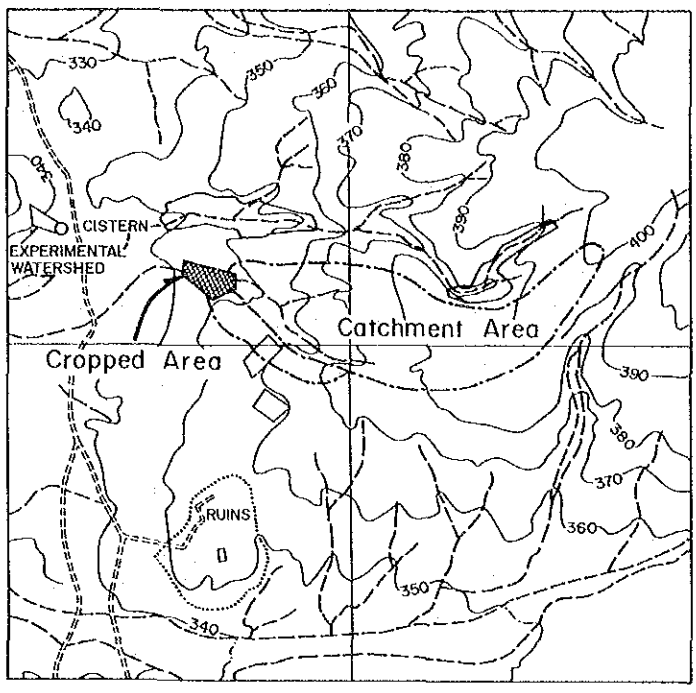
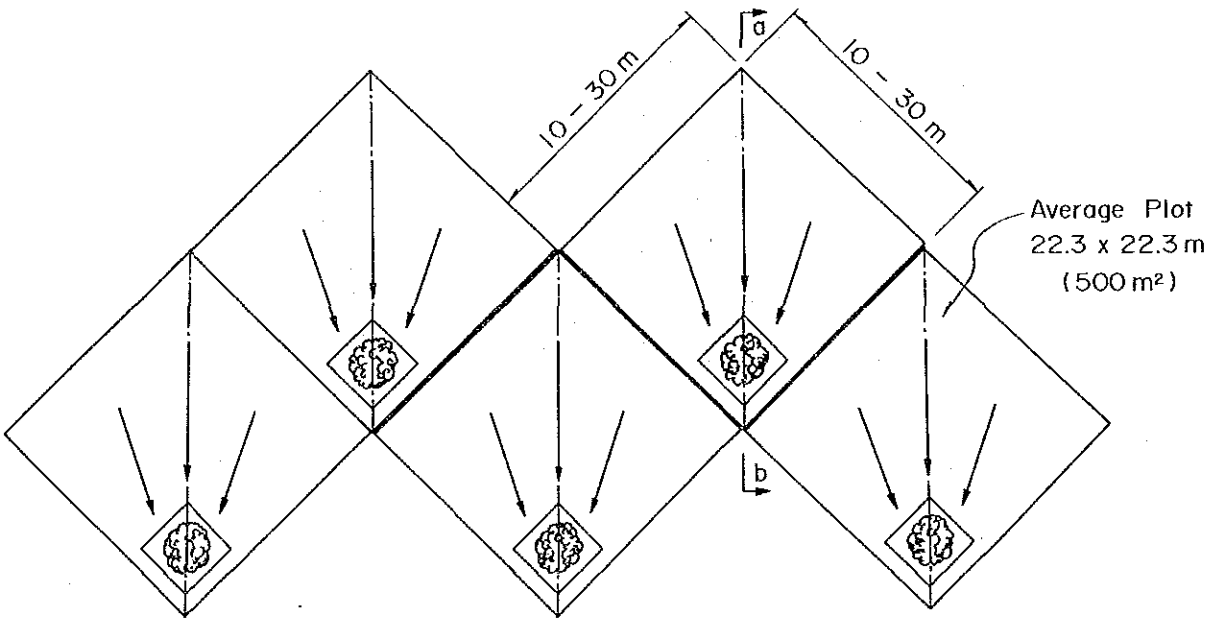


Fig. 2-1 Illustration of Runoff Farming



(The Arrows Indicate Direction of Runoff Flow.)

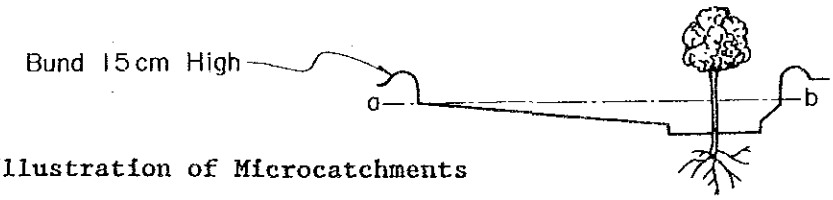


Fig. 2-2 Illustration of Microcatchments

Fig. 2-1 Illustration of Runoff Farming

Fig. 2-2 Illustration of Microcatchments

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

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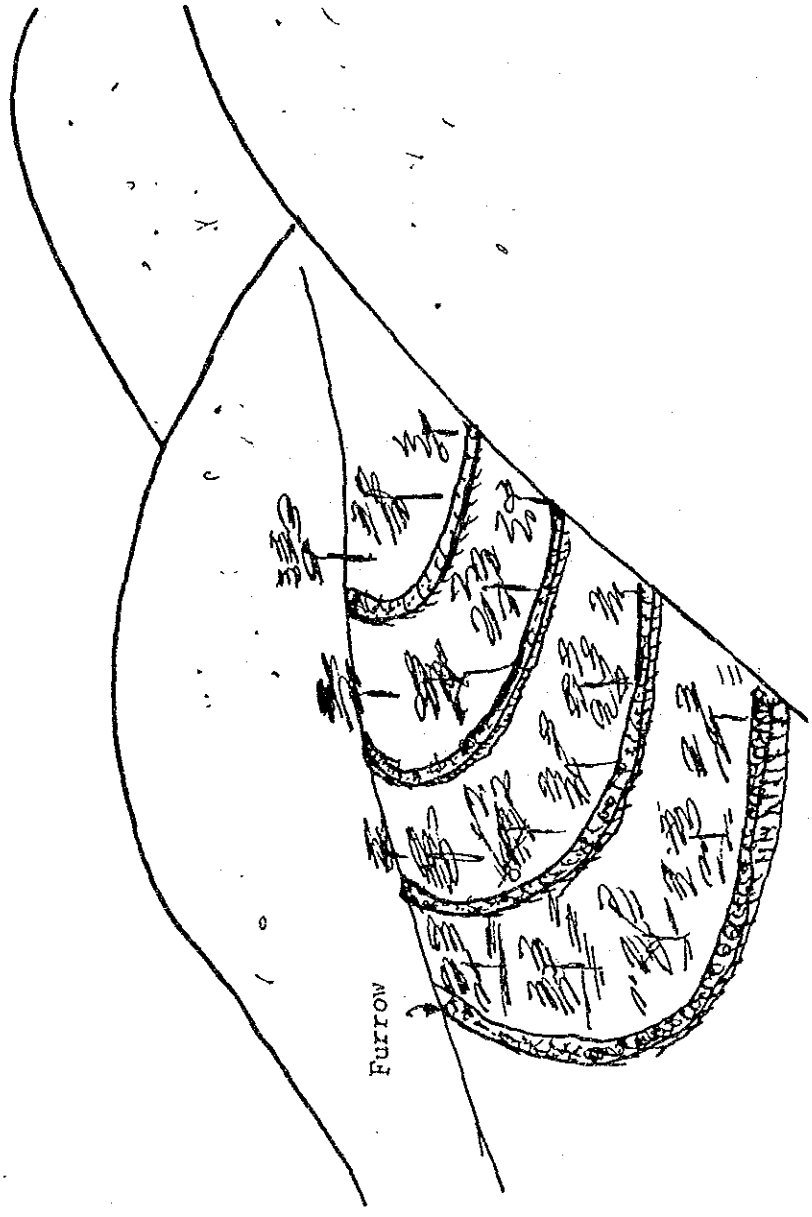

Fig. 2-3 Illustration of Contour Furrow

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION
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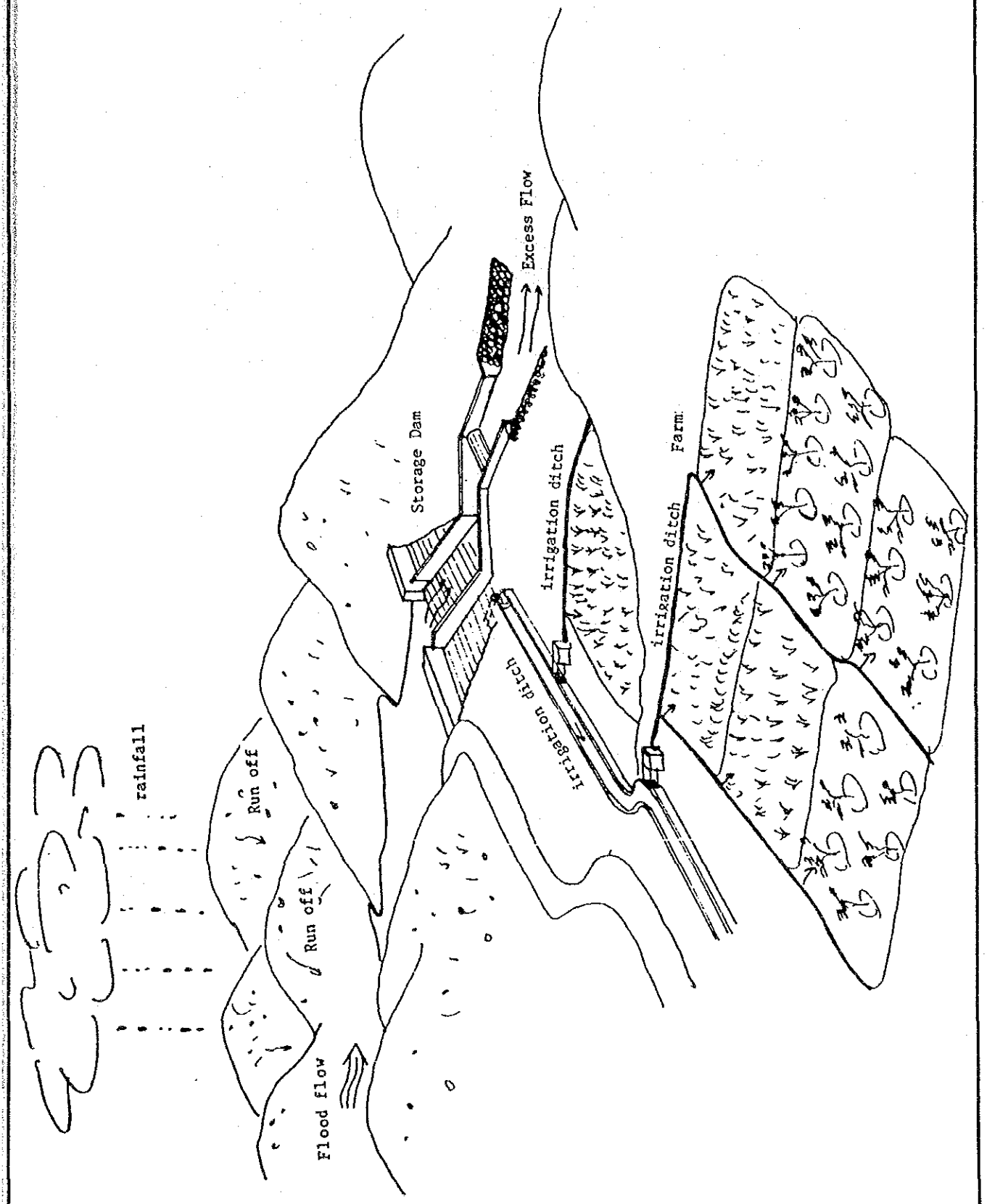
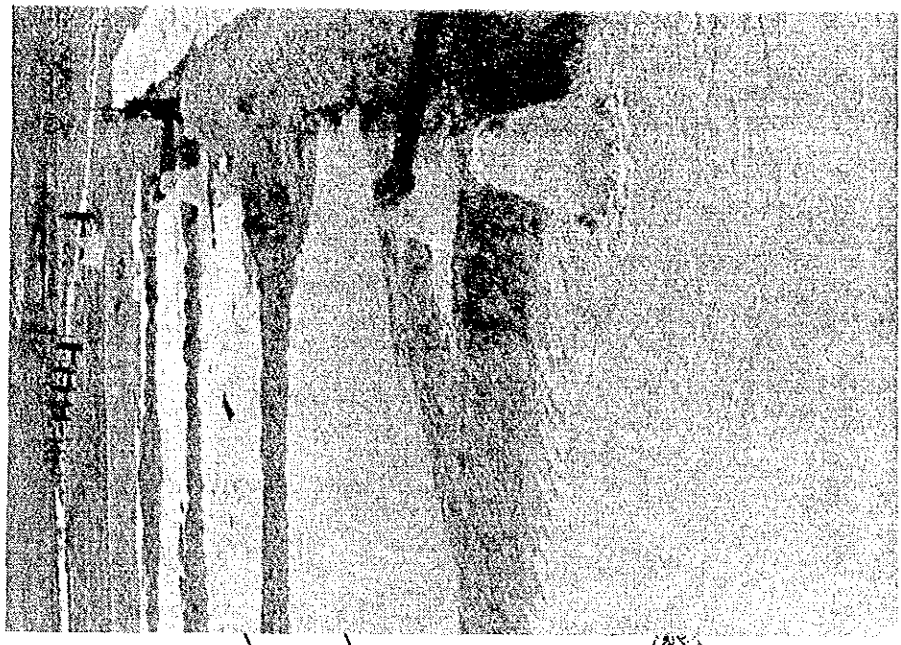


