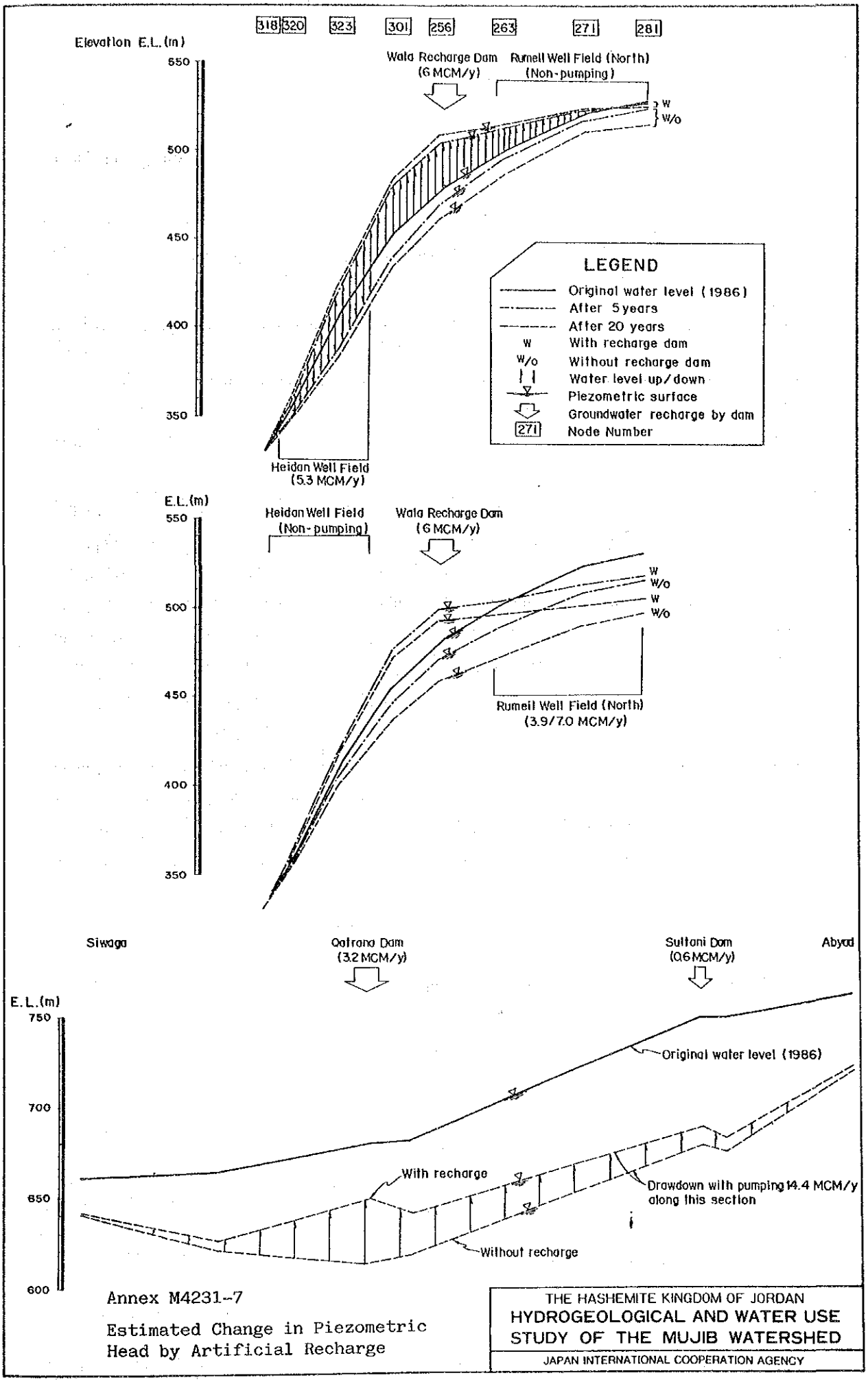


Annex M4231-7

Estimated Change in Piezometric Head by Artificial Recharge

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M4314-1 MONTHLY WATER SUPPLY VOLUME, 1984

(m^3)

Month	Amman	Irbid	Balqa	Karak	Ma'an
Jan.	2,477,520				
Feb.	2,434,608				
Mar.	2,688,072				
Apr.	2,657,520	927,079	189,360	239,010	646,980
May.	3,095,784	1,106,545	239,785	320,385	699,205
Jun.	3,418,560	1,090,170	211,740	318,450	689,460
July	4,084,560	1,243,038	207,142	323,050	734,390
Aug.	4,189,464	1,220,563	190,278	375,906	718,053
Sep.	4,114,800	1,064,700	179,430	391,500	681,090
Oct.	4,312,224	1,203,079	170,531	322,555	724,098
Nov.	3,795,420	1,114,920	160,890	319,410	527,910
Dec.	3,816,740	1,140,204	189,379	312,201	594,425
Total	41,085,272	10,110,298	1,738,535	2,922,467	6,015,611

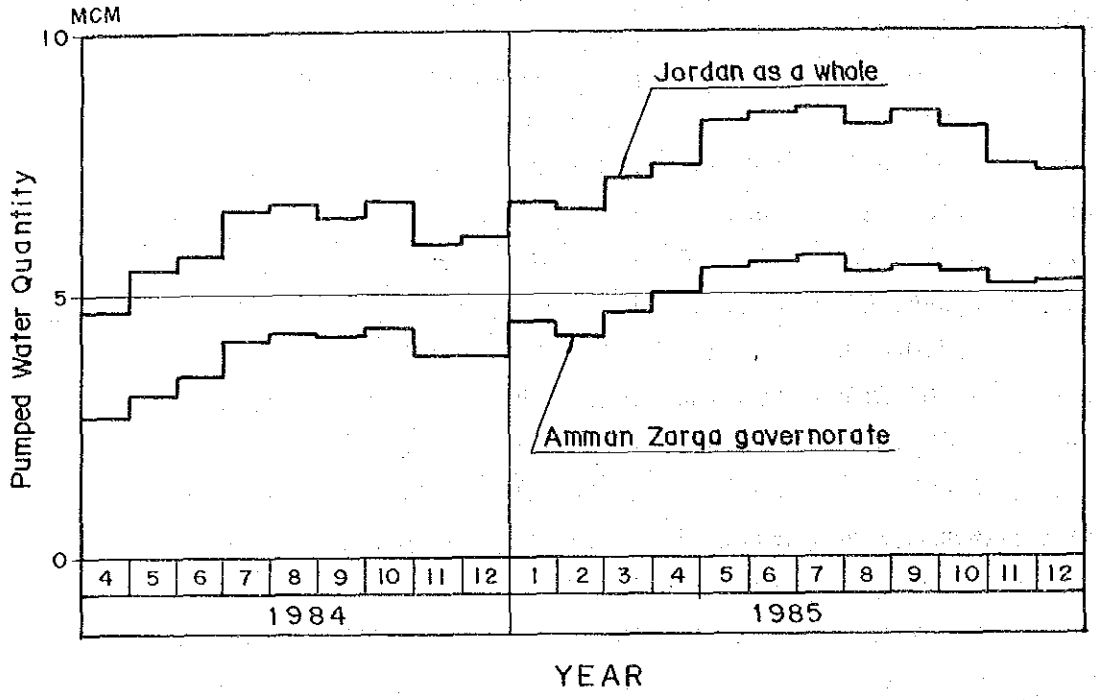
Source: Water Authority of Jordan

Annex M4314-2 MONTHLY WATER SUPPLY VOLUME, 1985

(m^3)

Month	Amman	Zarqa	Irbid	Balqa	Karak	Ma'an
Jan.	3,878,596	600,204	1,242,418	176,961	309,225	527,881
Feb.	3,551,604	552,344	1,088,500	189,616	248,808	543,500
Mar.	4,162,618	548,179	1,283,090	239,103	289,509	611,072
Apr.	4,235,400	713,736	1,307,400	241,680	305,550	628,800
May	4,696,407	888,057	1,448,909	259,966	382,881	726,144
Jun.	4,710,840	885,240	1,420,830	238,800	420,360	763,440
July	4,765,816	905,789	1,459,356	232,779	428,110	800,575
Aug.	4,405,534	918,313	1,504,430	213,152	469,712	722,145
Sep.	4,697,760	851,490	1,420,170	211,620	436,685	683,220
Oct.	4,622,224	841,805	1,423,582	218,302	400,148	742,171
Nov.	4,280,580	739,800	1,280,940	202,110	360,720	609,000
Dec.	4,336,621	710,241	1,191,547	200,570	320,912	611,227
Total	52,344,000	9,155,198	16,071,172	2,624,659	4,372,620	7,968,175

Total 92,536,824



Annex M4314-3
Monthly Water Supply Volume

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M4316-1 ASSUMED RATE OF SUPPLY AND ITS ACTUAL SUPPLY RATE FROM EXISTING SYSTEM TO AMMAAN & ZARQA GOVERNORATE

