design flood water level

(1) Height of wave due to wind

Height of wave due to winds is considered to be caused by deep-water wave, and then, the height of significant wave is adopted based on S.M.B. (Sherdrup-Munk-Breschneider) method which is derived from factors such as fetch and wind speed. On the other hand, since up-rushing height varies considerably with embankment slope and roughness of slope, height to significant wave should be adjusted adequately with Saville method to obtain height of wave due to the wind.

The calculation results with various slopes and fetches are shown in the following figure.



Wave uprush (including wave height) obtained by combining the S.M.B. Method with Saville Method

In order to obtain the height of wave due to wind in the Al Bassierah damsite, the wind speed of 20 m per second in 10 minutes on an average is to be assumed taking into account the observed data of maximum wind movement in Dibba station (observed maximum value is 649.2 km per day).

The upstream surface of the Al Bassierah Dam is formed with handplaced riprap by the materials mainly consisting of excavated rocks of more than 20 cm in diameter; therefore, an intermediate value of 0.45 m at the smooth slope and the riprap slope in the above-mentioned figure was adopted as the height of wave due to wind.

(2) Height of wave due to earthquake

The height of wave due to earthquake can be obtained by Sato's formula as follows;

$$he = \frac{k \cdot t}{2\pi} \sqrt{g \cdot H_o}$$

Where, he; height of wave at upstream face of the dam due to earthquake

k; horizontal seismic intensity (0.10[1/])

t; period of seismic waves adopted by 1.0 second

g; gravitational acceleration

H_o; depth of reservoir water adopted by 9.0 m

From the above-mentioned formula, the height of wave due to earthquake is to be 0.15 m at the Al Bassierah Dam.

(3) Dam crest elevation

According to the results of calculation for the heights of wave due to the wind and earthquake, the crest elevation of the non-overflow section of dam can be obtained as follows:

Hf + 2.00 = EL 115.00 + 2.00 = EL 117.00 m (in case of hw+he<1)

Hd + 2.00 = EL 120.50 + 2.00 = EL 122.50 m (in case of hw<1)

From the above formulas, the Al Bassierah Dam crest elevation without extra bank is to be EL 122.50 m.

If the freeboard is defined as a difference between the crest elevation and the maximum water surface level of a reservoir, the said freeboard can be estimated at 2.0 m.

3-5-3. Extra Bank

The settlement of dam body which may be caused by the weight of embankment materials and the storage water pressure should be

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1/ From the observed data of earthquake around the Arabian peninsula, there were no epicenters in UAE. However, in the southern part of neighbouring Iran approx. 200 km away from the Dibba, a number of big earthquakes have occurred in the past. In this case, it seems to be reasonable that the intensity of 0.10 will be adopted as horizontal seismicity in designing the dambody owing to the attenuation of the shock wave over those distance from the epicenters.

considered in designing a fill dam. It is desirable that the settlement after construction of dam should be estimated by applying the results of soil test; however, the consolidation test has not yet been conducted for the embankment materials. Thus, its value is presumed by the following experimental formula.

$$\Delta H = 0.001 \cdot H^{3/2}$$

Where, ΔH; settlement of the dam body

H; height of the dam adopted by 19.5 m

The settlement after construction of the dam is computed to be about 0.1 m from the above equation, and to this value 0.2 m is added in considering the settlement of dam foundation and spectable. The total settlement, therefore, reaches 0.3 m, and it corresponds to about 1.5 percent of the dam height.

The height of extra bank is determined at zero meter on both abutment and at 0.3 meter on river-bed portion, and the profile of dam crest forms in trapezoidal shape.

3-6. Stability Analysis

In general, the stability of dam is studied from their structural and hydrological viewpoints shown below;

° Structural stability:
Stability of dam slope by the slide analysis method

° Hydrological stability:
Study on the seepage water through the dam body

3-6-1. Design Values

Design values of the sand and gravel and rock materials to be used for the stability analysis of a dam body should be decided according to the results of soil test, however, since effective tests for these materials have not been conducted, the estimations are made on the data which have been obtained through various past soil test in similar nature.

(1) Sand and gravel materials

Soil tests of sand and gravel materials deposited on the river course have been conducted regarding to those auxiliary items of gradation analysis and specific gravity, and the relevant result is shown in the Figure 3-1 in Appendix.

Generally, the soil mechanics of those coarse materials is comparatively well correlated with the distribution of gradation.

The results1/ of soil test for sand and gravel materials in similar gradation distribution as shown in the above-mentioned figure are tabulated as follows:

Max.size (mm)	D10 (mm)	D60 (mm)	Uc	Gs	γt (t/m^3)	e	ϕ (°-')	C (t/m^2)
100	0.2	10.0	50.0	2.67	1.98	0.35	36°-00'	0.0
200	0.5	20.0	40.0	2.66	1.90	0.40	39°-10'	0.98
200	1.3	34.6	26.6	2.70	2.05	0.32	36°-20'	0.07
200	0.27	21.0	77.8	2.54	2.02	0.26	33°-30'	0.0
250	0.7	33.0	47.0	2.92	2.30	0.27	37°-00'	0.0

Where, D10, D60; grain size of materials finer than respective percenta-e by weight of total volume of materials

Uc; coefficient of uniformity, Uc = D60/D10

γt; wet density

e; porocity

ϕ; angle of internal friction

C; cohesion

Gs; specific gravity

1/ Data obtained through past soil tests in Japan.

Sand and gravel materials deposited around river-bed are good mixture of large and small size particles with the coefficient of uniformity is about 27 which indicates that they are the well-grade semi-pervious materials for the fill type dam.

The shearing strength of sand and gravel materials is well correlated with the degree of compaction which represents by the relative density[1/] as shown in the following table.

Grain size and gradation distribution	Relative density		
	>70%(dense)	70∿50%	<50%(loose)
Uniform mixture of fine and coarse size materials	35 ∿ 38°	32 ∿ 34°	28 ∿ 30°
Well-grade coarse sand and poor-grade mixed materials of sand and gravel	37 ∿ 45°	33 ∿ 36°	30 ∿ 33°
Well-grade mixed materials of sand and gravel	40 ∿ 45°	36 ∿ 41°	33 ∿ 36°

In general, the relative density of sand and gravel materials will be obtained easily more than 70 percent by compacted fill and it corresponds to about 93 percent of the maximum dry density in dry weight of the materials.