Fig. 2-4 Illustration of Storage Dam Scheme

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY



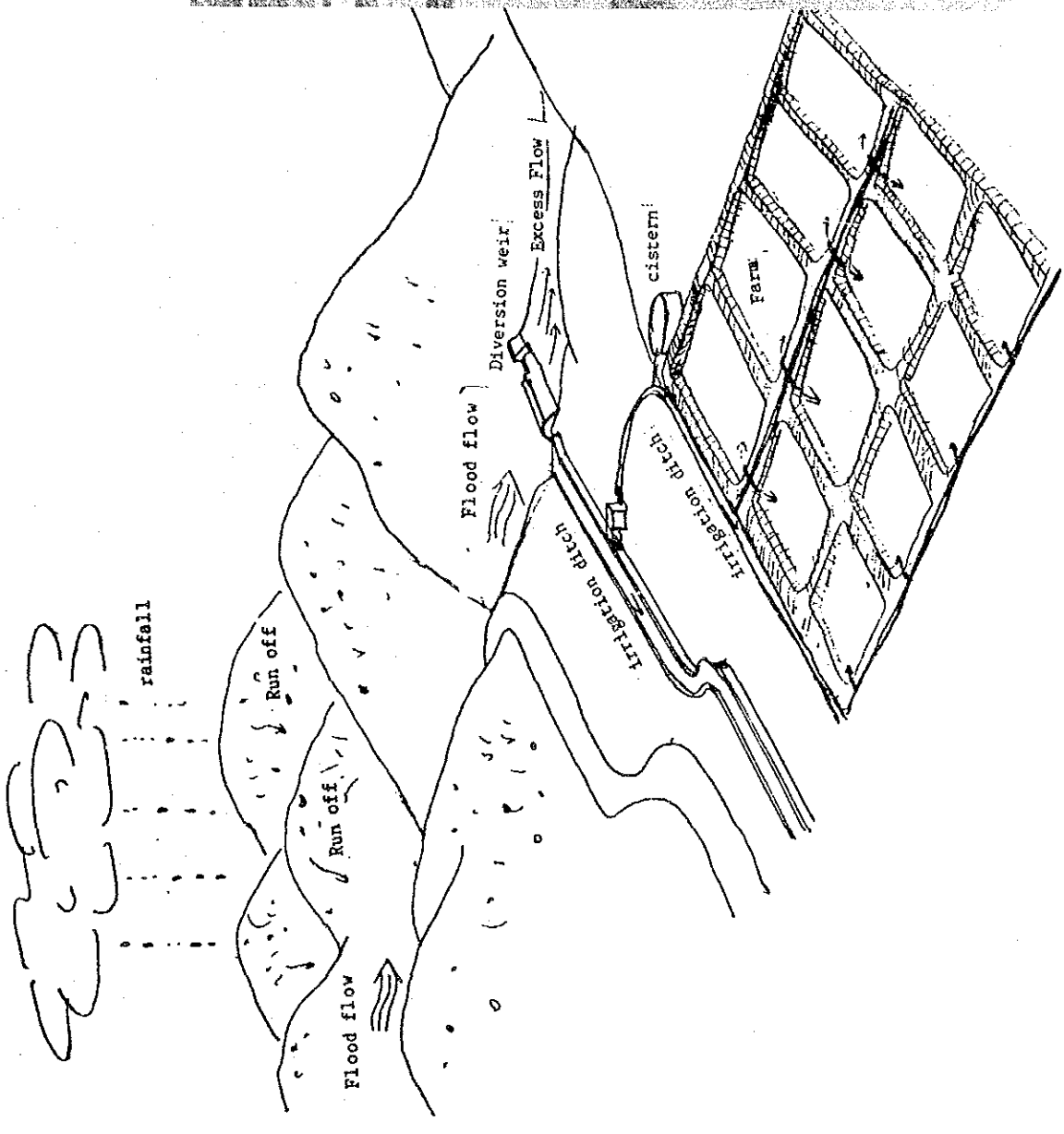


Illustration of Diversion Weir Scheme

Fig. 2-5 Illustration of Diversion Weir Scheme

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY

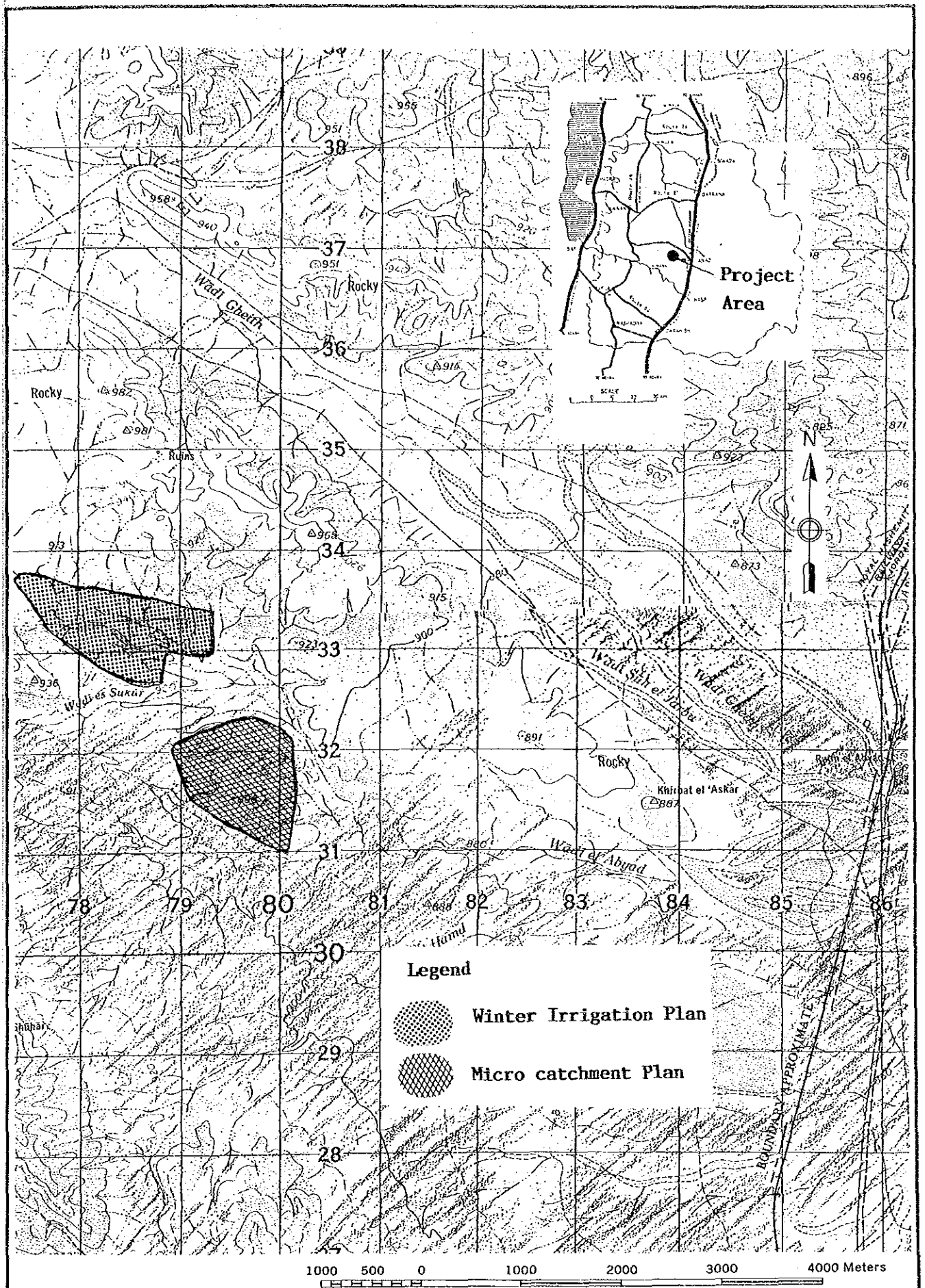


Fig. 2-6 Location Map of Proposed Pilot Scheme

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY

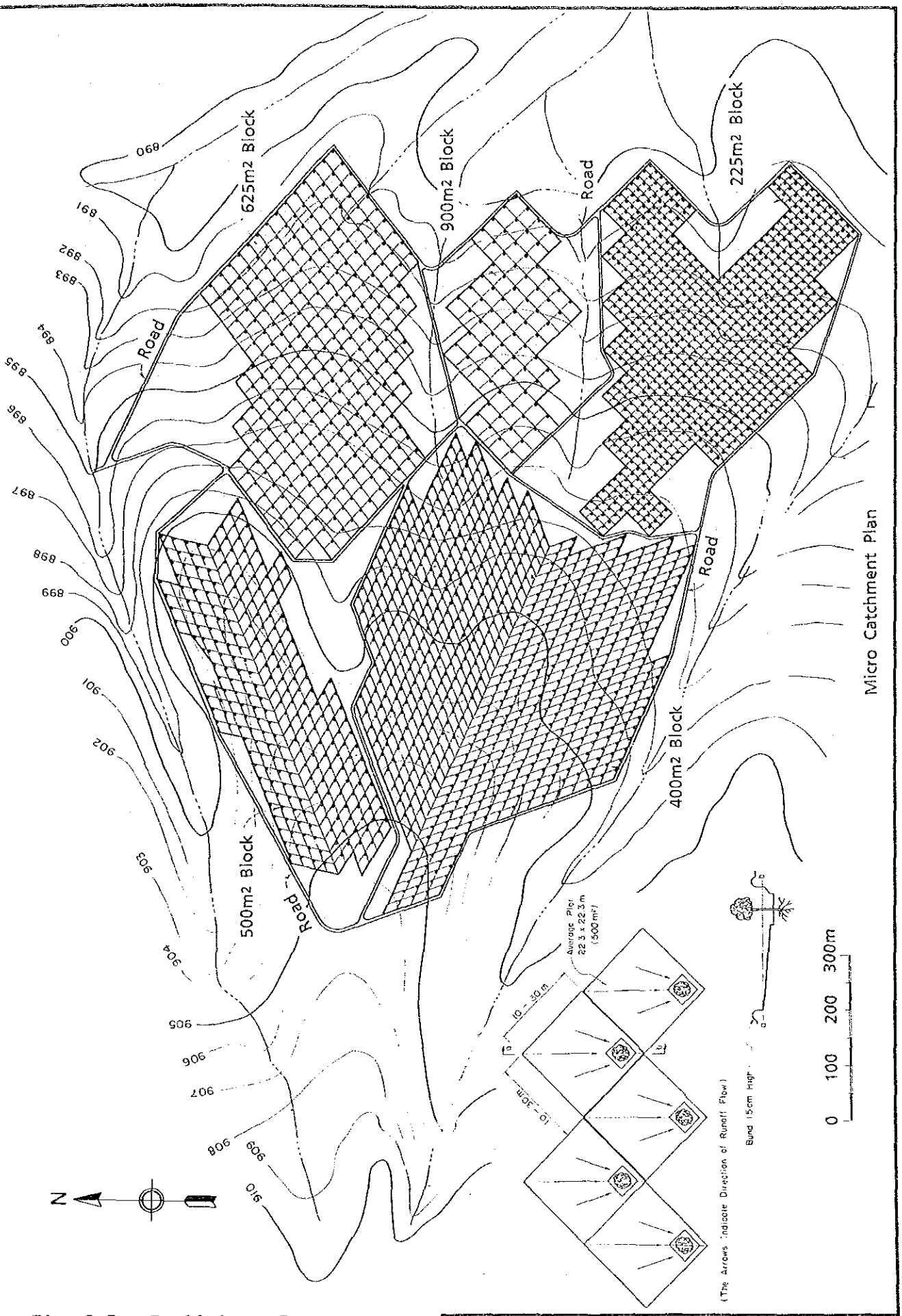
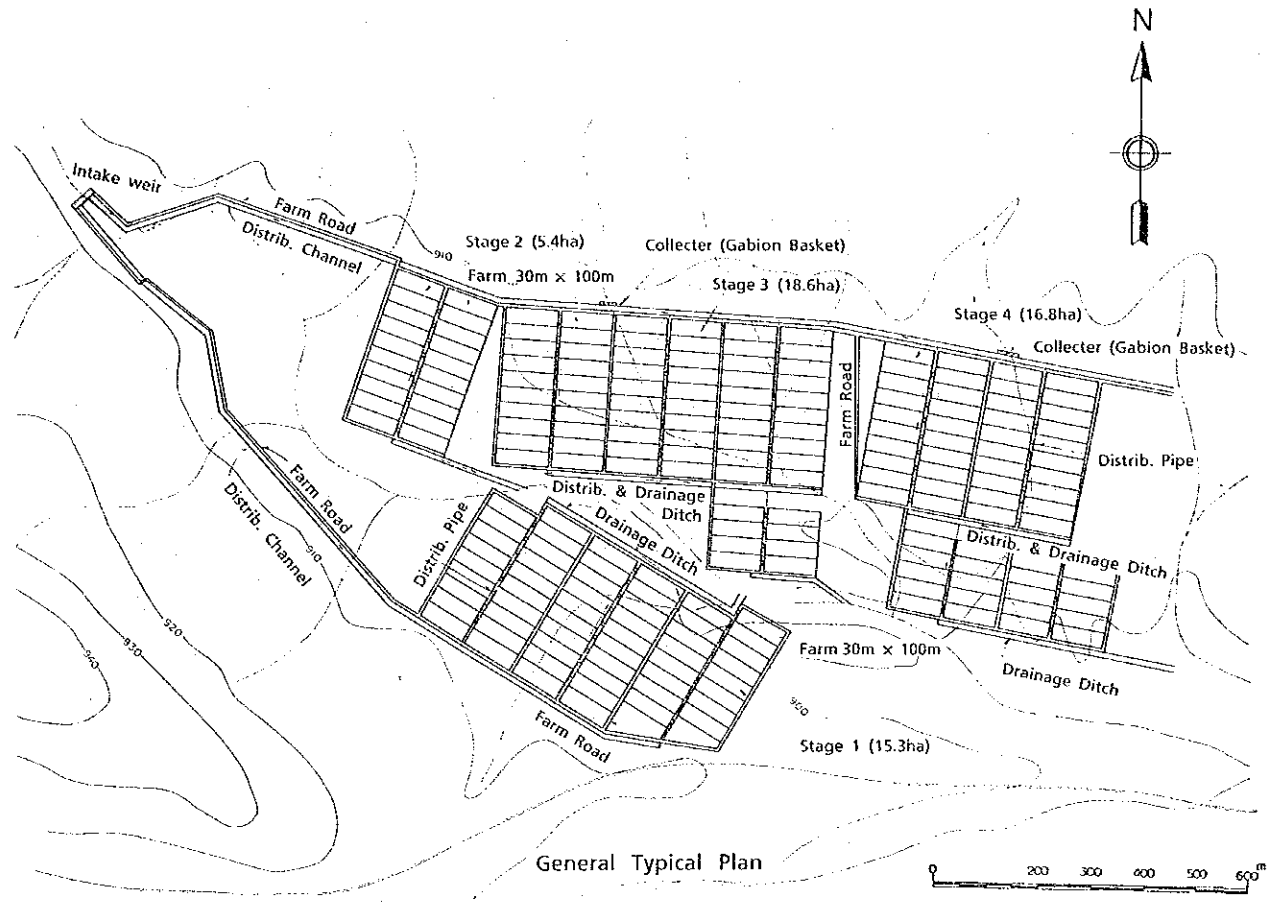
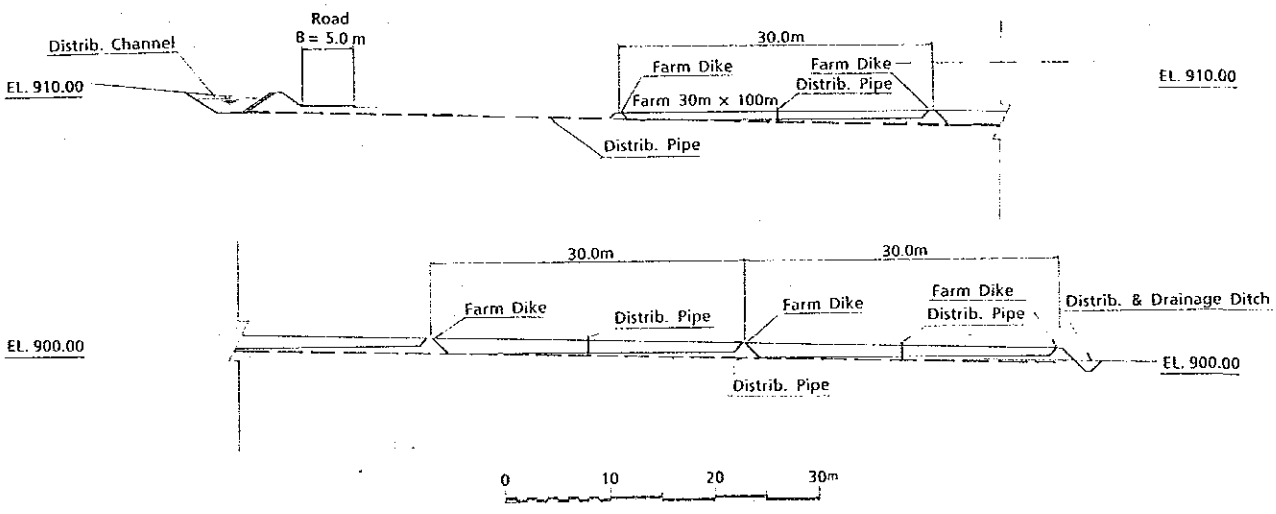