(MCM/y)

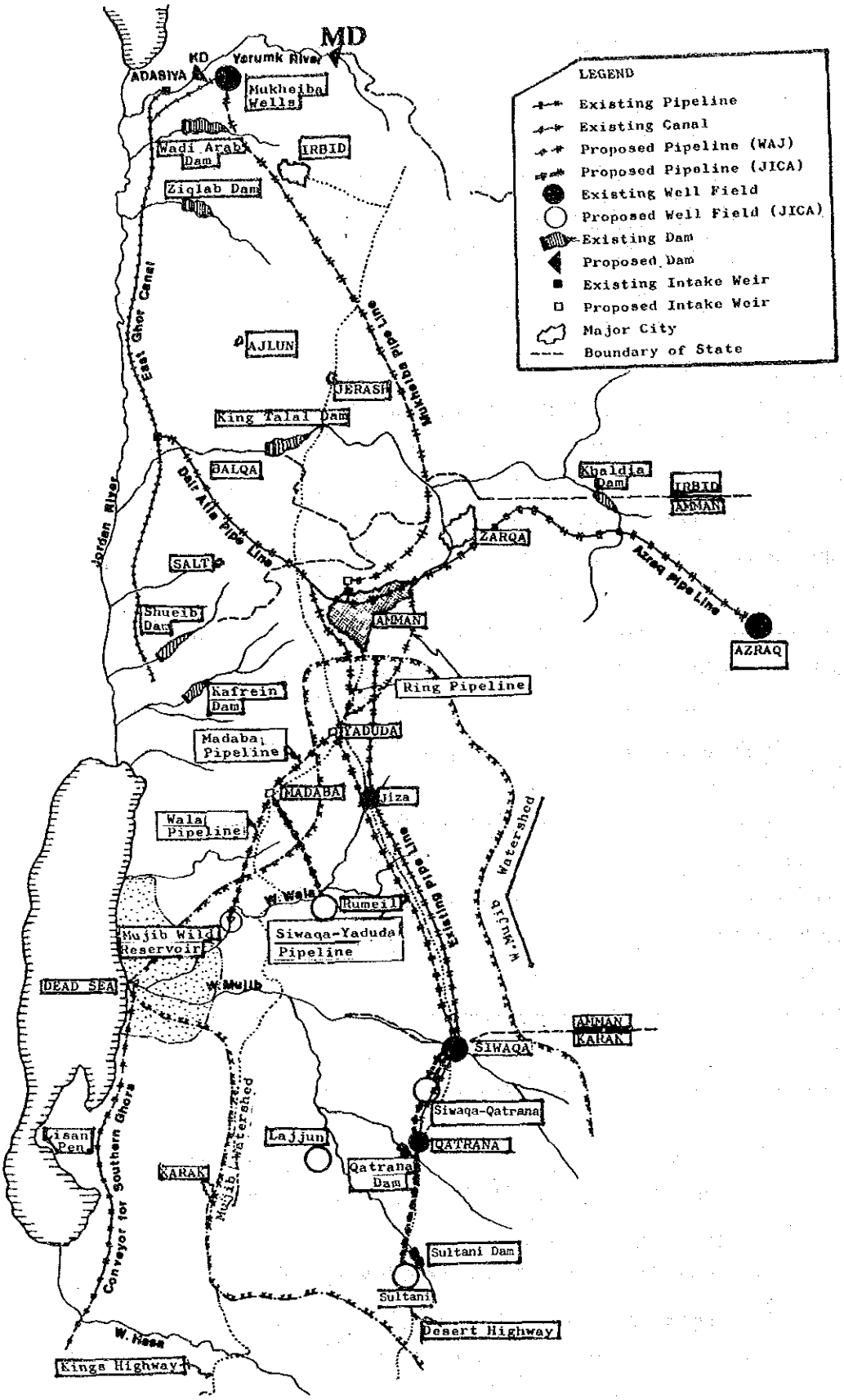
Source	Rate of Supply (assume)*		Actual Supply Rate**	
	Average	Peak	Average	Peak
E. Ghor Main Canal (Deir Alla) ***	(45)	(45)	1.5	-
Azraq Well Field	12	15	15.6	19.0
Qatrana, Siwaqa, Qastal Well Field	7	9	15.1	20.2
Amman Boreholes	13	20	20.1	
Zarqa/Russeifa Boreholes	7	10	9.2	10.8
Total	39	54	61.5	66.8

Source : * Report of Study of the Primary Secondary Conveyance Systems - April, 1984 - by Watson Hawksley.

** The data of 1985, estimated from WAJ data. Actual peak value of Amman Boreholes is not available.

*** Operated Period; Dec. 1985 - Feb. 1986.

Total Value is not include ( )



Annex M4316-2

Water Systems in Northern Jordan

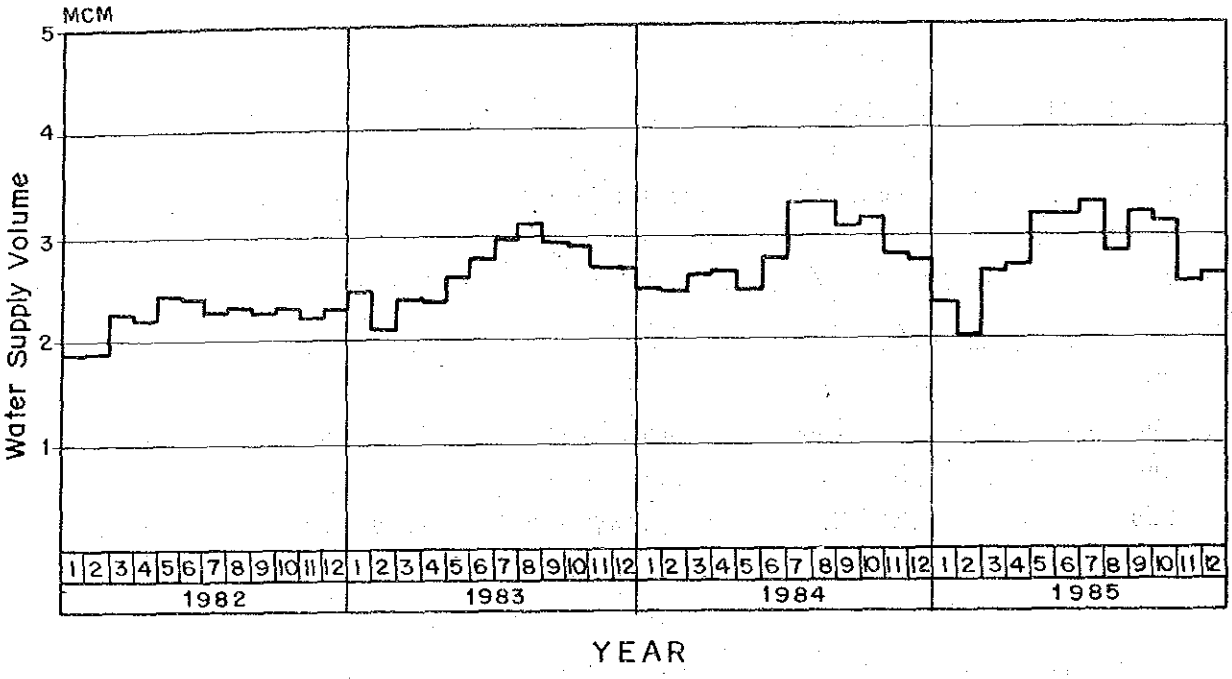
THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M4318-1 MONTHLY WATER SUPPLY VOLUME TO AMMAN MUNICIPALITY

(m^3)

Month	1982	1983	1984	1985
Jan.	1,904,346	2,449,783	2,477,520	2,366,596
Feb.	1,883,090	2,186,561	2,434,608	2,029,604
Mar.	2,257,649	2,351,040	2,688,072	2,650,618
Apr.	2,190,337	2,383,920	2,657,520	2,723,400
May.	2,433,500	2,627,064	2,470,824	3,184,407
Jun.	2,420,220	2,775,600	2,778,480	3,198,870
July	2,281,638	2,993,856	3,323,448	3,253,816
Aug.	2,321,110	3,111,408	3,299,640	2,896,534
Sep.	2,257,873	2,944,800	3,096,720	3,185,760
Oct.	2,320,335	2,920,200	3,154,060	3,110,024
Nov.	2,221,560	2,667,600	2,803,680	2,768,580
Dec.	2,285,577	2,674,680	2,763,216	2,824,621
Total	26,777,235	32,086,512	33,947,788	34,192,830

Source: Water Authority of Jordan



Annex M4318-2
Water Supply Volume to Amman Municipality

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M4319-1 PUMPED WATER VOLUME BY AZRAQ SYSTEM

(m^3)

Month	1982	1983	1984	1985	1986
Jan.		1,033,884	960,452	1,097,800	778,747
Feb.		808,172	857,265	1,012,500	482,096
Mar.		999,520	905,535	1,119,100	1,015,121
Apr.		841,951	894,946	1,181,900	1,331,553
May.		917,072	1,120,130	1,610,800	1,487,503
Jun.		968,249	1,198,563	1,488,450	
July	894,935	1,236,602	1,388,828	1,536,100	
Aug.	889,354	1,261,783	1,371,218	1,508,200	
Sep.	885,433	1,239,951	1,329,285	1,471,400	
Oct.	1,118,585	1,159,102	*(2,045,166)	1,328,453	
Nov.	1,018,090	944,221	1,159,350	1,178,059	
Dec.	952,135	899,904	1,127,904	1,106,075	
Total		12,310,411	13,696,847	15,638,837	

* Note (Abnormally high?)