Judging from the above data, the design values of sand and gravel materials for the Al Bassierah dam body are presumed as follows:

1/ Relative density = $\frac{\gamma max\ (\gamma - \gamma min)}{\gamma(\gamma max - \gamma min)}$ x 100(%)

Where, γmax; density in the most compact state

γmin; density in the loosest state

γ; density in-site

			Density		Shearing strength	
Gs	e	Dr (%)	γt (t/m³)	γsat (t/m³)	φ (°-')	C (t/m²)
2.75	0.35	770	2.04	2.30	36°-00'	0.0

Where, Gs; specific gravity adopted by 2.75 from obtained data

e; porocity assumed to be 0.35

Dr; relative density assumed to be more than 70%

γt; wet density

γsat; saturated density, $\gamma sat = (GS + e)/(1 + e)$

φ; angle of internal friction assumed to be 36°-00'

C; cohesion

The permeability coefficient of sand and gravel fill will be controlled less than 1×10^{-4} cm/sec as described in 3-4, Chapter III of this Report. In order to ensure the said value, the sand and gravel materials should be contained more than seven percent of finer particles which pass through the No.200 sieve by weight of total volume of the materials.

Prior to filling river-bed deposits as semi-pervious embankment, the gradation distribution of these materials should be checked at the borrow area and the improvement in gradation with mixture of proper particle materials should be considered, if necessary.

(2) Rock materials

The soil test for excavated rock materials of the spillway and the quarry sites has not been conducted excluding of the rock tests for the serpentinite rocks at the spillway site as tabulated below:

Test Item	Sample A	Sample B
Apparent specific gravity	2.75	2.73
Absorption (%)	0.64	0.70
Durability by sodium sulfate(%)	1.71	9.0

As for the design values of rock materials, the presumption is made based on the data obtained from the past soil tests in Japan considering the results of rock tests. The result is shown in the following table.

Gs	e	Density		Shearing strength	
		γt (t/m³)	γsat (t/m³)	φ (°-')	C (t/m²)
2.75	0.4	1.98	2.25	38°-00'	0.0

Where; the notes in the table are same that in the former paragraph of sand and gravel materials.

(3) Filter materials

The materials to be used for the filter zone are obtained from the river-bed deposits with arrangement in gradation distribution.

Since the embankment of filter materials is mostly same procedures of the sand and gravel fill, the design values of filter materials can be quoted completely from that of sand and gravel materials.

Design values of the above-mentioned sand and gravel, rock and filter materials are summarized as follows:

Materials	Density		Shearing strength	
	γt (t/m³)	γsat (t/m³)	φ (°-')	C (t/m²)
Sand and gravel	2.04	2.30	36°-00'	0.0
Rock	1.98	2.25	38°-00'	0.0
Filter	2.04	2.30	36°-00'	0.0

Where, the notes in the table are same that in the former paragraph of sand and gravel materials.

The above-mentioned design values should be checked based on the results of test embankment at the site before commencement of dam embankment.

3-6-2. Stability Analysis

Fill type dam has a sufficient resistivity against the sliding failures through the dam body itself and the foundation in consideration of the properties of embankment materials and the foundation conditions of the damsite.

Since the foundation of this damsite consists of sand and gravel materials having a sufficient resistivity, the stability of dam body will be herein studied assuming the following conditions;

Reservoir Conditions	Slopes	Seismic Coefficient	Water surface elevations	Pore pressure
Full water level	Upstream & downstream	0.10	F.W.L. EL 115.0m	Steady flow
Immediately after completion of fill	Upstream & downstream	0.05	Nil	Nil
Middle water level	Upstream	0.10	M.W.L. EL 111.0m	Steady flow
Rapid drawdown	-do-	0.10	F.W.L. to M.W.L. F.W.L. to L.W.L.1/	Unstead flow
Flood water level	Upstream & downstream	Nil	H.W.L. EL 120.5m	Steady flow

The following table shows results of the stability analysis under the above-mentioned conditions.

1/ Low water level EL 107.0 m.

Case	Reservoir Conditions	Water surface elevation	Seismic Coefficient	Slopes	Safety factor
1-1 1-2	Full water level	F.W.L. EL 115.0m	0.10	Upstream Downstream	1.340 1.477
2-1 2-2	Immediately after completion of fill	Nil	0.05	Upstream Downstream	1.890 1.681
3	Middle water	M.W.L. EL 111.0m	0.10	Upstream	1.387
4-1 4-2	Rapid drawn-down	F.W.L. to M.W.L. F.W.L. to L.W.L.1/	0.10	Upstream Downstream	1.635 1.367
5-1 5-2	Flood water level	H.W.L. EL 120.5m	Nil	Upstream Downstream	2.084 1.932

The dam body will have a sufficient stability since the safety factor is more than the minimum safety factor of 1.2 under the varying conditions mentioned above. Results of the stability analysis and the contour of safety factors are shown in the Table 3-1 (A) to (E) and Figure 3-2 (a) to (j) in Appendix, respectively.

3-6-3. Seepage Analysis

(1) Seepage through dam body

The permeability in horizontal and vertical directions of embanked sand and gravel materials is quite different. In this case the embankment should be considered as an anisotropic medium with the permeability depending on the directioin of flow. The ratio of vertical coefficient of permeability (Kv) to horizontal one (Kh) at the compacted sand and gravel materials differs depending on the method of compaction. Generally, in case that compaction is made by flat type vibrating rollers, Kh may nearly be equal to 25 Kv. The effect of an anisotropy in the permeability can be replaced by an equivalent shrinking of the coordinates. Namely, transformed section which is obtained by shrinkage of horizontal dimension of

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1/ Low water level EL 107.0 m.

coordinates by the ratio of $\sqrt{Kv/Kh}$ = 5.0. In the transformed section, the phreatic line can be obtained by using Casagrande method at EL 120.5 m, EL 115.0 m EL 111.0 m and EL 107.0 m of reservoir surface levels. The phreatic lines in original section are shown in the Figure 3-3 in Appendix.