Fig. 2-7 Preliminary Layout of Microcatchments Pilot Scheme

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY





Cross Section

Fig. 2-8 Preliminary Layout of Winter Irrigation Pilot Scheme

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION
JAPAN INTERNATIONAL COOPERATION AGENCY

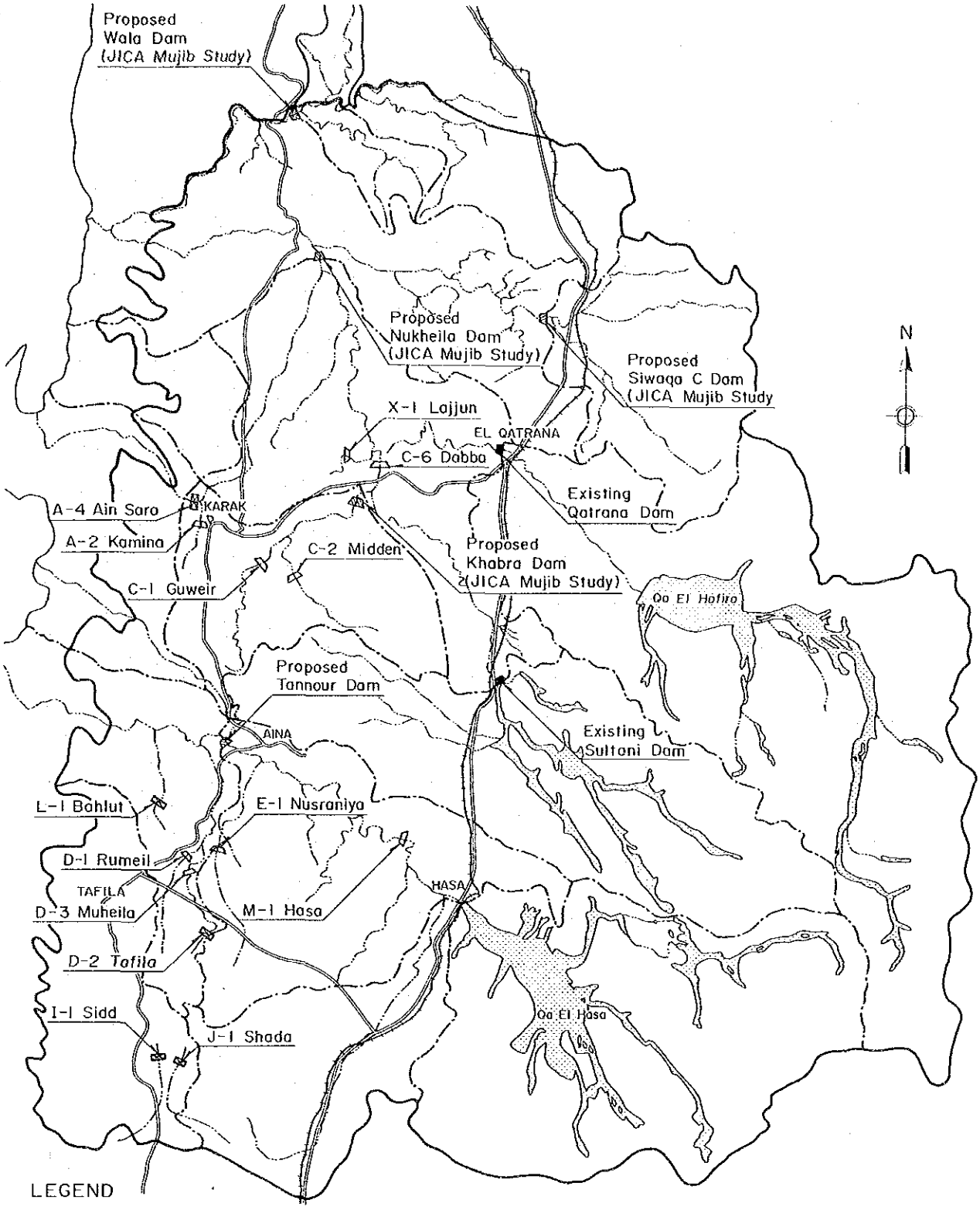


Fig. 2-9 Location Map of Prospective Dam and Weir Sites

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY

No.	A-4
Type	weir
Catchment Area(Km²)	891
Reservoir Capacity(MCM)	---
Dam Height(m)	---
Expected yield(MCM/yr)	0.86
Irrigable Area(ha)	124.20
Distribution Channel	Pipeline

No.	A-2
Type	S.dam
Catchment Area(Km²)	41.20
Reservoir Capacity(MCM)	1.75
Dam Height(m)	50.00
Expected yield(MCM/yr)	0.86
Irrigable Area(ha)	124.20
Distribution Channel	Pipeline

No.	C-2
Type	S.dam
Catchment Area(Km²)	51.80
Reservoir Capacity(MCM)	1.07
Dam Height(m)	22.00
Expected yield(MCM/yr)	0.52
Irrigable Area(ha)	75.10
Distribution Channel	Pipeline

No.	Lajjun
Type	R.dam
Catchment Area(Km²)	55.80
Reservoir Capacity(MCM)	1.30
Dam Height(m)	32.00
Expected yield(MCM/yr)	---
Irrigable Area(ha)	---
Distribution Channel	---

No.	C-1
Type	S.dam
Catchment Area(Km²)	30.40
Reservoir Capacity(MCM)	0.60
Dam Height(m)	21.00
Expected yield(MCM/yr)	0.30
Irrigable Area(ha)	36.10
Distribution Channel	Pipeline

LEGEND

- Dam
- Intake weir
- Reservoir
- Boundary of catchment area
- Pump station
- Pond
- Irrigation area
- Pipeline

Fig. 2-10 General Layout of Prospective Winter Irrigation Schemes (1/3)

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK-TAFILA DEVELOPMENT REGION
JAPAN INTERNATIONAL COOPERATION AGENCY

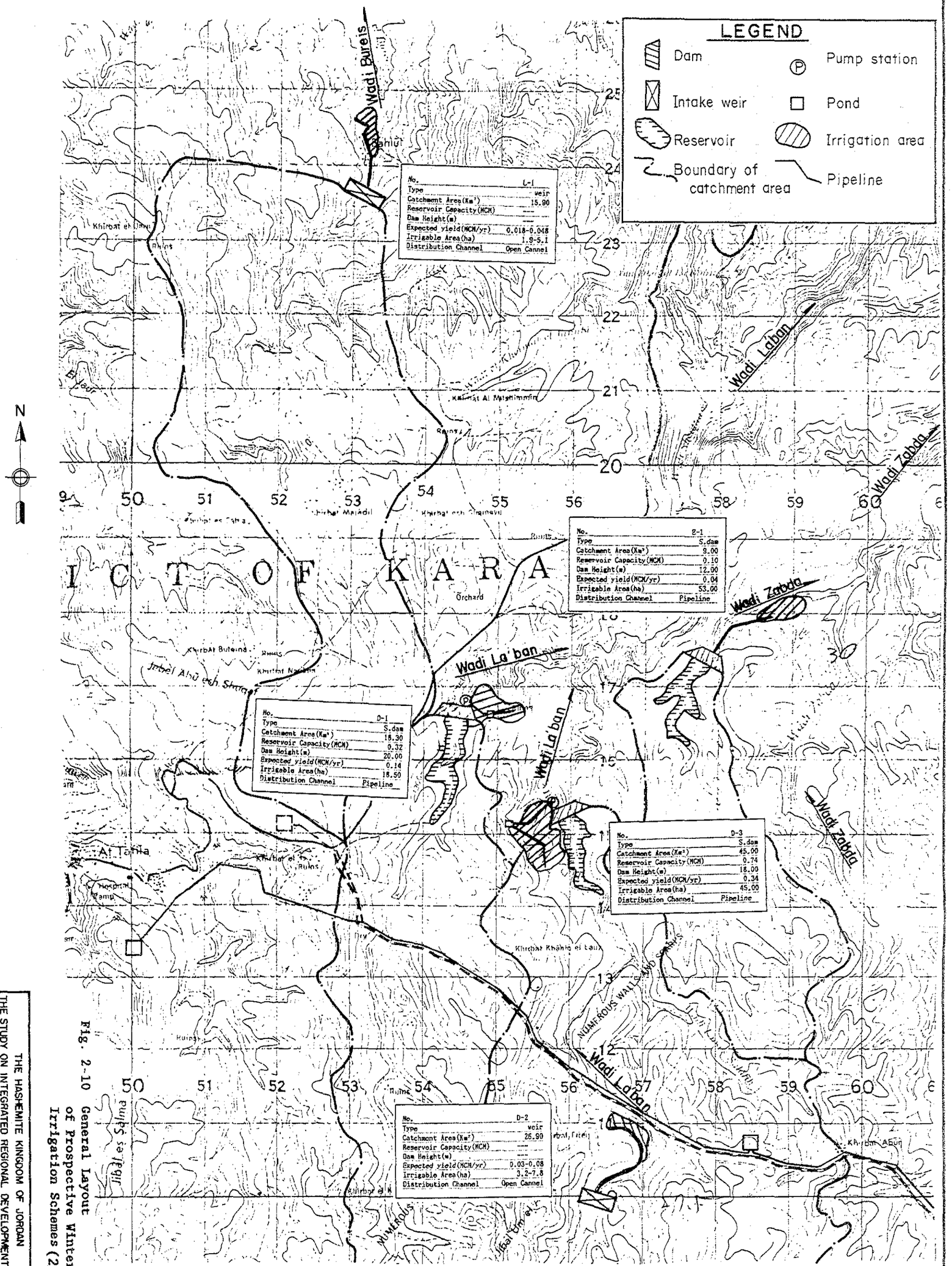


Fig. 2-10 General Layout of Prospective Winter Irrigation Schemes (2/3)

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK-TAFILA DEVELOPMENT REGION
JAPAN INTERNATIONAL COOPERATION AGENCY

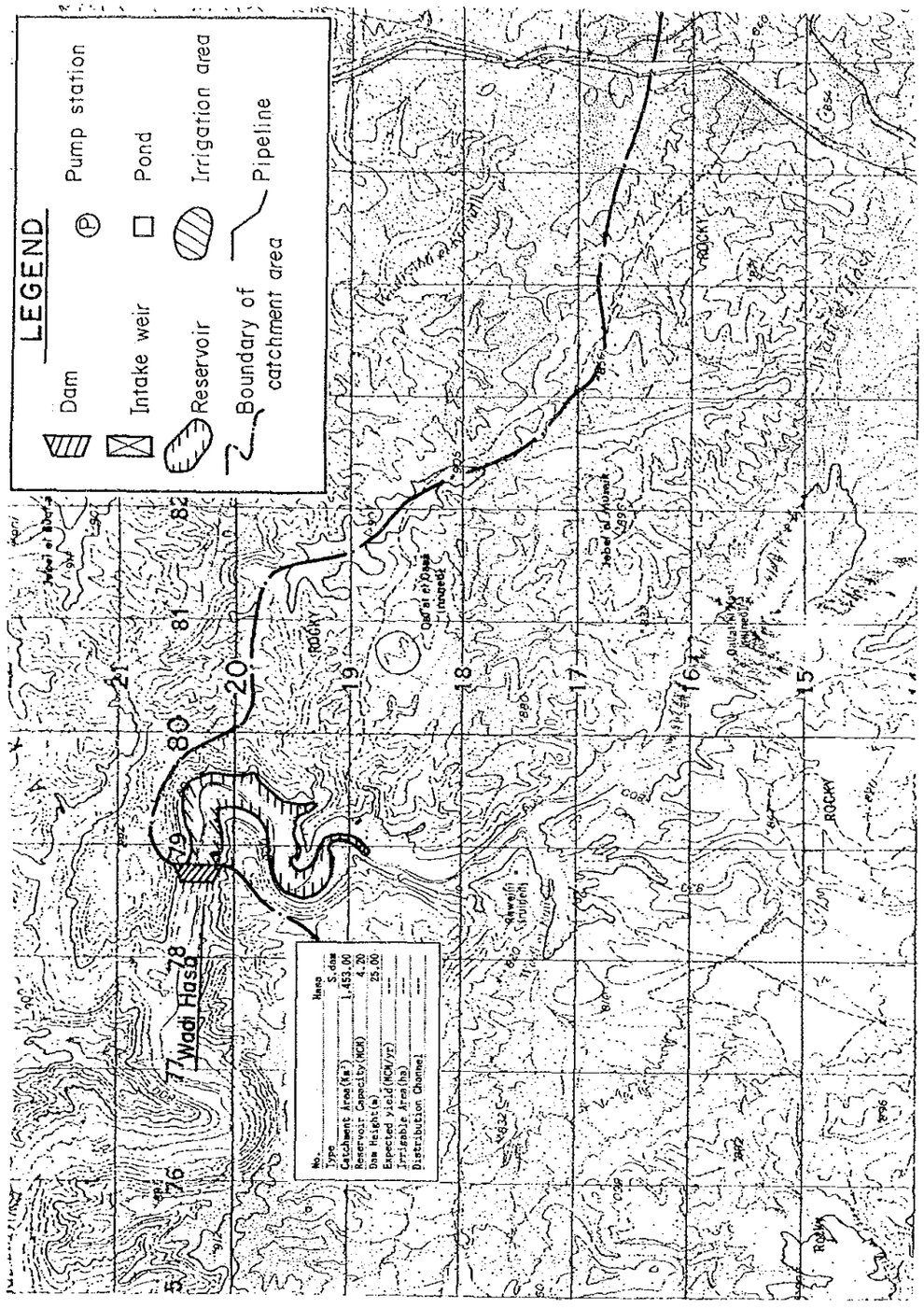


Fig. 2-10 General Layout of Prospective Winter Irrigation Schemes (3/3)