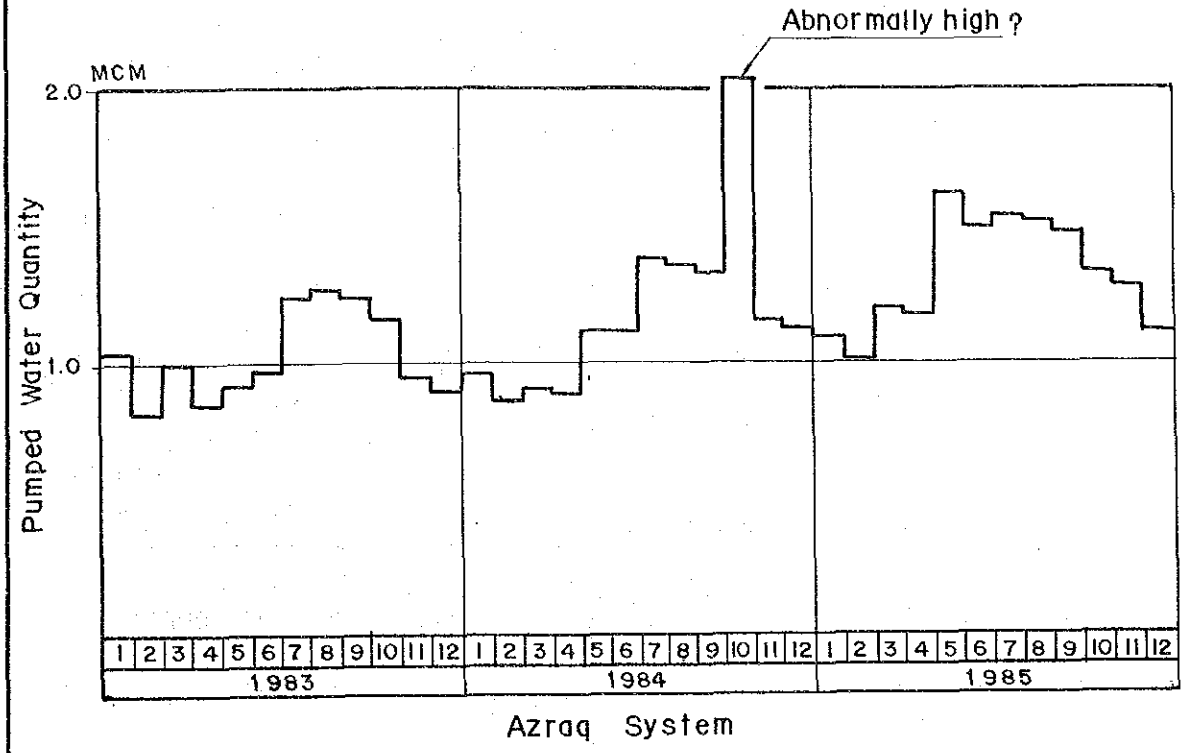
Source: Water Authority of Jordan

Annex M4319-2 PUMPED WATER VOLUME BY QATRANA-SIWAQA-QASTAL SYSTEM

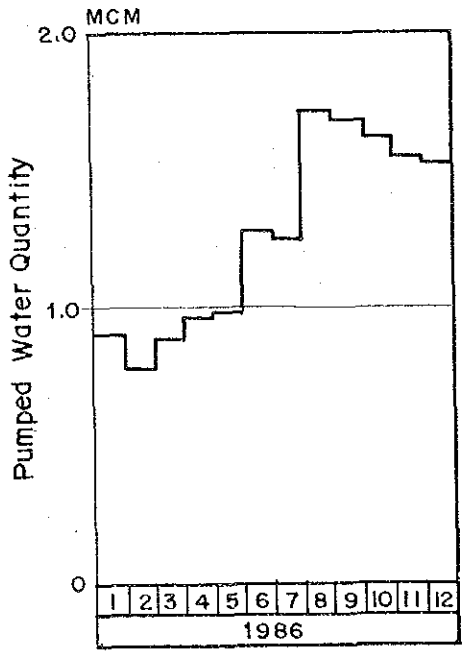
(m^3)

MONTH	1985	1986
Jan.	908,800	651,604
Feb.	775,000	656,673
Mar.	891,000	749,631
Apr.	970,400	1,059,991
May	987,500	1,277,226
Jun	1,265,600	1,275,488
July	1,234,800	1,552,037
Aug.	1,717,400	1,385,992
Sep.	1,679,500	
Oct.	1,617,800	
Nov.	1,543,000	
Dec.	1,529,000	
Total	15,119,800	

Source: Water Authority of Jordan

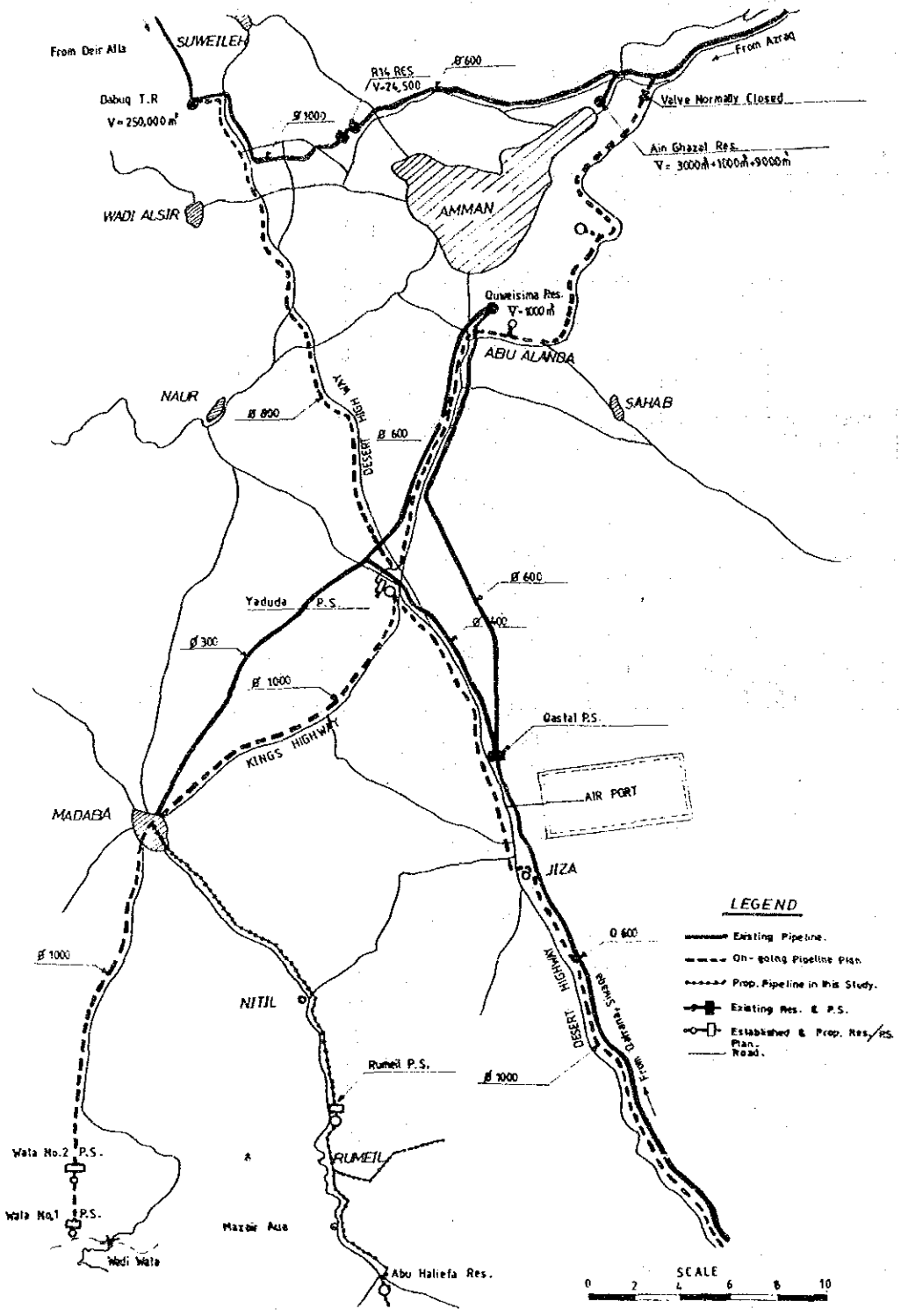


Azraq System



Annex M4319-3
Qatrana, Siwaqa, Qastal System
Pumped Water Volume to Amman

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



Annex M4321
Existing, On-going and Proposed Pipeline

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M5221 AVERAGE ANNUAL RATE OF POPULATION GROWTH USED FOR POPULATION PROJECTION