Since the embanked sand and gravel sone is an anisotropic media, the computation of a quantity of seepage water is made on the isotropic media in using transformation coordinate system mentioned above. It is also required that the coefficient of permeability in anisotropic media should be converted to modified permeability coefficient of $\sqrt{Kv \cdot Kh}$. On the assumption that the flat type vibrating rollers are used for compaction of sand and gravel materials and the permeability coefficient of these materials are controlled at 1×10^{-4} cm/sec, the modified permeability coefficient is computed as follows:

$$\bar{K} = \sqrt{25} \times (1 \times 10^{-4}) \times 864 = 4.32 \times 10^{-1} \text{ m/day}$$

A quantity of seepage water is calculated in the following formula.

$$Q = \bar{K} \cdot Yo \cdot L$$

Where, $\bar{K}$; modified coefficient of permeability ($\sqrt{Kh \cdot Kv} = \sqrt{n} \times Kv$)

Kh; coefficient of horizontal permeability

Kv; coefficient of vertical permeability

n; rate of permeability coefficient, Kh/Kv = 25

Yo; height of discharge face $(\sqrt{h^2 + d^2} - d)$ = 5.81 m1/

L; crest length of dam, adopted by 883.5 m

$Q = 4.32 \times 10^{-1}$ (m/day) x 5.81(m) x 883.5(m)

= 2,218 (cu.m/day)

= 0.03 (cu.m/sec)

1/ Refer to Figure 3-3 in Appendix

(2) Piping in dam body

The proposed dam body mainly consists of the sand and gravel zone and the rock zone. The rock zone will have a large coefficient of permeability of more than 1×10^{-3} cm/sec and a large resistivity against the action of seepage water. Under the situations, no attentioin may be required to the stability of the rock zone against the piping. It is assumed that the sand and gravel zone will have a permeability coefficient of 1×10^{-4} cm/sec taking into consideration the grain size distribution of the materials. The zones will be affected by the seepage water pressure, accordingly. When the seepate water pressure exceeds a certain limit, it causes to collapse the dam through piping, etc. In general, the following formula for computing the critical hydraulic gradient is employed to study the stability against piping.

$$ic^{1/} = \frac{H}{L} \leq \frac{G - 1}{1 + e}$$

Where, ic; critical hydraulic gradient

L; creep length

H; difference of water heads within the creep length

G; specific gravity of embankment materials

e; porocity of embankment materials

Computation of the critical hydraulic gradient is made for the contact face of the sand and gravel zone and the foundation assuming the full water level of the reservoir.

$$ic = \frac{H}{L} = \frac{12}{77} = 0.16$$

$$\frac{G - 1}{1 + e} = \frac{2.75 - 1}{1 + 0.35} = 1.30$$

$$ic = 0.16 < \frac{G - 1}{1 + e} = 1.30$$

1/ In general, critical hydraulic gradient (ic) of 0.5 to 0.8 is employed in case of sand and gravel materials having no cohesion.

The computation result suggests that the sand and gravel zone has a sufficient resistivity against piping.

3-6-4. Filter Criteria

In order to prevent washing-out of fines contained in the zones which are protected by the filter and to safely permit seepage water to flowout of the zones, the filter zones are planned at the up and downstream surfaces of the sand and gravel zone. It is also required that contact face of the base of downstream rock zone and river-bed foundation, the horizontal filter zone should be constructed to prevent against the piping for the foundation. These filter materials should be satisfied relation of gradation between the filter zone and that of the zones protected by the filter as follows:

1 $\frac{\text{15\% grain size of filter materials}}{\text{15\% grain size of materials protected by filter}} > 5$

2 $\frac{\text{15\% grain size of filter materials}}{\text{85\% grain size of materials protected by filter}} < 5$

3 It is desirable that gradation curve of filter materials is approximately parallel to that of the materials protected.

4 If materials to be protected by filter contain coarse materials, 1 and 2 shall be applied to the materials under 25 mm size.

5 Filter materials shall not be cohesive and not contain more than five percent fine passing the No.200 sieve.

6 The maximum grain size of filter materials is to be 76 mm.

The gradation distribution of filter materials based on the above filter criteria is shown in the Figure 3-4 in Appendix.

3-6-5. Riprap

The embanked materials at the upstream slope should be protected by the hand-placed riprap in order to prevent from moving and washing out by wave action. Riprap materials must be hard and sound having enough durability against weathering.

The required thickness of riprap zone can be obtained by the following equations.

$$T = 20 \left(\frac{WA}{62.4\ Gs}\right)^{1/3}, \quad WA = \frac{62.4 \cdot Gs \cdot H^2}{1.82\ (Gs - 1)^3 \cdot \mathrm{Cot}\alpha}$$

where, T; thickness of riprap (in)

WA; weight of riprap (lb)

Gs; specific gravity of riprap material

H; height of wave due to wind adopted by 1.48 ft

α; angle of slope adopted by 19.6518°

The required thickness of riprap zone is computed to be about 0.25 m from the above formula, however, total thickness of 0.5 m is adopted in considering the allowance of construction. An average grain size of the riprap materials is to be 0.2 m due to the wave action.

3-7. Foundation Treatment

Al Bassierah Dam aims to store temporarily flood discharge that appears once or twice a year for flood control in the downstream area by means of cutting the peak of floods, and to recharge groundwater through infiltration of the stored water by the dam into aquifers.

Being different from ordinary storage dams, Al Bassierah Dam will require no barrier structures in its foundation. In other words, Al Bassierah Dam will require the foundation treatment to secure a sufficient bearing capacity to free the dam body itself from unsuitable settlement caused by a weight of the embankment and the stored water as well as to secure the stability against the collapse due to piping failure.

3-7-1. Foundation Excavation

Excavation of the dam foundation is classified into two parts, one is for the whole of dam body base and the other for the trench base along the dam axis.

In the former excavation objectionable materials such as top-soil, loose rocks, debries, mud, plants and roots shall be removed. The excavation depth of the whole dam base is different in places; however, is assumed to reach 0.5 m on an average.

A trench along the dam axis shall be excavated to obtain a good bond between the materials embanked and the dam foundation. The excavation shall be performed not to create an extremely irregular surface, very steep slope and vertical or overhanging abutments.