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION
JAPAN INTERNATIONAL COOPERATION AGENCY

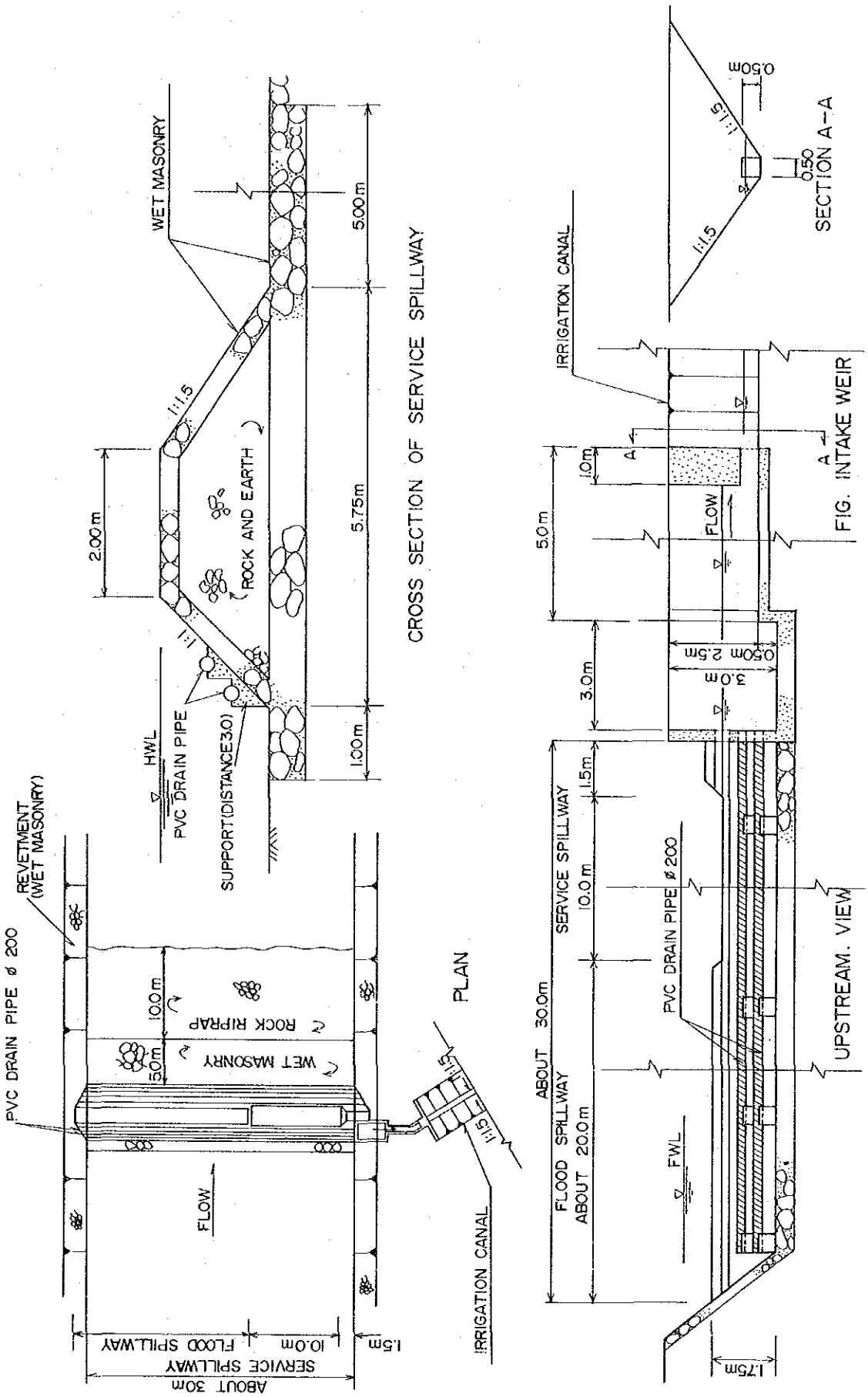


Fig. 2-11 Typical Design of Diversion Weir

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY

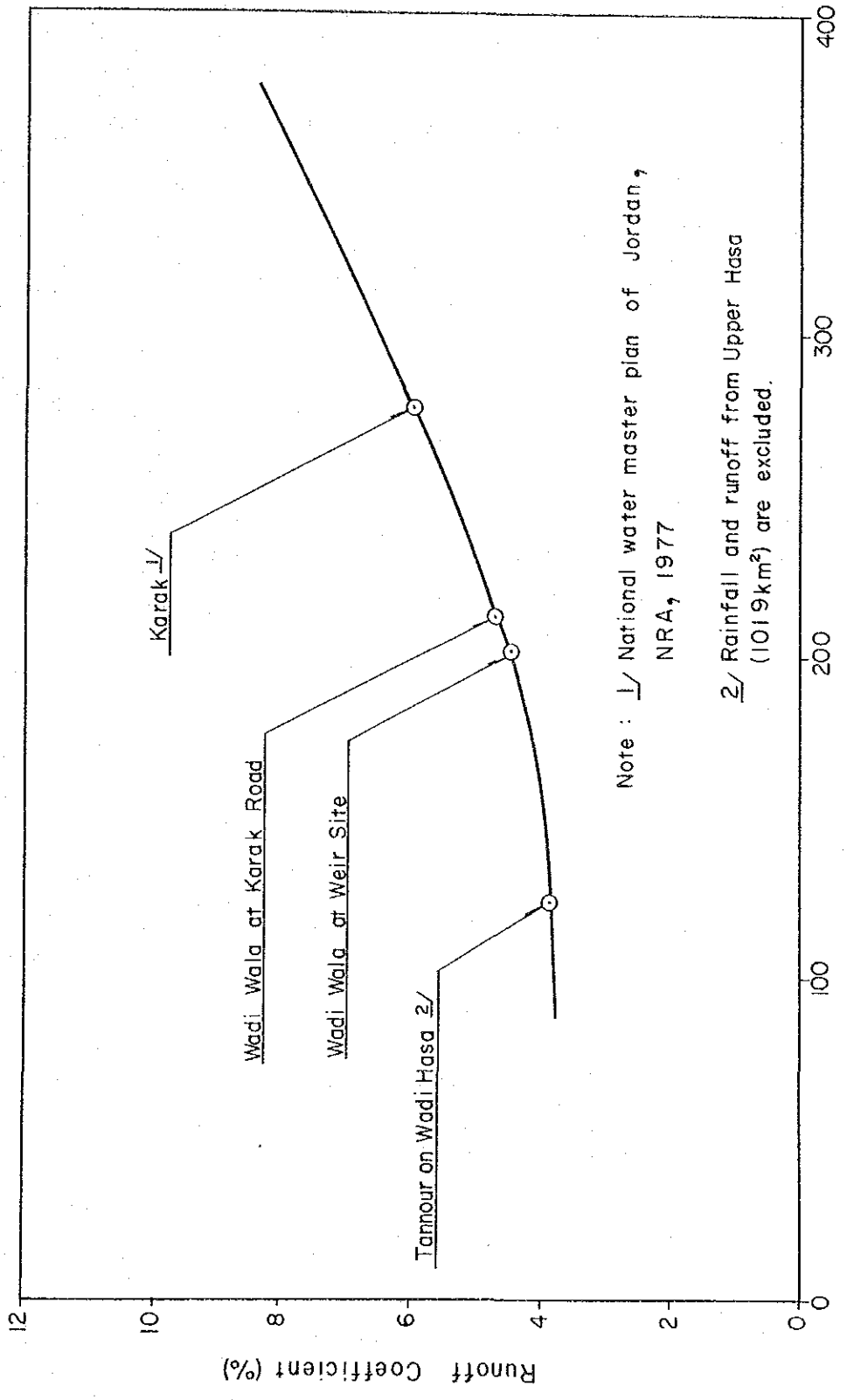


Fig. 2-12 Estimated Annual Runoff Coefficient

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION
JAPAN INTERNATIONAL COOPERATION AGENCY

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C.A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H/Lw m/Km	R.B.S. m/Km
A-2	Kaminna	Karak	Concrete gravity	Karak	31°10.0′	35°41.1′	845	41.8	340	1060	385/19	20.3
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
894	50	104	78.7	891	130	1750	700	860	124.2	5150 (15147)	22.2	2.94

Features of site topography and geology

A-2: Geology of damsite consists of massive, hard, weakly jointed, silicified marly limestone with N50°W strike and 8°N dip. Debris covers lower slope of right bank at 6 m or more thick and 4 m or more thick at lower slope of left bank. Wadi gravels are 2 to 3 m thick. Steep cliffs of marly limestone occur at both upper slopes.

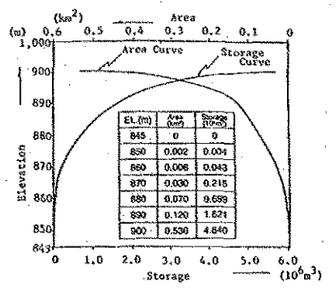
Features of irrigable area

A-2: There is about 1 ha of farmland, planted with olive trees. The stored water in the reservoir can be transmitted to farmlands around El Ifranji by pumping or to farmlands on downward slopes by gravity flow. According to a sounding test made in this downward farmlands, soil depth is about 70 cm.

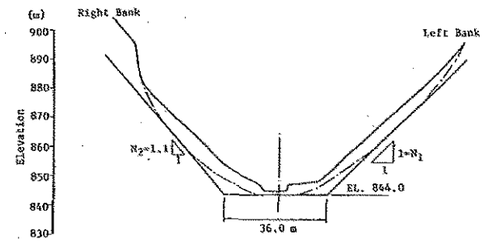
Features of submerged area

A-2: Because of a steep river slope and a narrow valley, a high dam will be required to have enough reservoir capacity. About 1 ha of olive cultivation will be submerged.

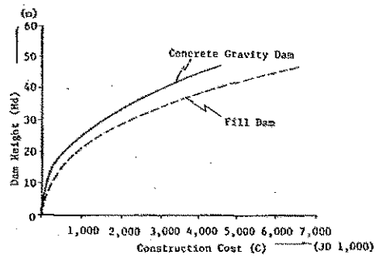
Curve of El. - R. A. and El. - Vs



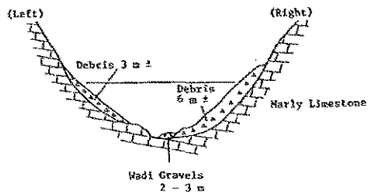
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD/m^3
860	16	67	6	857	4	40	–			392 (1153)	6.7	9.80
870	26	86	16.9	867	20	140	–			1105 (3250)	8.3	7.89
880	36	105	35.6	877	56	520	–			1232 (3624)	14.6	4.48
890	46	124	63.7	887	104	1280	230			4106 (12076)	20.1	3.21

Note

C.A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R.B.S. ; River bed slope
Crest El. ; Crest elevation
Hd ; Height above lowest foundation dam
Crest L. ; Crest length
Vd ; Dam volume
HWL ; Elevation of reservoir surface
R.A. ; Reservoir area
Vs ; Initial storge capacity
Ve ; Ultimate storage capacity
I.A. ; Irrigable area
C ; Construction cost
F1 ; Initial storge capacity / Dam volume
F2 ; Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (1/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H / Lw m / Km	R. B. S. m / Km
C - 1	Ghuweir	Kebra	Fill	Karak	31°13.1′	35°47.0′	935	30.4	237	370	225/12	18.8
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
951	21	211	159.3	948	70	600	320	300	36.1	2150 (6324)	3.8	3.58

Features of site topography and geology

C-1: Only outcrop of hard, coquinal, silicified limestone with N30°SW dip occurs at upper slope of right bank of damsite. Lower slope of right bank is covered by debris at 5 m thick in maximum. Slope of left bank consists of stony, thick soil covers which are 5 m or more thick. Wadi beds are composed of terrace gravels at 5 m or more thick and thin recent wadi gravels.