Unit : (%)

Locality	1979 to 1985	1985 to 1990	1990 to 2005*
Amman city	5.0	5.0	4.0
Zarqa & Irbid cities	4.5	4.5	3.5
Ruseifa city	4.5	4.5	4.5
Other cities (over 10,000 pop.)	3.5	3.0	2.8
Towns (3,000 to 10,000 pop.)	3.0	2.8	2.5
Small communities (below 3,000 pop.)	2.0	1.8	1.6
National Average	3.7	3.6	3.1

* The period "1990 to 2000" shown in World Bank's report was altered to "1990 to 2005", assuming that the same growth rate will continue till the year 2005.
(after "Water Sector Study Report", World Bank, 1984)

Annex M5231 POPULATION IN STUDY AREA AND JORDAN

Unit: Thousand Persons

Governorate	1979 (Census)					1985 (Estimation)					1990 (Estimation)					2000 (Estimation)					2005 (Estimation)				
	(1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)	(1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)	(1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)	(1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)	(1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)
Amman	1,132	22	1,154	19	1,173	1,471	24	1,495	22	1,517	1,825	27	1,852	24	1,876	2,612	32	2,644	29	2,673	3,129	35	3,164	32	3,196
Irbid	4	-	4	607	611	5	-	5	725	730	5	-	5	834	839	6	-	6	1,067	1,073	6	-	6	1,209	1,215
Balqa	177	-	177	31	148	140	-	140	36	176	160	-	160	40	200	206	-	206	48	254	233	-	233	53	286
Karak	-	47	47	79	126	-	53	53	93	146	-	58	58	104	162	-	69	69	129	198	-	75	75	144	219
Ma'an	-	-	-	75	75	-	-	-	89	89	-	-	-	101	101	-	-	-	127	127	-	-	-	143	143
Total	1,253	69	1,322	811	2,133	1,616	77	1,693	965	2,658	1,990	85	2,075	1,103	3,178	2,824	101	2,925	1,400	4,325	3,368	110	3,478	1,581	5,059
" (%)	(59)	(3)	(62)	(38)	(100)	(61)	(3)	(64)	(36)	(100)	(62)	(3)	(65)	(35)	(100)	(65)	(3)	(68)	(32)	(100)	(67)	(2)	(69)	(31)	(100)

Note: Notation on population show in the table is classified according to the following categories of area;
(1) Greater Amman area (within 30km with center in the Amman city)
(2) Wadi Mujib basin area
(3) Study area; (1)+(2)
(4) Other area than (1) and (2) in Jordan
(5) Jordan

Annex M5311

ESTIMATES OF THE PER CAPITA DOMESTIC WATER DEMAND (PCDWD)

Unit : l/c/d

Locality	1979	1985	1990	1995	2000	2005
Amman city	90	95	100	105	110	115
Zarka & Irbid cities	75	80	85	90	95	100
Cities over 10,000 pop.	65	70	75	80	85	90
Towns 3,000 to 10,000 pop.	60	65	70	70	75	80
Communities below 3,000 pop.	40	45	50	55	60	65

Annex M5322 ESTIMATES OF NON-DOMESTIC WATER DEMAND

Unit: %*

Locality	1979	1985	1990	1995	2000	2005
Amman city	20	20	20	25	25	25
Zarqa & Irbid cities	15	15	15	20	20	20
Cities over 10,000 pop.	10	10	10	15	15	15
Towns 3,000 to 10,000 pop.	10	10	10	15	15	15
Communities below 3,000 pop.	10	10	10	10	10	10

* Percent (%) shows a ratio of the non-domestic water demand to the domestic water demand.

Annex M5332 WATER LOSSES IN DISTRIBUTION SYSTEMS

Unit: %*

Reference Locality	1975	1982	1985	1990	2000	2005
[1]						
Amman Zarqa & Irbid cities	35	-	25	-	15	-
Other localities	30	-	20	-	15	-
[2]All localities	20	-	-	-	20	-
[3]All localities	-	20	-	20	-	20

Note: [1], [2] & [3] mean respective reference shown in Section M5.1.

* Percent (%) shows a ratio of water loss to the domestic and non-domestic water supplies (except large-scale industrial water supply).

Annex M5341 ESTIMATES OF THE PER CAPITA MUNICIPAL WATER DEMAND

Unit: l/c/d

Locality	1979	1985	1990	1995	2000	2005
Amman city	130	137	144	158	165	172
Zarqa & Irbid cities	104	110	117	130	137	144
Cities over 10,000 pop.	86	92	99	110	117	124
Townqs 3,000 to 10,000 pop.	79	86	92	97	104	110
Communities below 3,000 pop.	53	59	66	73	79	86

* Municipal water demand consists of domestic and non-domestic water demand and water losses in the distribution systems.

Annex M5351-1(1/2) ESTIMATES OF MUNICIPAL WATER DEMEND IN STUDY AREA AND JORDAN

Unit : MCM/year

Governorate*	1979					1985					1990				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
			(1)+(2)		(3)+(4)			(1)+(2)		(3)+(4)			(1)+(2)		(3)+(4)
Amman	46.19	0.45	46.64	0.41	47.05	64.08	0.57	64.65	0.53	65.18	84.82	0.70	85.52	0.65	86.17
Irbid	0.08	-	0.08	16.70	16.78	0.09	-	0.09	21.83	21.92	0.12	-	0.12	27.47	27.59
Balqa	3.30	-	3.30	0.70	4.00	4.30	-	4.30	0.88	5.18	5.33	-	5.33	1.08	6.41
Karak	-	0.94	0.94	1.96	2.90	-	1.19	1.19	2.52	3.71	-	1.46	1.46	3.08	4.54
Ma'an	-	-	-	2.00	2.00	-	-	-	2.58	5.58	-	-	-	3.21	3.21
Total	49.57	1.39	50.96	21.77	72.73	68.47	1.76	70.23	28.34	98.57	90.27	2.16	92.43	35.49	127.92

Note: Nation on population shown in the table is classified according to the following categories of area;

(1) Greater Amman area (within 30 km with center in the Amman city)
(2) Wadi Mujib basin area
(3) Study Area; (1)+(2)
(4) Other area than (1) and (2) in Jordan
(5) Jordan
* According to the former administrative units.