For the trench base, the excavation depth is assumed to reach two m on an average; however, the maximum depth may be less than four m in consideration of the deposited condition at the river course and weathering condition of rocks at the both abutments.

3-7-2. Surface Treatment

Prior to placing embankment materials, the excavated surfaces should be made to a smooth finish without undue irregularities, and then compacted to obtain a good bond with the materials embanked on or against it.

In case of rock foundation at the abutments, the excavated surfaces shall be cleaned of loose materials, and cavities and depressions in finished rock surfaces shall be filled with selected sand and gravel materials before embankment materials are being placed on it.

3-8. Spillway

3-8-1. Type and Alignment

In general, a fill dam should be equipped with an open-type spillway from the view point of hydraulic characteristics since the fill dam has no resistivity against overtopping caused by unexpected floods. The non-control type spillway, i.e., the overflow type spillway having no gate, is selected among others taking into account the designed flood discharge, topography and surrounding environment of the spillway site and possible dangerousness in gate operation if provided.

As regards the alignment of spillway, the right abutment with the small saddle is more advantageous than the left abutment due to the applicability of the topographic conditions.

The spillway will consist of the three structures, i.e., the control structure of a perfect overflow-type, the carrier structure of a shute-type, and the river bed protection structure of a horizontal riprap.

3-8-2. Designed Flood Discharge

In designing the spillway, a 10,000-year probability flood discharge of 2,320 cu.m/sec is employed taking into account the lack of hydrological data and precedent in UAE.

A discharge to be released through the spillway when the flood discharge of 10,000-year probability flows into the reservoir has been computed by using the following formula in which the relationship between the flowOout capacity of spillway and the storage effect of reservoir are taken into consideration;

$$1/2\ (I_1 + I_2)\cdot\Delta t + S_1 - 1/2\cdot O_1\cdot\Delta t = S_2 + 1/2\cdot O_2\cdot\Delta t$$

Where, I_1; inflow discharge at t_1 time in m^3/sec

I_2; inflow discharge at t_2 time in m^3/sec

O_1; outflow discharge at t_1 time in m^3/sec

O_2; outflow discharge at t_2 time in m^3/sec

S_1; storage volume at t_1 time in m^3

S_2; storage volume at t_2 time in m^3

$$\Delta t = t_2 - t_1,\ (t_2 > t_1)$$

The following table shows the relationship between a rise of the reservoir water level, direct construction costs and varying length of crest of the spillway in consideration of storage effects of the reservoir:

	Length of Crest at Spillway (m)			
	60	80	100	120
Water surface elevation (EL m)	120.92	120.36	119.78	119.30
Flow-out discharge (m^3/sec)	1,830	2,100	2,210	2,270
Overflow depth1/ (m)	5.92	5.36	4.78	4.30
Construction Costs2/ (x 10^6 Dh)	11.3	10.7	35.7	-

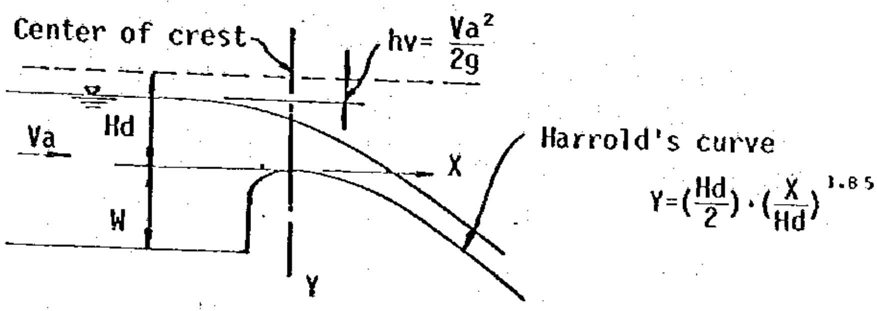
The above table suggests that the discharge of 2,050 cu.m/sec is reasonable as the designed flood discharge of the spillway with the crest length of 75.5 m in consideration of the construction costs and topographic restrictions of the spillway site.

3-8-3. Hydraulic Dimensions

The dimensions of a weir under the complete overflow condition have a close relation with a shape of the weir. Provided that the Harrold's standard type shown in the following figure is employed for the overflow crest, the coefficient of discharge and the length of weir can be obtained from the following equations:

1/ Overflow depth = water surface elevation - 115.0 (m)

2/ Direct construction costs of spillway and dambody



$$C = 2.200 - 0.0416\ (Hd/W)^{0.990} = 2.109$$
$$L = Q/C\ Hd^{3/2} = 75.36\ m \doteqdot 75.50\ m$$

Where, C; coefficient of discharge
Hd; overflow head at crest, 5.50 m
W; depth of entrance channel, 2.50 m
L; effective crest length
Q; design flood discharge, 2,050 m^3/sec

The water depth of chute at the discharge carrier is calculated by applying the following Bernoulli's theorems setting up a control point at 20.0 m downstream from the crest along the center of spillway.

$$D_1\ \cos\theta + \frac{V_1^2}{2g} + \Delta x.\tan\theta = D_2 \cdot \cos\theta + \frac{V_2^2}{2g} + n^2 \frac{Vm^2 \cdot \Delta \ell}{Rm^{4/3}}$$

Where, D_1, V_1; depth and velocity at the front section
D_2, V_2; depth and velocity at a section under consideration
θ; angle of bottom slope at the chute
g; gravitational acceleration
Δx; increment of distance
n; coefficient of roughness, adopted by 0.025 in chute
Vm; mean velocity of flow, $Vm = 1/2\ (V_1 + V_2)$
Δℓ; increment of distance measured along the bottom of chute
Rm; mean hydraulic radius, $Rm = 1/2\ (R_1 + R_2)$

The results of calculation of water depth at the chute are shown below:

Distance[1/] (m)	Bottom elevation (El m)	Bottom Width (m)	Water surface elevation (El m)	Water Depth (m)	Velocity (m/sec)	Fr.[2/]
0.0	115.0	75.5	119.22	4.22	6.44	1.00
6.836	112.5	70.5	115.14	2.64	11.01	2.16
20.0	112.5	70.5	116.92	4.42	6.59	1.00
40.0	109.0	70.5	111.40	2.40	12.11	2.50
81.888	109.0	70.5	111.66	2.66	10.95	2.15
101.888	107.0	65.731	109.54	2.54	12.29	2.47
146.888	107.0	55.5	110.46	3.46	10.67	1.83

Judging from discharges, velocity and Froude number in the above table, there is no definite hydraulic jump occurring in the spillway, except the undulated jump or weak jump accompanied by surgace turblence at the end of crest. However, the running water through the chute possess some energy to bring about erosion and scouring.