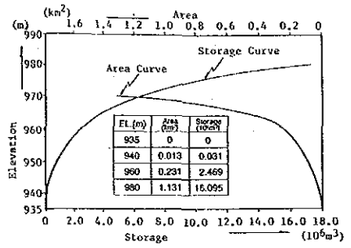
Features of irrigable area

C-1: Potential land exists downstream from E-1 site. Soil depth is considered to be thick. Some land is used for rainfed farming, but the yield may be low. As the land is flat, terraces could easily be constructed for storing flood water diverted from a weir. Therefore, not only a dam scheme but also a diversion weir scheme are conceivable.

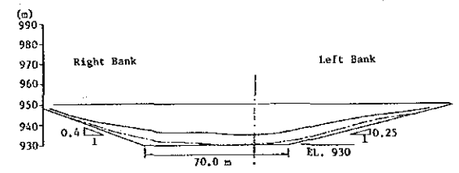
Features of submerged area

C-1: A groundwater well exists at about 200 m to the east. Little compensation would be required in the reservoir area.

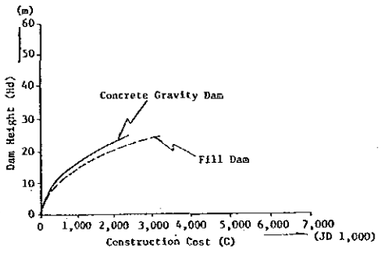
Curve of El. - R. A. and El. - Vs



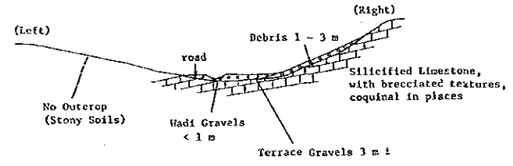
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD / m^3
940	10	135	32.5	937	5	10	–			439 (1291)	0.3	43.9
945	15	168	75.7	942	25	150	–			1022 (3006)	2.0	6.81
950	20	200	142.8	947	60	500	220			1928 (5671)	3.5	3.86
955	25	233	238.2	952	110	950	670			3216 (9459)	4.0	3.38

Note

C. A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R. B. S. ; River bed slope
Crest El. ; Crest elevation
Hd ; Height above lowest foundation dam
Crest L. ; Crest length
Vd ; Dam volume
HWL ; Elevation of reservoir surface
R. A. ; Reservoir area
Vs ; Initial storge capacity
Ve ; Ultimate storage capacity
I. A. ; Irrigable area
C ; Construction cost
F1 ; Initial storge capacity / Dam volume
F2 ; Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (2/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H/Lw m/Km	R. B. S. m/Km
C-2	Midden	Kabra	Concrete gravity	Karak	31°08.1′	35°44.4′	970	51.8	237	630	270/18.2	14.8
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
990	22	142	14.3	987	126	1040	460	520	75.1	940 (2765)	72.7	0.90

Features of site topography and geology

C-2: Hard, weakly jointed, silicified limestone interbedded by thin layers of marl exposes at lower slopes of both right and left banks of damsite. Limestone strikes N60°E and dips up to 18° to N. Debris covers both upper slopes of damsite at 1 m or more thick. Wadi sediments composed of gravels are estimated at 1 m or more thick.

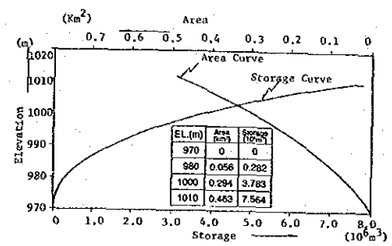
Features of irrigable area

C-2: Farmlands exist downstream from the town of Ghuweir. Land along the wadi contains many stones and is not suitable for agriculture. However, land located higher up is suitable and could be irrigated in winter by a diversion weir scheme.

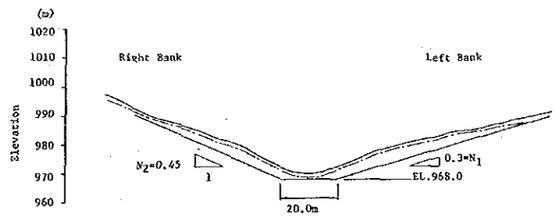
Features of submerged area

C-2: The wadi forms a deep valley having a V-shaped section.

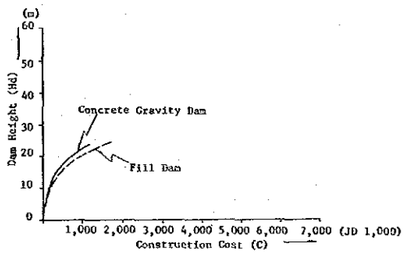
Curve of El. - R. A. and El. - Vs



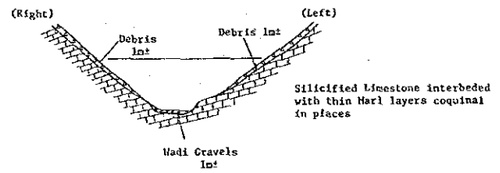
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD/m^3
980	12	87	3.5	977	40	160	–			229 (674)	45.7	1.43
985	17	114	7.7	982	80	440	–			504 (1482)	57.1	1.15
990	22	142	14.3	987	126	1040	460			940 (2765)	72.7	0.90

Note

C. A.	Catchment area	Crest L.	Crest length	C	Construction cost
Rm	Annual average rainfall	Vd	Dam volume	F1	Initial storge capacity / Dam volume
Qm	Annual average runoff	HWL	Elevation of reservoir surface	F2	Construction cost / Initial storge capacity
Lw	Water course length	R. A.	Reservoir area		
R. B. S.	River bed slope	Vs	Initial storge capacity		
Crest El.	Crest elevation	Ve	Ultimate storage capacity		
Hd	Height above lowest foundation dam	I. A.	Irrigable area		

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (3/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C.A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H/Lw m/Km	R.B.S. m/Km
X-1	Lajjun	Lajjun	Concrete gravity	Karak	31°14.4′	35°51.4′	715	55.8	251	761	285/14	20.4
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
745	32	180	35.2	742	110	1300	470	620		2300 (6765)	36.9	1.77

Features of site topography and geology

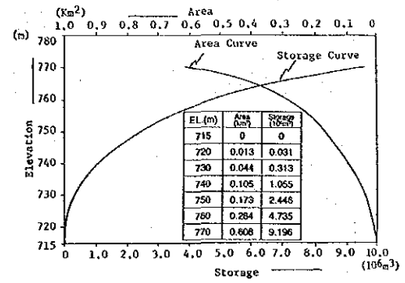
X-1: The lower horizon of damsite is composed of alternation of chert, marl and silicified limestone. The upper horizon consists of phosphorite interbedded by coquina layers. Debris is very thin on both valley slopes of damsite.

Features of irrigable area

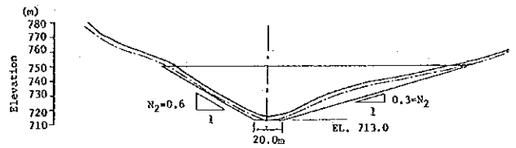
Features of submerged area

X-1: Lajjun Spring is used for irrigation of farmlands spreading downstream. This dam could be used for groundwater recharging.

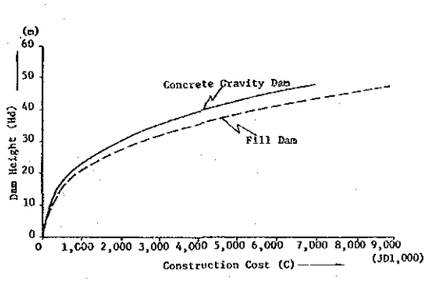
Curve of El. - R. A. and El. - Vs



Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)

Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD/m^3
730	17	105	7.2	727	30	150	–			471 (1385)	20.8	3.14
740	27	155	22.7	737	80	800	–			1485 (4368)	35.2	1.86
750	37	205	52.1	747	150	2000	1170			3407 (10020)	38.4	1.70
760	47	255	100.0	757	235	3950	3120			6540 (19235)	39.5	1.66

Note

C.A. : Catchment area
Rm : Annual average rainfall
Qm : Annual average runoff
Lw : Water course length
R.B.S. : River bed slope
Crest El. : Crest elevation
Hd : Height above lowest foundation dam
Crest L. : Crest length
Vd : Dam volume
HWL : Elevation of reservoir surface
R.A. : Reservoir area
Vs : Initial storge capacity
Ve : Ultimate storage capacity
I.A. : Irrigable area
C : Construction cost
F1 : Initial storge capacity / Dam volume
F2 : Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (4/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C.A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H/Lw m/Km	R.B.S. m/Km
D-1	Rumeila	La'ban	Concrete gravity	Tafila	30°47.7'	35°34.4'	1130	18.3	201	167	250/180	13.9
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
1147	20	120	11.9	1144	40	320	120	140	18.5	780 (2294)	26.9	2,44

Features of site topography and geology

D-1: Geology of damsite consists of chert interbedded by silicified chalk layers with N80°E strike and 5°S dip. Debris mainly covers lower slope of left bank, which is 2 to 3 m thick. Wadi beds are composed of debris gravels and soils at 3 to 4 m thick and thin recent wadi gravels.

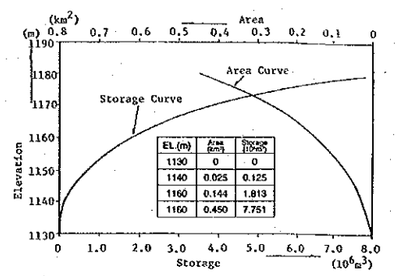
Features of irrigable area

D-1: The wadi develops toward downstream and, therefore, farmlands are not available. For irrigation of farmlands located upstream from the site, pumping of 50-80 m in static head will be required. This upstream land may be irrigated by a diversion weir scheme although the topography is a little steep and requires small plot size for storing flood water.

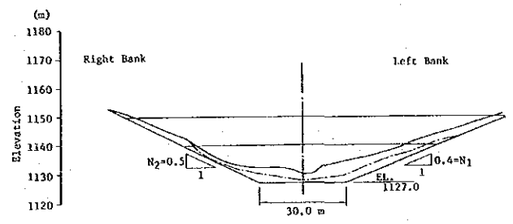
Features of submerged area

D-1: Part of the upstream farmlands will be submerged.