Annex M5351-1(2/2) ESTIMATES OF MUNICIPAL WATER DEMEND IN STUDY AREA AND JORDAN

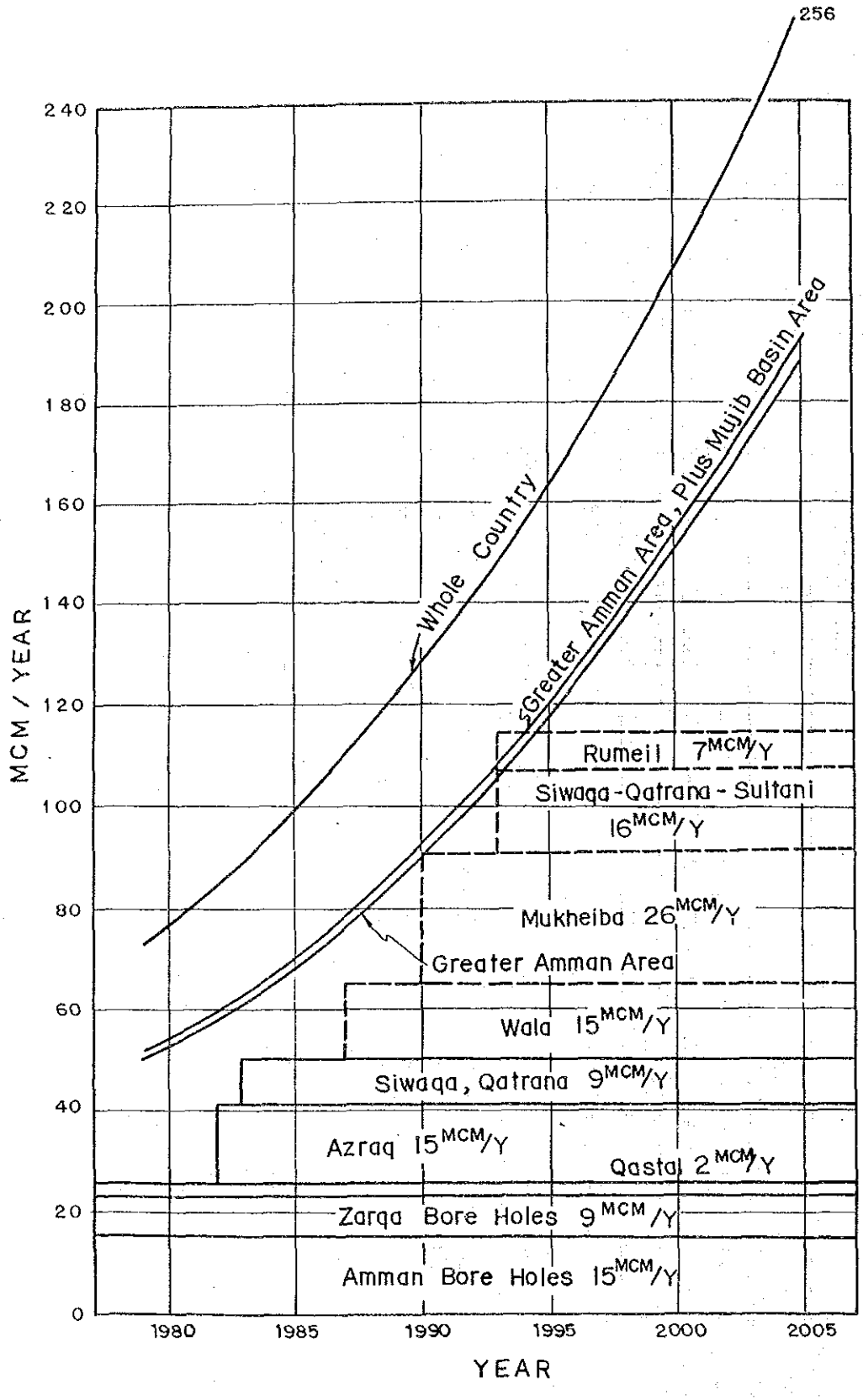
Unit : MCM/year

Governorate*	2000 (1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)	2005 (1)	(2)	(3) (1)+(2)	(4)	(5) (3)+(4)
Amman	141.56	0.99	142.55	0.92	143.47	178.30	1.17	179.47	1.08	180.55
Irbid	0.17	-	0.17	41.30	41.47	0.20	-	0.20	50.01	50.21
Balqa	8.11	-	8.11	1.54	9.65	9.82	-	9.82	1.83	11.05
Karak	-	2.06	2.06	4.59	6.65	-	2.43	2.43	5.49	7.92
Ma'an	-	-	-	4.83	4.83	-	-	-	5.83	5.83
Total	149.84	3.05	152.89	53.18	206.07	188.32	3.60	191.92	64.24	256.16

Note: Nation on population shown in the table is classified according to the following categories of area;

(1) Greater Amman area (within 30 km with center in the Amman city)
(2) Wadi Mujib basin area
(3) Study Area; (1)+(2)
(4) Other area than (1) and (2) in Jordan
(5) Jordan

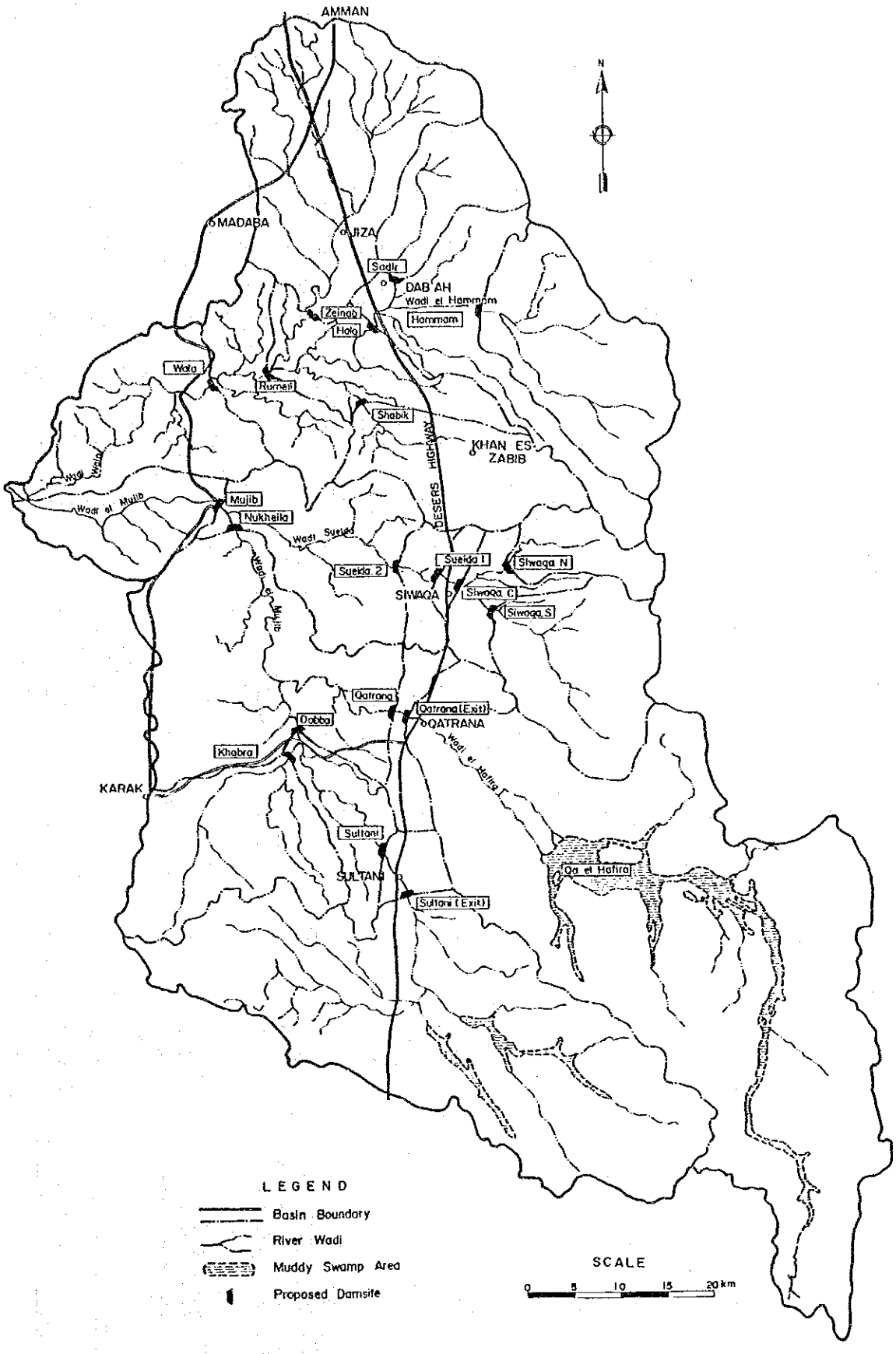
* According to the former administrative units.



Annex M5351-2

Municipal Water Demand and Supply

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



Annex M6312

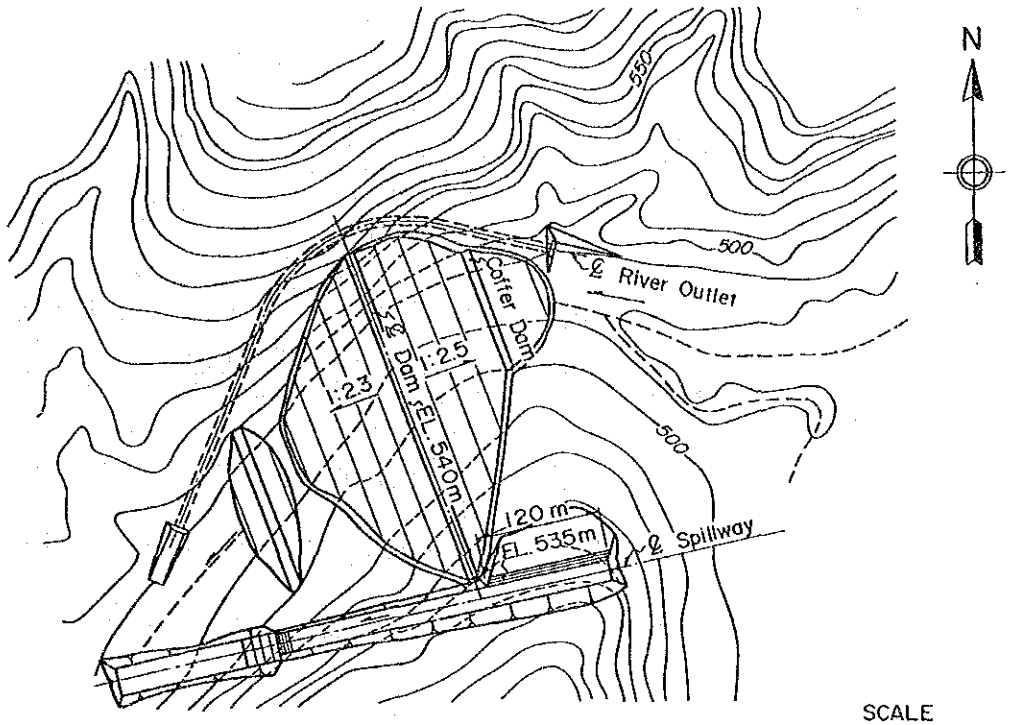
Study Area and Planned Dam Sites

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M6319-1 PRINCIPAL FEATURE OF PROPOSED DAM SITES