Since the surface portion of the natural ground around the spillway site has no sufficient resistivity against erosion and scouring, the protection works with gabion should be executed at such the site of the spillway. At the end of chute, the running water will have a comparatively high velocity, and causes erosion and scouring of alluvial deposites, therefore, horizontal riprap with gabion should be placed as the river-bed protection. The required length of river-bed protection can be obtained by the following Bligh's formula;

$$Ls = 0.6C\sqrt{H} = 44.1 \text{ m} \doteqdot 45 \text{ m}$$

Where, Ls; required length of river-bed protection

C; Bligh's coefficient, adopted by 20

H; difference of elevation between reservoir water surface and top of river-bed protection

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1/ Distance is measured from the crest along the center of spillway

2/ Froude number, $Fr = V/\sqrt{g \cdot d}$

3-8-4. Ultimate Outflow Capacity

A discharge capacity of the spillway when an unexpected flood discharge of more than the designed flood discharge of the spillway flows into the reservoir is roughly computed by using the following formula in consideration of a storage effect of the reservoir:

$$\Delta H = \frac{2}{3} \cdot \alpha \cdot \frac{H}{1 + \frac{A \cdot H}{QD \cdot T}}$$

Where, ΔH; height of the reservoir water raised by an unexpected flood discharge

α; increased rate of an unexpected flood discharge in comparison with the designed flood discharge

H; design overflow depth

A; reservor water area with the designed flood discharge

QD; design flood discharge

T; continuation hours of an unexpected flood of more than the designed flood discharge, adopted by 2 hrs.

From results of the calculation, the relationship among an increase in water surface, flow-out peak discharge and return period for the Al Bassierah Dam is shown below:

	α (Safety rate to an unexpected flood discharge)				
	0.1	0.2	0.3	0.4	0.5
$(1+\alpha)Qd(m^3/sec)$	2,255	2,460	2,665	2,870	3,075
Return Period (Year)	20,000	41,000	85,000	170,000	-
ΔH (m)	0.24	0.49	0.73	0.98	1.22

$Qd = 2,050\ m^3/sec$, $H = 5.50\ m$, $A = 1,350 \times 10^3 m^2$

It is learned that the overtopping at Al Bassierah Dam is out of the question. Even if a 100,000-year probability flood discharge flows into the reservoir, it only causes to raise the reservoir water level by 0.80 m. If it is defined that the utimate outflow capacity of the spillway is equivalent to the discharge released through the spillway when the reservoir water has arrived at the dam crest elevation, the said capacity counts 3,730 cu.m/sec. The return period is indefinite in this case.

3-9. Conduit

An outlet conduit will be embedded beneath the dam body in consideration of the existing condition of the water route, effective recharging of groundwater in the downstream river deposits, and neccessity to flush-out fine materials around the entrance of the outlet conduit.

3-9-1. Hydraulic Design

As a result of the reservoir operation study, a reinforced concrete conduit of the circular shape with the inner diameter of 1,420 mm has been proposed as the outlet facility of Al Bassierah Dam.

On outlet discharge of this conduit at the varying reservoir water levels can be obtained as a pipeline flow by the following equation.

$$Q = \frac{\sqrt{2g} \cdot A}{\sqrt{fv + fe + fr}} \sqrt{H}, \quad A = 0.7854D^2$$

Where,
- Q; outlet discharge of conduit pipeline
- g; gravitational acceleration
- A; flow area
- D; inner diameter of outlet conduit pipes
- fv; coefficient of changing velocity loss adopted by 1.0
- fe; coefficient of the entrance loss inclusive of the trash rack loss adopted by 0.5
- fr; coefficient of friction loss, $fr = 124.5 \times n^2/d^{4/3} \times L$
- n; coefficient of roughness, adopted by 0.015
- L; length of conduit
- H; total head, measured from top surface at the end of conduit

Based on the results of the above-mentioned computation, the relationship between an outlet discharge and a reservoir water level can be attained as follows:

	Reservoir water surface level (EL m)				
	110.0	113.0	116.0	119.0	122.5
Outlet discharge (m /sec)	9.29	11.27	12.95	14.44	16.00

The running water flows out from the outlet conduit with a relatively high velocity, therefore, horizontal riprap with gabion should be placed downstream of the conduit in order to protect the river bed from erosion and scouring.

3-9-2. Structural Design

The circular section has been adopted for the reinforced concrete conduit as outlet facility of Al Bassierah Dam in consideration of the structural characteristics as well as the construction method of this facility. The basic values and formulas used in the computation for structural design are shown below:

Basic values:

Unit weight of plain concrete	2.3 t/m^3
Unit weight of reinforcement concrete	2.4 t/m^3
Unit weight of embankment and back-fill materials	2.1 t/m^3
Static elastic modulus of concrete	200,000 kg/cm^2
Static elastic modulus of river deposits	50,000 kg/cm^2
Poisson's ratio of concrete	0.2
Poisson's ratio of river deposit	0.3
Allowable compressive stress in concrete	70 kg/cm^2
Allowable shearing stress in concrete	9 kg/cm^2
Allowable tensile stress in reinforcement bar	1,800 kg/cm^2

Calculation formulas:

$$Ms = N\ (e + c),\ C = 1/2\ t - d',\ d = t - d' \text{ or } d = C_1\sqrt{M/b}$$

$$As = \frac{C_1 \cdot C_2 \cdot Ms}{d} - \frac{N}{\sigma sa} \text{ or } As = \frac{M}{\sigma sa \cdot j \cdot d}$$

$$\tau = \frac{S}{b \cdot j \cdot d},\quad j = 1 - 1/3\ k,\ k = \sqrt{2pn + (np)^2} - np$$

Where, M; bending moment at section under consideration

N; thrust at section under consideration

S; shear at section under consideration

Ms; moment relative to thrust, eccentricity and C.