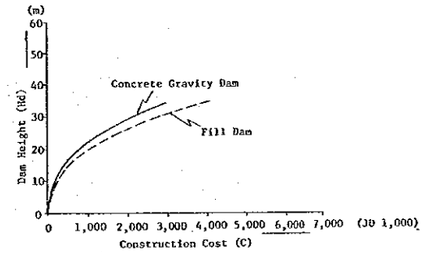
Curve of El. - R. A. and El. - Vs



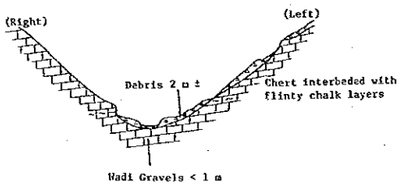
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R.A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I.A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD/m^3
1140	13	89	4.5	1137	16	80	–			294 (865)	17.8	3.68
1150	23	134	16.5	1147	52	520	320			1079 (3174)	31.5	2.08
1160	33	179	40.5	1157	116	1440	1240			2648 (7788)	35.6	1.84

Note

C.A.	Catchment area	Crest L.	Crest length	C	Construction cost
Rm	Annual average rainfall	Vd	Dam volume	F1	Initial storge capacity / Dam volume
Qm	Annual average runoff	HWL	Elevation of reservoir surface	F2	Construction cost / Initial storge capacity
Lw	Water course length	R.A.	Reservoir area		
R.B.S.	River bed slope	Vs	Initial storge capacity		
Crest El.	Crest elevation	Ve	Ultimate storage capacity		
Hd	Height above lowest foundation dam	I.A.	Irrigable area		

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (5/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km²	Rm mm	Qm × 10³ m³	H / Lw m / Km	R. B. S. m / Km
D - 3	Muheima	La'ban	Concrete gravity	Tafila	30°50.5′	35°40.3′	1130	26.9	201	245	350/19.5	17.9
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd × 10³ m³	HWL m	R. A. × 10³ m²	Vs × 10³ m³	Ve × 10³ m³	Yield × 10³ m³	I. A. ha	C × 10³ JD(× US$)	F1	F2
1147	18	116	8.9	1144	106	740	260	340	45	580 (1706)	83.1	0.78

Features of site topography and geology

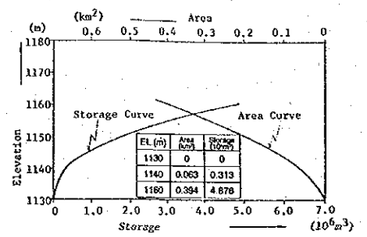
D-3: Slope of right bank consists of alternation of chart and silicified limestone which has N50°W strike and 5°N dip. Slope of left bank is almost covered by debris of 5 m thick in maximum and only small outcrops of silicified limestone are found at lower slope. Wadi sediments are estimated at 1 m or more thick.

Features of irrigable area

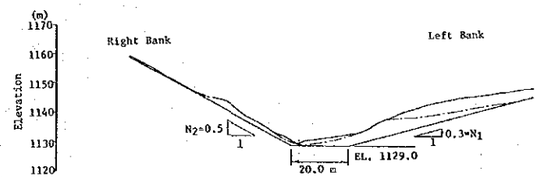
D-3: There is no farmlands in the right bank but a little in the left bank. Pumping of about 30-50 m in static head will be required. A diversion weir scheme needs to be examined upstream from D-3 site.

Features of submerged area

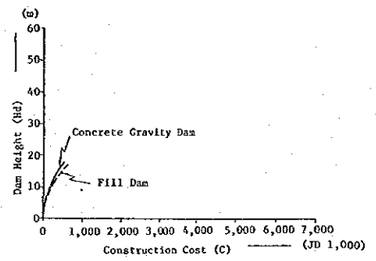
Curve of El. - R. A. and El. - Vs



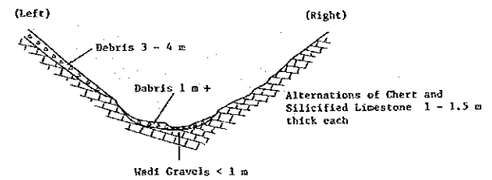
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd × 10³ m³	HWL m	R. A. × 10³ m²	Vs × 10³ m³	Ve × 10³ m³	Yield × 10³ m³	I. A. ha	C ×10³JD(×10³US$)	F1	F2 JD / m³
1135	6	52	1	1132	8	40	–			65 (191)	40.0	1.64
1140	11	79	2.8	1137	36	160	–			183 (538)	57.1	1.14
1150	16	105	6.5	1142	80	480	–			425 (1250)	73.8	0.89

Note

C. A.	Catchment area	Crest L.	Crest length	C	Construction cost
Rm	Annual average rainfall	Vd	Dam volume	F1	Initial storge capacity / Dam volume
Qm	Annual average runoff	HWL	Elevation of reservoir surface	F2	Construction cost / Initial storge capacity
Lw	Water course length	R. A.	Reservoir area		
R. B. S.	River bed slope	Vs	Initial storge capacity		
Crest El.	Crest elevation	Ve	Ultimate storage capacity		
Hd	Height above lowest foundation dam	I. A.	Irrigable area		

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (6/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H / Lw m / Km	R. B. S. m / Km
E - 1	Nusrānia	Zabda	Concrete gravity	Tafila	30°51.6′	35°41.5′	1050	9.0	151	54.7	150/5.5	27.3
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
1061	12	92	3.7	1058	20	100	30	40	5.3	240 (706)	27.0	2.40

Features of site topography and geology

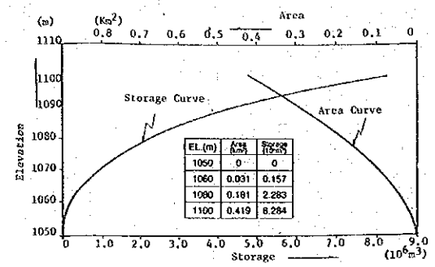
E-1: Alternation of chert and silicified limestone occurs at slope of right bank. Debris on right bank partly covers slope at 1 to 3 m thick. Slope of left bank is fully covered by thick debris which is estimated to be 4 to 5 m in thickness. Hard, massive, silicified limestone composes wadi beds of damsite.

Features of irrigable area

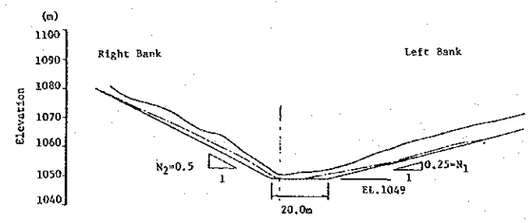
E-1: Potential land exists downstream from E-1 site and can be irrigated by gravity flow. Winter irrigation by a diversion weir scheme is conceivable.

Features of submerged area

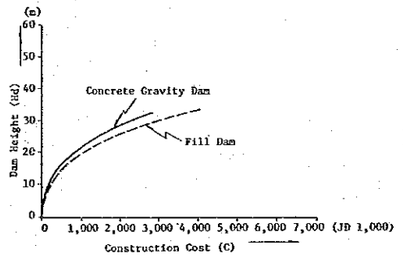
Curve of El. - R. A. and El. - Vs



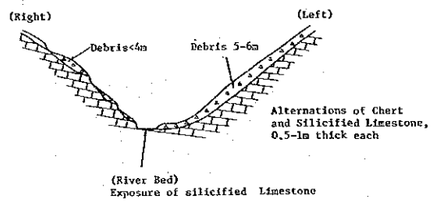
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD / m^3
1060	11	86	3	1057	18	80	10			196 (576)	26.7	2.45
1070	21	146	13.6	1067	72	680	610			889 (2615)	50.0	1.31
1080	31	206	37.3	1077	152	1800	1730			2439 (7174)	48.3	1.36

Note

C. A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R. B. S. ; River bed slope
Crest El. ; Crest elevation
Hd ; Height above lowest foundation dam

Crest L. ; Crest length
Vd ; Dam volume
HWL ; Elevation of reservoir surface
R. A. ; Reservoir area
Vs ; Initial storge capacity
Ve ; Ultimate storage capacity
I. A. ; Irrigable area

C ; Construction cost
F1 ; Initial storge capacity / Dam volume
F2 ; Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (7/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H / Lw m / Km	R. B. S. m / Km
E-2	Zabda	Zabda	Concrete gravity	Tafila	30°49.9′	35°42.7′	1100	21.3	151	129	220/9.7	22.7
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
1109	12	78	3.1	1106	28	280	80	100		203 (597)	90.3	0.73

Features of site topography and geology

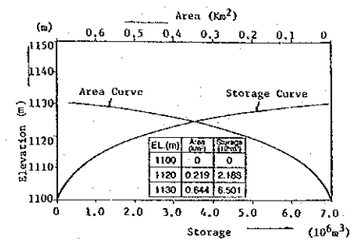
E-2: Hard, weakly jointed, silicified limestone with E-W strike and 8°S dip is found at foot of slope of right bank. Upper slope of right bank consists of outcrops of basalt. Debris composed of dominant basalt stones covers lower slope of right bank at 2 to 3 m thick. Slope of left bank is fully covered by debris composed of silicified limestone gravels and soils which is estimated at 4 to 5 m thick in maximum. Wadi beds are composed of stony fine soils, which is estimated at 4 m or more thick. Basalt body might intrude into limestone, which is found in the hills along right bank of wadi.

Features of irrigable area

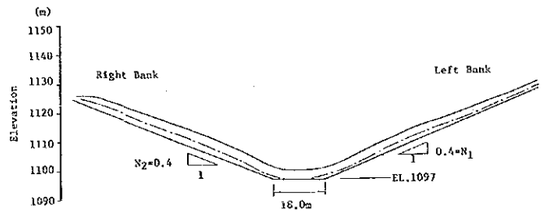
E-2: There is about 1 ha of farmland at about 1 km downstream from E-2 site. At around the confluence with the wadi of E-1, there are potential lands which can be irrigated by gravity flow although it needs a ditch of about 2 km long. In the right bank upstream from the site, there are farmlands which need pumping for irrigation.

Features of submerged area

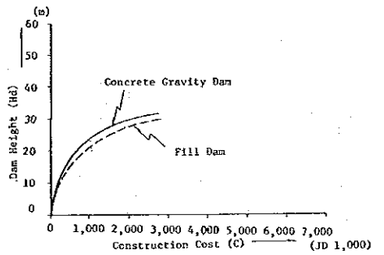
Curve of El. - R. A. and El. - Vs



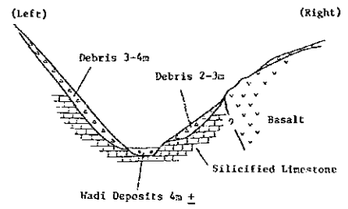
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD / m^3
1105	8	58	1.4	1102	6	60	--			92 (271)	42.9	1.53
1115	18	108	7.9	1112	80	800	600			517 (1521)	101.3	0.65
1125	28	158	24.2	1122	308	3160	2960			1583 (4656)	130.6	0.50

Note

C. A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R. B. S. ; River bed slope
Crest El. ; Crest elevation
Hd ; Height above lowest foundation dam
Crest L. ; Crest length
Vd ; Dam volume
HWL ; Elevation of reservoir surface
R. A. ; Reservoir area
Vs ; Initial storge capacity
Ve ; Ultimate storage capacity
I. A. ; Irrigable area
C ; Construction cost
F1 ; Initial storge capacity / Dam volume
F2 ; Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (8/14)

Dam No.	Dam Name	Wadi	Dam type	Location				Hydrological condition				
				Governorate	Latitude	Longitude	Altitude m	C. A. Km^2	Rm mm	Qm $\times 10^3 m^3$	H / Lw m / Km	R. B. S. m / Km
C - 6	Dabba	Dabba	Concrete gravity	Karak	31°15.0′	35°53.6′	618	1462	165	9900	250/60.5	4.1
Features of dam				Features of reservoir				Features water use		Other features		
Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$ JD($\times$US$)	F1	F2
668	50	232	122.5	665	1330	16500	6500	8130		8013 (23600)	134	0.49

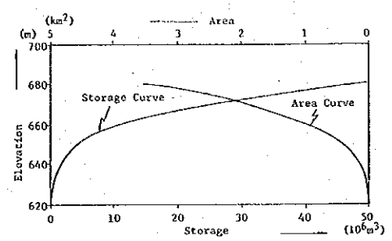
Features of site topography and geology

C-6: The area is underlain by a thick sequence of fossiliferous limestone and alternation of cherty rock, silicified limestone and marl, which trends north-easterly and dips slightly to the south. The western side is of a cliff and alternative rocks are exposed on the wadi-floor. The eastern side is covered with debris and wadi sediments.