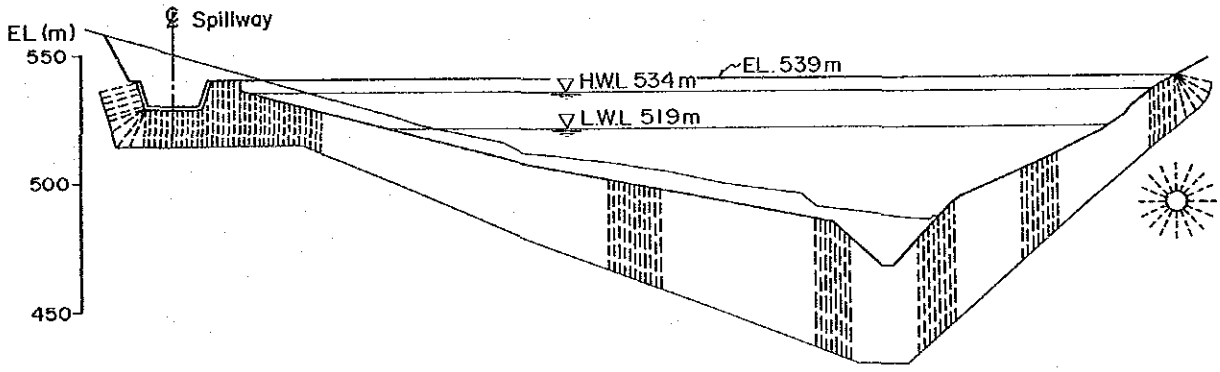
Item		(1) Wala	(2) (*) Hammam	(3) (*) Siwaqa C	(4) Khabra	(5) Nukheila	(6) (*) Qatrana(Exist)	(7) (*) Sultani(Exist)
Hydrological Condition								
- Catchment area	(km^2)	1,770	340	440	390	3,560	1,490	950
- Reservoir area	(km^2)	2.25	1.45	0.60	1.36	0.85	1.75	1.10
- Annual average runoff	(MCM)	21.52	2.15	1.32	9.01	26.15	2.28	3.19
- Most frequent annual runoff	(MCM)	19.31	1.91	1.10	6.12	20.75	1.78(4.00)<2	2.02
- 200-year return peak discharge	(m^3/sec)	1,550	620	525	490	2,250	-	-
Feature of Dam								
- Dam type		Rockfill	Rockfill or Earthfill	Rockfill or Concrete	Rockfill	Rockfill or Concrete	Rockfill	Rockfill
- Crest level	(El.m)	539.0	713.0	736.5	716.5	222.0	-	-
- Dam height from river bed	(m)	55.0	13.0	13.5	26.5	43.0	-	-
(structural height)	(m)	(65.0)	(16.0)	(16.5)	(29.5)	(49.0)	-	-
- Crest length	(m)	350	2,670	124	455	260	-	-
- Top width	(m)	8	8	8	8	8	-	-
- Dam volume	($10^3 m^3$)	920	680	28	290	420	-	-
Feature of Reservoir								
- Strage capacity	(MCM)	28.95	2.25	1.65	9.18	13.05	6.0	1.20
- Effective strage capacity	(MCM)	19.30	1.50	1.10	6.12	8.70	4.0	1.20
- Dead storage(Sediment volume)	(MCM)	9.65	0.75	0.55	3.06	4.35	2.0	-
Feature of Spillway								
- Overflow crest length	(El.m)	120	120	100	100	160	-	-
- Overflow crest level	(m)	534.0	712.0	733.5	713.5	217.0		
Storage Efficency<1		21	3	40	22	21	-	-
Available Potencial Water	(MCM/y)	16.9	0.8	0.6	2.7	5.3	3.2<2	0.7

Note: Features of dam are determined based on 1/7,500 topographic map but dam with a mark(*) are studied based on 1/15,000 topographic map.