e; eccentricity $e = M/N$

t; thickness of member at section under consideration

d; effective thickness of member at section under consideration

d'; covering thickness of reinforcement bar

As; area of tensile reinforcement bar

C_1, C_2; coefficient relative to allowable stress of concrete and reinforcement bar, $C_1 = 0.297$, $C_2 = 0.00213$

τ; shearing stress in concrete at section under consideration

b; unit width of member

j; distance from computed center of compression to centroid of tensile reinforcement bar relative to effective thickness d

k; distance from compression face to the computed position of the neutral axis relative to effective thickness d

p; ratio of total area of reinforcement bar to total area of concrete member at section under consideration

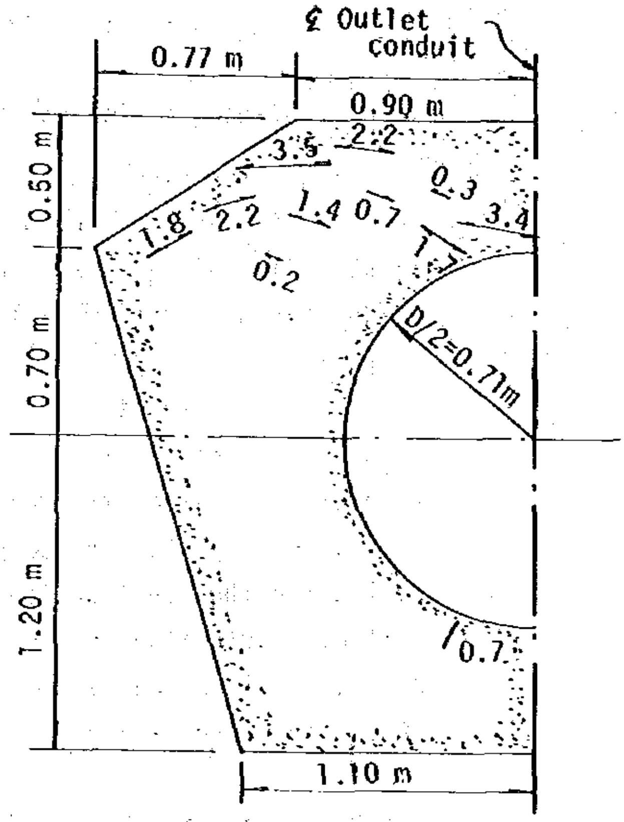
n; ratio of modulus of elasticity of reinforcement bar to that of concrete and adopted by 15

σsa; allowable tensile stress in reinforcement bar

For the distribution of tensile stress in the reinforcement concrete members and arrangement of bars at the conduit section, the structural calculation has been executed by the Finite Element Method and the results are shown in the Table 3-2 (A) to (C) in Appendix and summarized as follows:

Mesh Point	Tensile stress (kg/cm²)	Tensile force (kg)	Rein bar requirement (cm²)
1	1.8	5,400	6.7
2	2.2	6,600	8.2
3	3.5	10,500	13.0
4	0.2	600	0.7
5	1.4	4,200	5.2
6	2.2	6,600	8.4
7	0.7	2,100	2.6
8	1.7	5,100	6.3
9	0.3	900	1.1
10	3.4	10,200	12.7
11	0.7	2,100	2.6

Reinforcement bar requirements in the above table shows those for a length of 100 cm.



CHAPTER IV. CONSTRUCTION PLAN AND PROJECT COST ESTIMATION

4-1. Construction Method

The attached construction schedule itemized the construction works under the Al Bassierah Dam Project. Descriptions of the construction works are hereinafter made.

4-1-1. Staging of Dam Construction

Since the river bed in almost dry throughout the year except the winter season in February and March and is fair wide about 900 m, construction of Al Bassierah Dam in two stage by using the multiple-stage diversion system will be introduced.

In the first stage, while the existing water route near the right bank will be utilized as temporary open waterway, the construction of the left of the dambody including the conduit would be commenced in July 1982 and completed by April, 1983. During the above period for the construction of the dambody, construction of the spillway would also be made. The remaining construction works of dambody would be carried out during the months of May and June just after the winter season and completed by the end of June, 1983.

4-1-2. Excavation Works

The river bed and both abutments contain objectionable materials in their surface layer such as top-soil, loose rocks, debries, mud, plants and roots, therefore, the surface layer of about 0.5 m deep on an average should be removed before placing embankment materials.

For the trench along the dam axis, the excavation shall be performed not to create extremely irregular surface, very steep slope and vertical or over hanging abutments, and the excavation depth is assumed to reach 2 m on an average. These excavation works will be executed by in a conventional way to combine tractor shovels, bulldozers and dump trucks, and those excavated materials will be hauled to the spoil banks located immediately downstream of the dam body.

Excavation works along the conduit will be commenced concurrently with that for the dam foundation by combination of backhoes, bulldozers and dump trucks.

No special measurements such as coffering and dewatering will be required in excavation works for the dam foundation and conduit works.

Since there is no over burden around the spillway site, excavation works for the spillway will be mostly composed of rock excavation by the bench-cut method with blasting. The major equipment will be air-compressors and heavy dri-ling machines for drilling of the blasting holes and tractor shovels, bulldozers and dump trucks for quarrying and hauling of excavated rocks. These excavation works should be performed in accordance with the embankment schedule of the dam body.

4-1-3. Embankment Works

Al Bassierah Dam is designed mainly to have two zones, that is, central sand and gravel zone and rock zone taking into consideration the embankment materials available around the dam site and their mechanical characteristics.

Central sand and gravel zone is located in the central part of the dam body. For this zone less pervious materials with a diameter less than 20 cm will be obtained by means of screening river deposits at the upstream borrow area. The borrowing and embankment works will be made by construction equipment such as scraper, bulldozer and bivrating roller, etc.

Rock zone will be located on the both sides of central sand and gravel zone as the outer shells of the dam boyd and will be constructed rock materials to be excavated for the spillway construction and quarry site of the left bank. In embankment of the central sand and gravel zone, the materials should be compacted by the vibratory roller with watering, for each banking layer of about 40 cm. The spreaded rock materials should also be compacted by the vibratory roller.