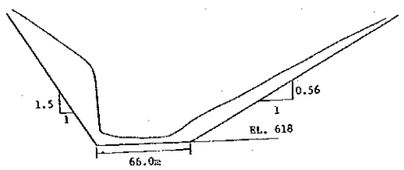
Features of irrigable area

Features of submerged area

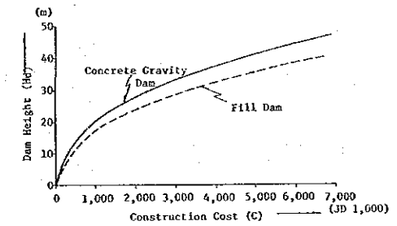
Curve of El. - R. A. and El. - Vs



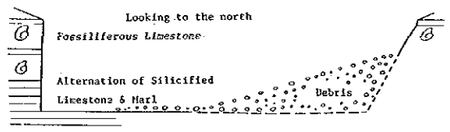
Longitudinal profile of dam



Curve of Hd - C



Sketch of site geology (not to scale)



Calculation table

Crest El. m	Hd m	Crest L. m	Vd $\times 10^3 m^3$	HWL m	R. A. $\times 10^3 m^2$	Vs $\times 10^3 m^3$	Ve $\times 10^3 m^3$	Yield $\times 10^3 m^3$	I. A. ha	C $\times 10^3$JD($\times 10^3$US$)	F1	F2 JD / m^3
643	23	123	21.3	640	150	1500	–			1393 (4097)	70.4	0.93
663	43	173	86.1	660	825	11300	1300			5632 (16565)	131.2	0.50
683	63	223	213.0	680	2662	46200	36200			13932 (40978)	216.9	0.30

Note

C. A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R. B. S. ; River bed slope
Crest El. ; Crest elevation
Hd ; Height above lowest foundation dam

Crest L. ; Crest length
Vd ; Dam volume
HWL ; Elevation of reservoir surface
R. A. ; Reservoir area
Vs ; Initial storge capacity
Ve ; Ultimate storage capacity
I. A. ; Irrigable area

C ; Construction cost
F1 ; Initial storge capacity / Dam volume
F2 ; Construction cost / Initial storge capacity

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (9/14)

Weir No.	Weir Name	Wadi	Location			
			Governorate	Latitude	Longitude	Altitude (m)
A-4	Ain Sara	Karak	Karak	31°10.0′	35°46.1′	640

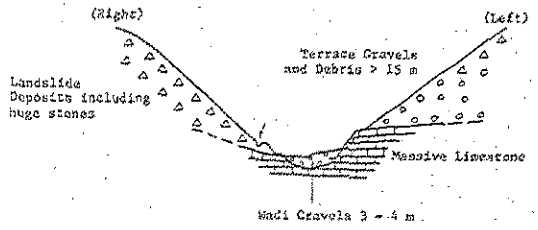
Hydrological condition					Features of Weir		
C.A. (km^2)	Rm (mm)	Qm ($\times 10^3 m^3$)	$H_{(m)} / L_W$ (km)	R.B.S. (m/km)	Hd (m)	Weir L. (m)	Vd ($\times 10^3 m^3$)
89.1	340	2260	510/13.5	37.8	2.0	27	0.24

Downstream of Ain Sara (Wadi Karak): Hard, massive limestone exposes at foot of right bank slope and lower slope of left bank and forms cliff of 4 m high. Thick landslide deposits including huge stones mainly compose right bank of damsite and thick terrace gravel beds including fallen stones also overlie on limestone basements. Wadi gravels are estimated at 3 to 4 m in thickness. This site could not be suitable for dam construction due to geological constraint.

A-4: With spring water from Ain Sara, fruit trees and vegetables are cultivated in both banks of Wadi Karak. According to an interview, there is excess water in winter while shortage in summer. New irrigation by pumping is conceivable for higher farmlands existing in the left bank of Wadi Karak (the same land as conceived for A-2 site) to utilize the excess water in winter when more base flow is available in addition to the spring flow.

A-4: Water use balance with the Southern Ghor needs to be examined if new irrigation by pumping is made also in summer. Diversion weir would soon be filled with deposits if constructed on the main stream.

Sketch of site geology (not to scale)



Note

C.A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R.B.S. ; River bed slope
Hd ; Height of weir above river bed
Weir L. ; Length of weir
Vd ; Weir Volume

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (10/14)

Weir No.	Weir Name	Wadi	Location			
			Governorate	Latitude	Longitude	Altitude (m)
D-2	Tafila	La'ban	Tafila	30°48.0'	35°41.0'	1230

Hydrological condition					Features of Weir		
C.A. (km^2)	Rm (mm)	Qm ($\times 10^3 m^3$)	$H_{(m)} / L_W$ (km)	R.B.S. (m/km)	Hd (m)	Weir L. (m)	Vd ($\times 10^3 m^3$)
26.9	201	245	250/13	19.2	2.0	60	0.54

Features of site topography and geology

D-2: Hard, weakly jointed, silicified limestone occurs at right bank slope. Debris is very thin, which covers slope at less than 1 m. No outcrop of rocks at left bank slope, which is covered by debris at 4 m or more thick. Thickness of gravely wadi sediments is estimated at 6 m or more.

Features of irrigable area

Sketch of site geology (*not to scale*)

Note

C.A.	; Catchment area	Lw	; Water course length		Weir L.	; Length of weir
Rm	; Annual average rainfall	R.B.S.	; River bed slope			
Qm	; Annual average runoff	Hd	; Height of weir above river bed		Vd	; Weir Volume

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (11/14)

Weir No.	Weir Name	Wadi	Location			
			Governorate	Latitude	Longitude	Altitude (m)
I-1	Sidd	Sidd	Tafila	30°39.0′	35°38.6′	1380

Hydrological condition					Features of Weir		
C.A. (km^2)	Rm (mm)	Qm ($\times 10^3 m^3$)	$H_{(m)} / L_W$ (km)	R.B.S. (m/km)	Hd (m)	Weir L. (m)	Vd ($\times 10^3 m^3$)
10.2	275	167	160/3.5	45.7	2.0	30	0.27

Features of site topography and geology

I-1: Hard, massive, silicified limestone occurs at left bank slope. Very gently slope of right bank is fully covered by stony soils, which overlies on older fluviatile gravel beds. Thickness of stony soils is estimated at 3 m or more and that of older fluviatile gravel bed at more than 10m. Recent wadi gravels are 2 m or more thick.

Features of irrigable area

I-1: Farmlands exist both upstream and downstream from I-1 site and can be irrigated by gravity flow. However, soil condition is not good.

I-1: Since the riverbed is wide, a long weir in crest length will be required.

Sketch of site geology (not to scale)

Note

C.A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R.B.S. ; River bed slope
Hd ; Height of weir above river bed
Weir L. ; Length of weir
Vd ; Weir Volume

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (12/14)

Weir No.	Weir Name	Wadi	Location			
			Governorate	Latitude	Longitude	Altitude (m)
J-1	Kerbat Shada	Khaur	Tafila	30°38.5′	35°39.5′	1360

Hydrological condition					Features of Weir		
C.A. (km^2)	Rm (mm)	Qm ($\times 10^3 m^3$)	$H_{(m)} / L_W$ (km)	R.B.S. (m/km)	Hd (m)	Weir L. (m)	Vd ($\times 10^3 m^3$)
19.8	275	323	220/8.5	25.9	3.0	55	0.95

Features of site topography and geology

J-1: Hard, strongly jointed basalt occurs at left bank slope. Gentle slope of right bank is covered by soils bearing dominant basalt stones. Thickness of these stony soils is estimated at 3 m or more. Broad wadi beds consist of stony soils which are 4 to 5 m thick.

Sketch of site geology (*not to scale*)

Features of irrigable area

J-1: Farmlands exist both upstream and downstream from the site and can be irrigated by gravity flow.

J-1: Since the riverbed is wide, a long weir in crest length will be required. A reservoir area is wide to submerge wide farmlands.

Note

C.A.	; Catchment area	Lw	; Water course length		Weir L.	; Length of weir
Rm	; Annual average rainfall	R.B.S.	; River bed slope				
Qm	; Annual average runoff	Hd	; Height of weir above river bed		Vd	; Weir Volume

Fig. 2 - 13 Site Characteristics of Dam and Weir Scheme (13/14)

Weir No.	Weir Name	Wadi	Location			
			Governorate	Latitude	Longitude	Altitude (m)
L-1	Bahlut	Bureis	Karak	30°55.1′	35°38.6′	840

Hydrological condition					Features of Weir		
C.A. (km^2)	Rm (mm)	Qm ($\times 10^3 m^3$)	$H_{(m)} / L_W$ (km)	R.B.S. (m/km)	Hd (m)	Weir L. (m)	Vd ($\times 10^3 m^3$)
15.9	201	145	320/8.5	376	2.0	36	0.32

Features of site topography and geology

L-1: SLope of left bank consists of weathered, strongly jointed marly limestone. Debris covers slope at 1 to 2 m thick. No outcrop of rocks at right bank slope, which is covered by landslide sediments composed of stony soils at more than 15 m thick. Wadi beds consist of gravels at 5 m or more.

Features of irrigable area

Sketch of site geology (not to scale)

Note

C.A. ; Catchment area
Rm ; Annual average rainfall
Qm ; Annual average runoff
Lw ; Water course length
R.B.S. ; River bed slope
Hd ; Height of weir above river bed
Weir L. ; Length of weir
Vd ; Weir Volume

Fig. 2-13 Site Characteristics of Dam and Weir Scheme (14/14)

Fig. 2-14
Preliminary Implementation Schedule
for the Water Harvesting Development
Project

Item No.	Work Items	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
		Year																	
(1)	Pilot Scheme																		
	- Detailed planning and design																		
	- Construction																		
	- Experiment																		
(2)	Feasibility Study																		
(3)	Karak and Tafila Highlands Dam Schemes																		
	- Basic design																		
	- Detailed design																		
	- Financing and pre-construction arrangements																		
	- Construction																		
(4)	Overall Project																		
	- Basic design																		
	- Detailed design																		
	- Financing and pre-construction arrangements																		
	- Construction																		

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JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2-14 Preliminary Implementation Schedule for the Water Harvesting Development Project