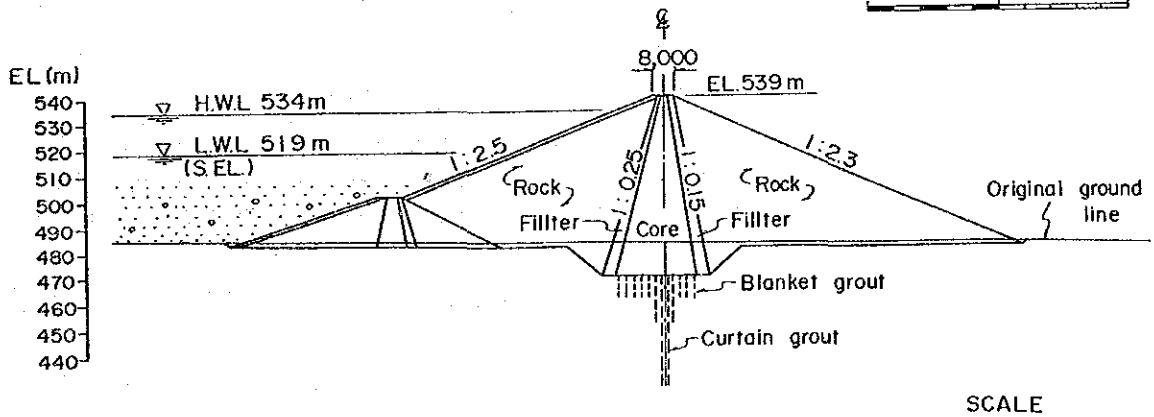
WALA DAM PLAN

SCALE 0 100 200m



UPSTREAM VIEW OF DAM

SCALE 0 50 100

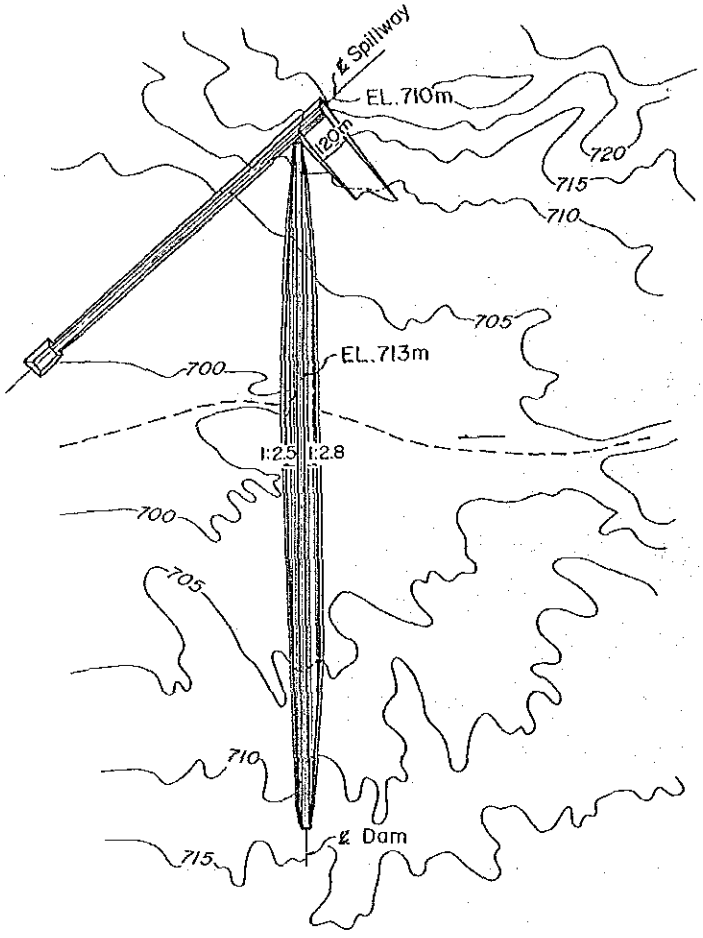


TYPICAL SECTION OF DAM

SCALE 0 50 100

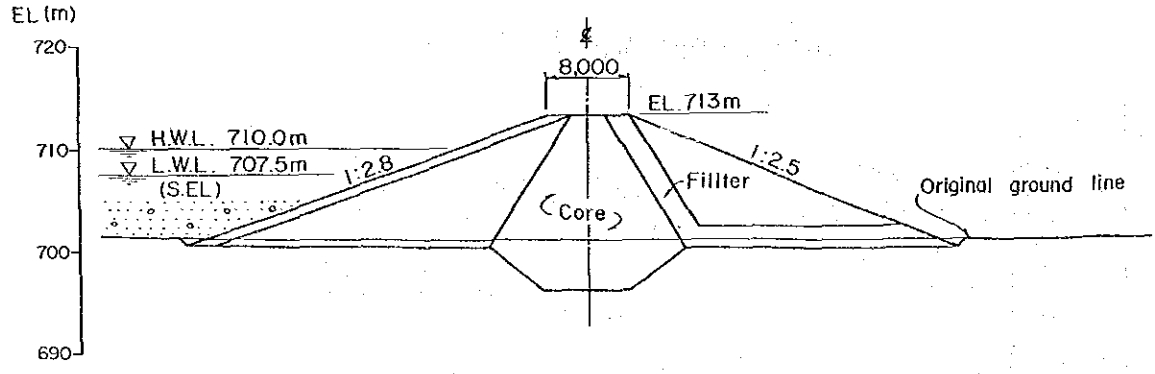
Annex M6319-2 Proposed Wala Dam

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



HAMMAM DAM PLAN

SCALE
0 500 1,000m

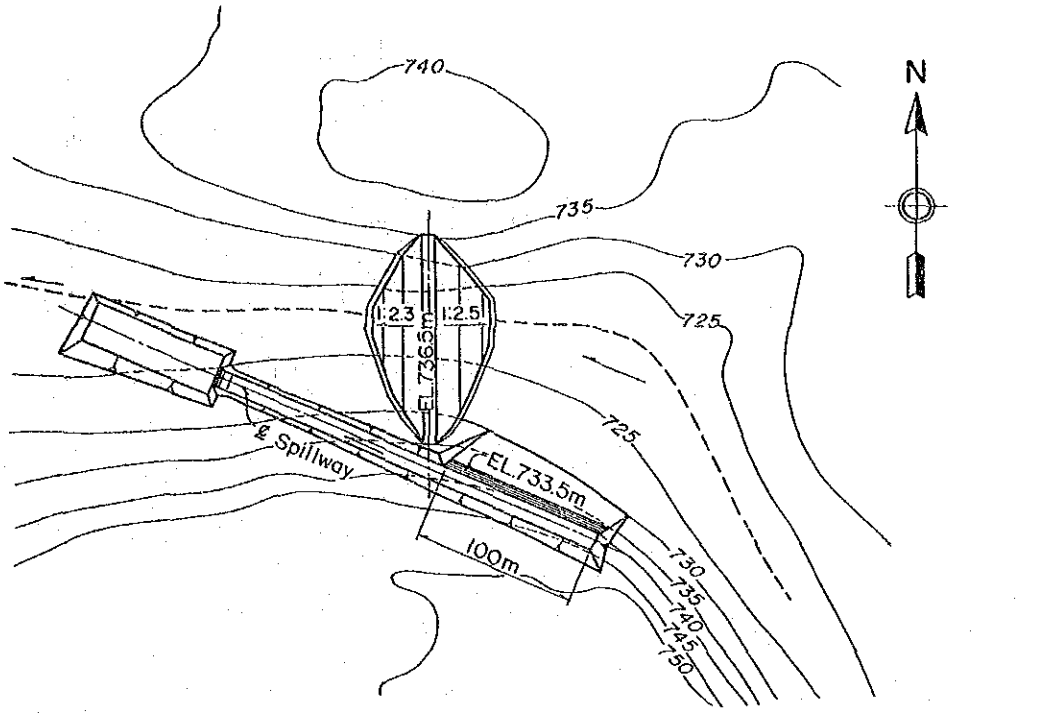


TYPICAL SECTION OF DAM

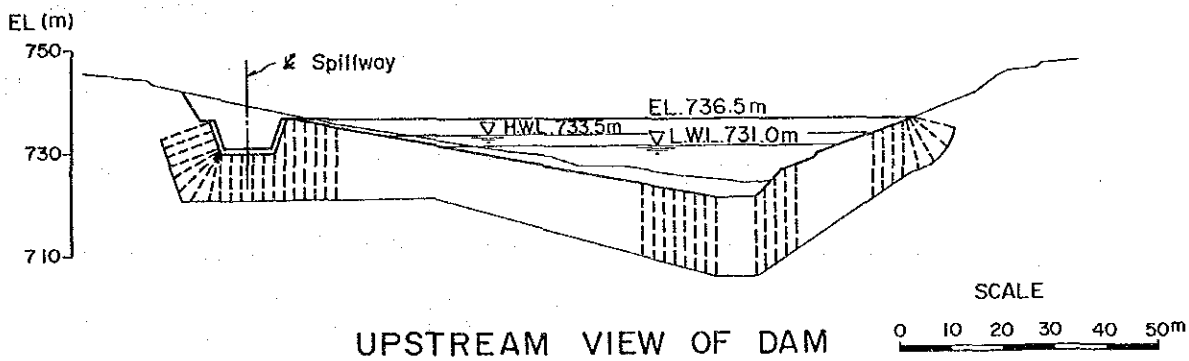
SCALE
0 10 20m

Annex M6319-3 Proposed Hammam Dam

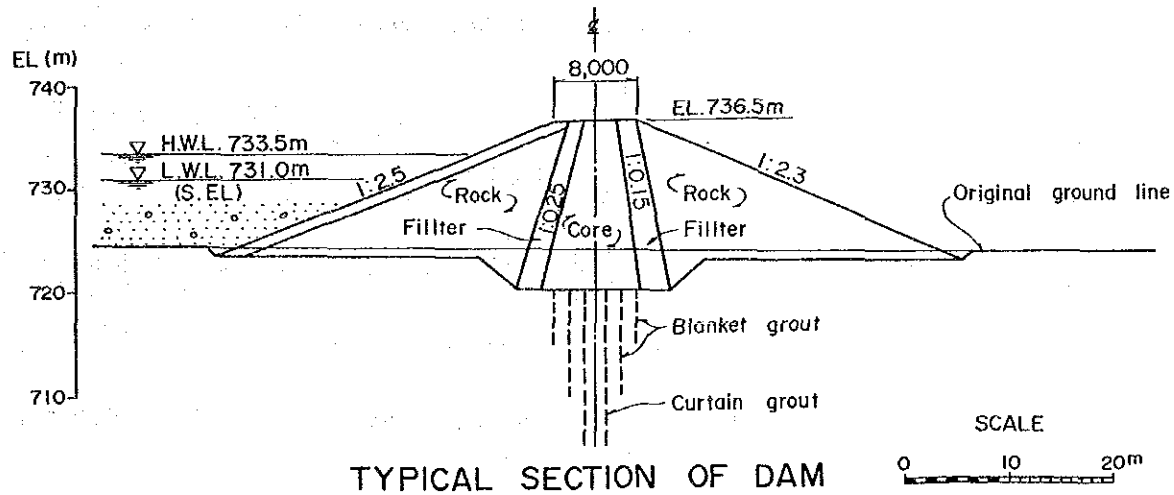
THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