4-1-4. Concrete Works

Concrete to be used for the concrete works of the Project will be classified into the following two specifications:

Kind of Concrete		Standard of Proportion: Weight of cement (kg/m³)	Standard of Proportion: Max-size of aggregate (mm)
Reinforced concrete	(Class A)	350	40
Plain concrete	(Class B)	250	40

As regards cement, the portland cement will be used since it can be obtained in the market of the UAE. Aggregate materials will be collected from river deposits around the dam site. In order to remove the silty materials including in the river deposits and to obtain appropriates size of aggregate, river deposits will be washed and screened at an aggregate plant to be provided at the site.

Concrete will be mixed by portable mixer with a capacity of 0.5 cu.m/batch at site, and mixed concrete there will be hauled by agitator truck to respective job sites, and placed by chuting gutter or centipede conveyor.

4-1-5. Plant and Equipment for Construction Works

Combination of tractor shovels, backhoes, bulldozers with rippers or rakes, and dump trucks may be the major working force in excavation and scraper and dump trucks might be used for hauling, whereas the vibratory rollers in compaction of the embankment. Rocks for dam embankment will be produced at the spillway site and the left bank quarry site by bench-cut method with blasting. The stationary air-compressors will be installed at the spillway and quarry sites.

Filter materials and aggregate for concrete will be produced to screen the river bed materials at the screening plant to be provided.

A 0.5 cu.m/batch plant will be erected on the right bank near the crest of spillway. Concrete mixed here will be delivered to the respective placing sites by a 2.0 cu.m agitator trucks. A chutting gutter or centipede conveyer will be employed to place concrete. The construction plant and equipment required for the Project are listed in the Table 4-1 in Appendix.

4-2. Construction Schedule

Al Bassierah Dam Project is expected to be completed by June, 1983 in order to store temporary flood discharges from the rainy season. The construction period of about 16 months has been scheduled in consideration of the present river flood conditions as well as construction methods. Under the situations, the construction should start in March, 1982. The Ministry of Agriculture and Fisheries, UAE, will be the executing body of construction works under the Al Bassierah Dam Project. The construction schedule covering the entire works is shown in Figure 4-2 the attached construction schedule.

4-2-1. Service Road

A 7.0 m wide service road with asphalt pavement will be constructed from the Dibba-Masafi national road to the dam site. The road will be about 2.0 km long. The construction of the road will require two months prior to the commencement of the dam construction.

4-2-2. Relocation of Power Line

The existing 3,300 KV power line through the damsite shall be partially relocated on the left bank for the construction works.

The Construction will take about one month prior to the commencement of the dam construction.

4-2-3. Spillway and Conduit

It is economical and safe to execute the construction works of the dam by using the multiple-stage diversion system. The construction plan schedules to start the works of the left bank in July, 1982, while keeping space of the right bank for flood way during the rainy season, whereas the right bank construction works of the dam will be commenced immediately after the rainy season of 1983, and completed by June of the same year.

The excavation works of the spillway may be commenced concurrently the embankment works of the dam body in consideration of the direct haul of rock materials excavated at the spillway site to the embankment place. The excavation period of the spillway will be about five months as shown in the attached construction schedule.

Since the outlet conduit is located beneath the dambody, the conduit works will be completed prior to the embankment works of the dambody.

4-3. Project Cost Estimation

4-3-1. Project Cost

The Project Cost contained construction costs of the dam, spillway, conduit, service road, relocation of power line and administrative expences as well as contingency is shown in the following table. The Project Cost has been carefully estimated based upon quantities computated in detail designing as well as upon analyses of construction methods, equipment required and construction schedules so as to cover all the costs and expenses incurred in the construction works under the Project.

Costs of construction materials, plants and equipment have been estimated based upon their purchasing prices in assuming these are available in the UAE. Depreciation costs of plants and equipment have been estimated based on their estimated durable lives.

The Project Cost thus estimated is summarized in the following table.

Description	Project Cost (Unit: 1,000 DH)
(1) Dam	14,885
(2) Spillway	3,580
(3) Conduit	1,290
Sub-total	19,755
(4) Administrative Expenses	2,964
(5) Contingency	2,964
Total	25,683 ≑ 25,700 (1,542 Million Yen)

4-3-2. Phasing of Project Cost

According to the construction schedule mentioned in Paragraph 4-2, the Project Cost in each year is estimated as follows:

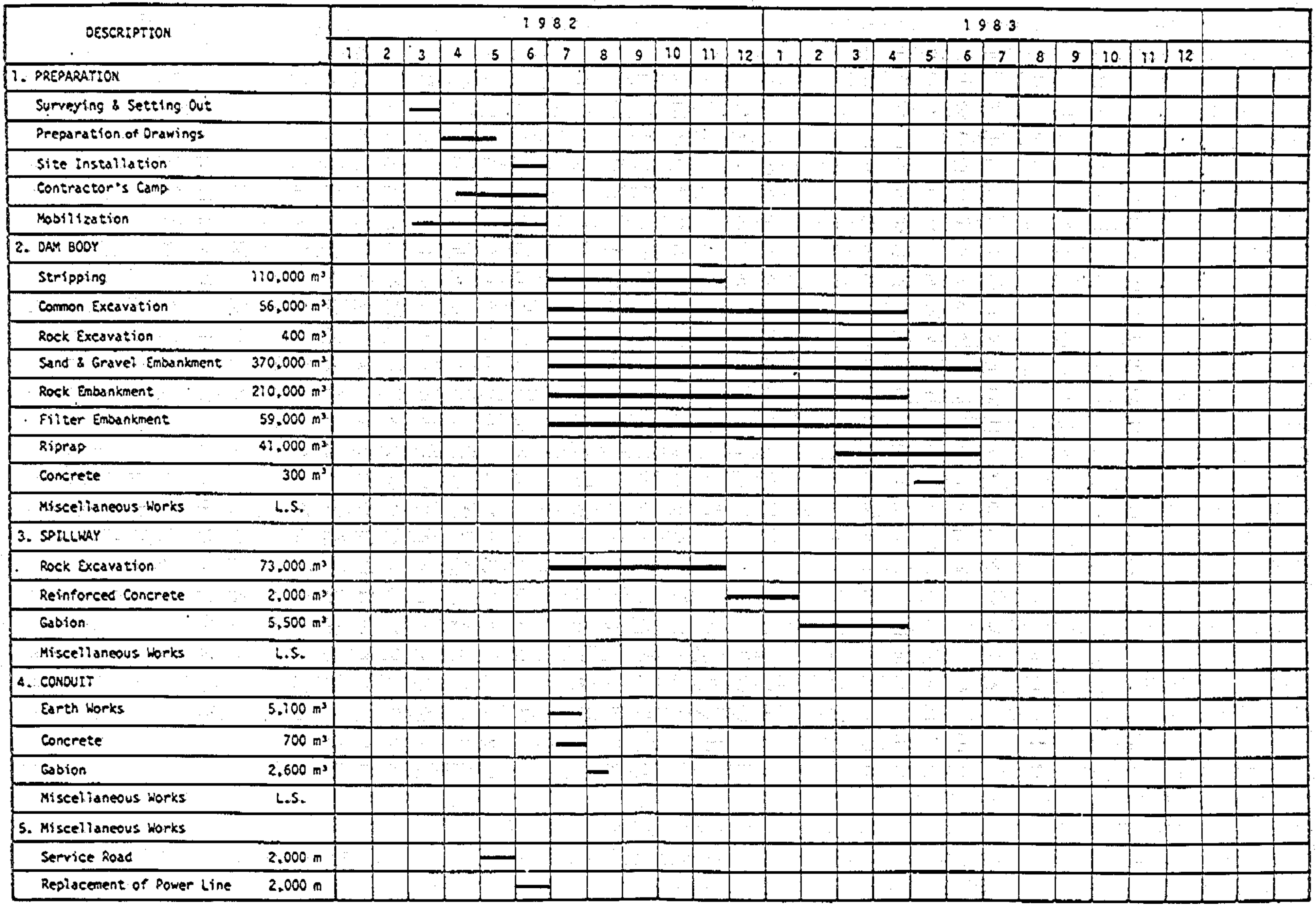
Description	Total	Year	
		1982	1983
Project cost Unit: 1,000 DH			
(1) Dam	14,885	10,428	4,465
(2) Spillway	3,580	2,510	1,070
(3) Conduit	1,290	900	390
Sub-total	19,755	13,830	5,925
(4) Administrative Expenses	2,964	2,077	894
(5) Contingency	2,964	2,070	894
Total	25,684 ≑ 25,700	17,970	7,713

Table 4-1 Project Cost of Al Bassierah Dam

(Unit: 1,000 Dirhams)

Description	Unit	Quantities	Amounts
1. Construction Cost			
1) DAM BODY			
Stripping	cu.m	110,000	850
Common Excavation	"	56,000	260
Rock Excavation	"	400	5,510
Sand & Gravel Embankment	"	370,000	5,510
Rock Embankment	"	210,000	5,260
Filter Embnakment	"	59,000	1,290
Riprap	"	41,000	1,470
Concrete	"	300	90
Miscellaneous Works		L.S.	85
Sub-total			14,885
2) SPILLWAY			
Rock Excavation	cu.m	73,000	1,630
Reinforced Concrete	"	2,000	750
Gabion	"	5,500	950
Miscellaneous Works		L.S.	250
Sub-total			3,580
3) CONDUIT			
Earth Works	cu.m	5,100	30
Concrete	"	700	730
Gabion	"	2,600	450
Miscellaneous Works		L.S.	80
Sub-total			1,290
4) TOTAL of 1) + 2) + 3)			19,755
2. Administrative Expenses			
5) Management Fee 5% of 4)			988
6) Engineering Fee 10% of 4)			1,976
7) Total of 5) + 6)			2,964
3. Contingency			
8) Contingency 15% of 4)			2,964
Grand Total			25,683

Fig.4-2 Construction Schedule of Al Bassierah Dam



CHAPTER V. OPERATION AND MAINTENANCE

5-1. Organization

The Al Bassierah Dam Project will be implemented as part of the water resources development project in the Wadi Al Bassierah basin, and the water resources to be developed will be utilized for domestic water, industrial water and irrigation water purposes under the joint control of the Ministry of Agriculture and Forestries and the Ministry of Electricity and Water.

Under the circumstances, the operation and maintenance of Al Bassierah Dam shall be made by the Dibba Office, Ministry of Agriculture and Fisheries as part of duties of this office, accordingly. The organization for operation and maintenance should be established in the office taking into consideration the water use in the entire Wadi Al Bassierah basin as detailed information is available in Chapter V of the Feasibility Study Report.

The operation and maintenance of Al Bassierah Dam itself is divided into ordinal periodical check and works in rainy season. The periodical check will be made once a month, however, in rainy season, the storage water quantity, storage duration, sediment accumulation volume and the condition of inlet and outlet portions of the conduit shall be carefully checked and recorded after each flooding. Sediment accumulated at the entrance of the conduit if any should be removed in order not to decrease the function of the conduit.

Man-power required for such works will be as follows;

° Engineer	One
° Technician	One
° Driver	One
° Laborers	Two
Total	Five

The above-mentioned man-power will be only required in rainy season, therefore, the existing staff of the Dibba Office, Ministry of Agriculture and Fisheries will be able to meet such man-power requirement.

5-2. Operation and Maintenance Cost

The operation and maintenance of Al Bassierah Dam throughout the year were described above. The rainy season is herein determined at six months from October to coming March in estimation of the operation and maintenance cost.

In estimation, buildings, vehicles, trucks and laborers belonging to the Dibba Office, Ministry of Agriculture and Fisheries, have been taken into account.

The estimated operation and maintenance cost amounts to 80,000 DH per year in total and this value is equivalent to 25 percent of the working budget for the Dibba Office, Ministry of Agriculture and Fisheries.

Starting about 10 years after the completion of the Al Bassierah Dam, an annual sediment of 20,000 cu.m to be deposited by the Wadi Bassierah should be removed away and estimated to cost about 100,000 DH per year. During the construction of the said dam, about 370,000 cu.m of sand and gravel would be excavated at the reservoir area and used for the embankment of the dam which is equivalent to volume of the sediments to be occurred for 19 years.

However, it is recommendable to remove away the silty materials sedimented in the reservoir area after the flood to augment a function of recharging aquifer.