SIWAQA C PLAN



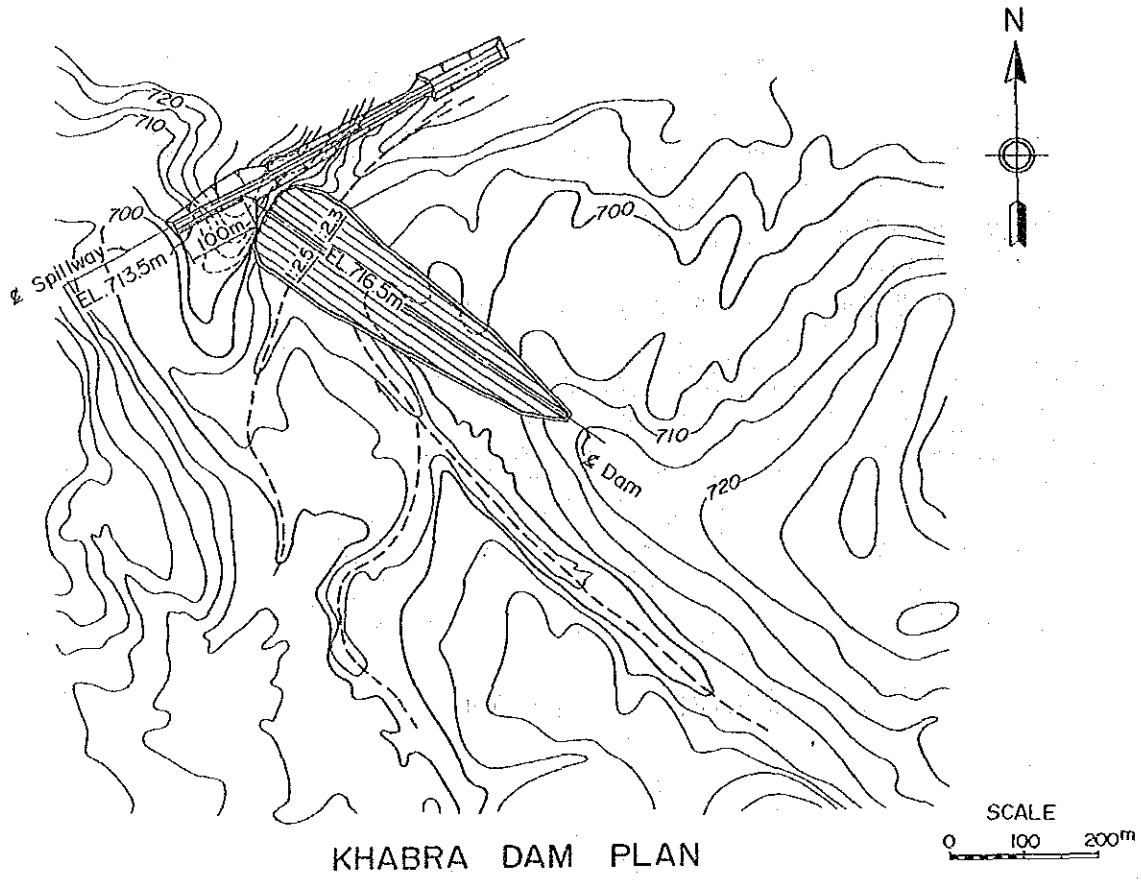
UPSTREAM VIEW OF DAM



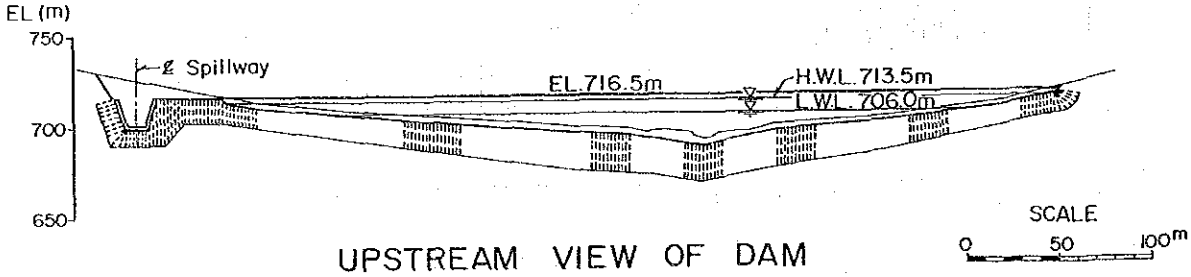
TYPICAL SECTION OF DAM

Annex M6319-4 Proposed Siwaqa-C Dam

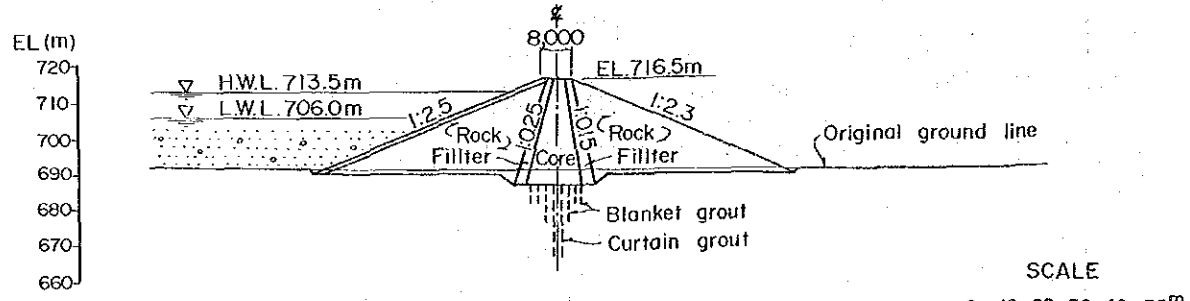
THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



KHABRA DAM PLAN



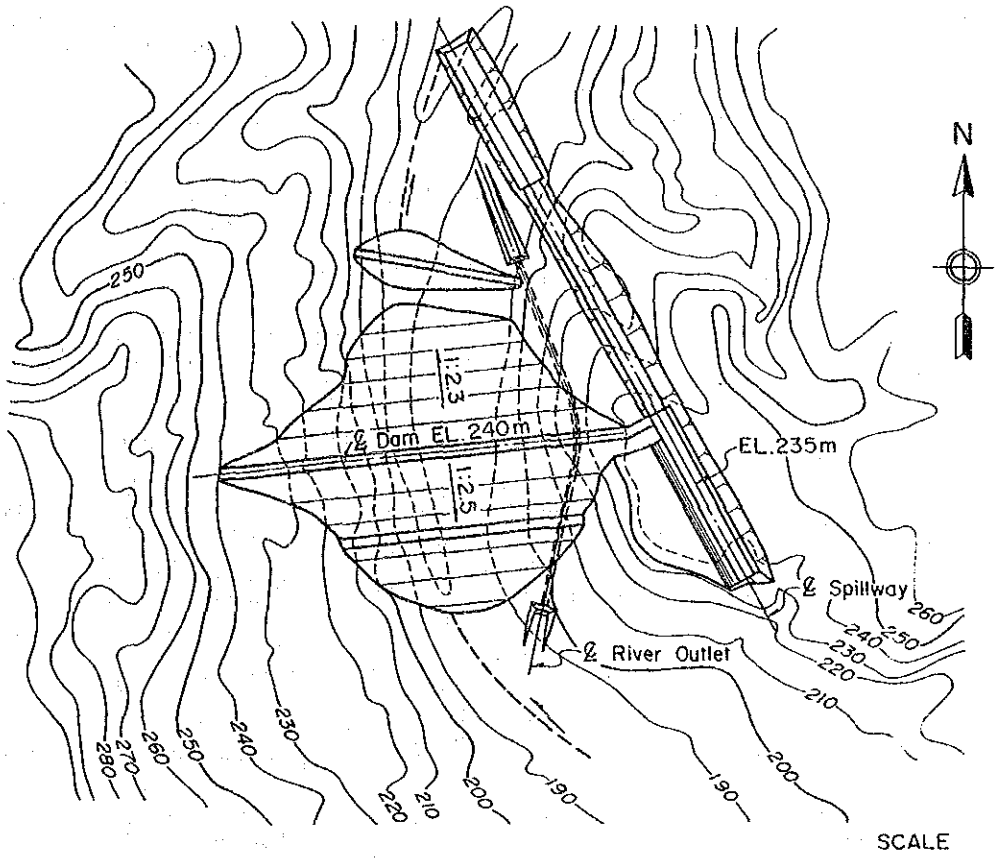
UPSTREAM VIEW OF DAM



TYPICAL SECTION OF DAM

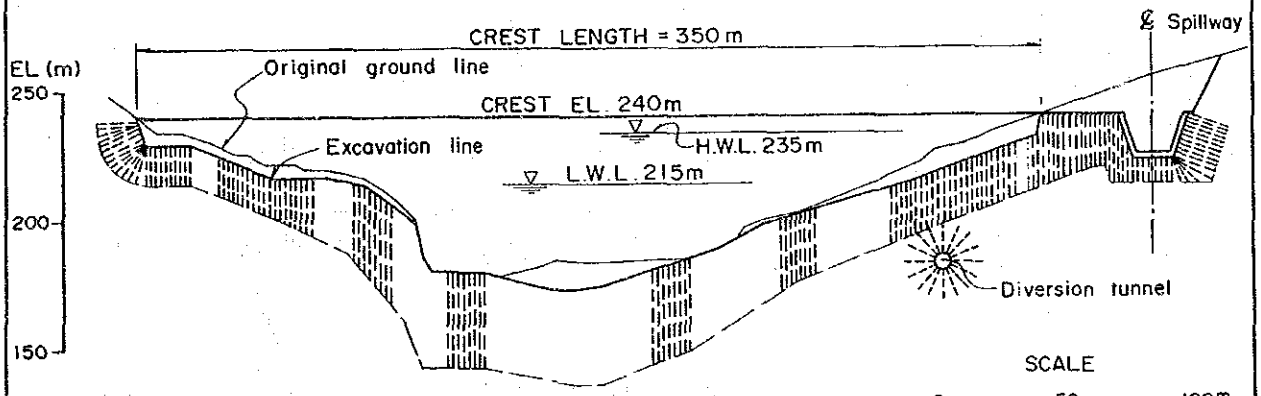
Annex M6319-5 Proposed Khabra Dam

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



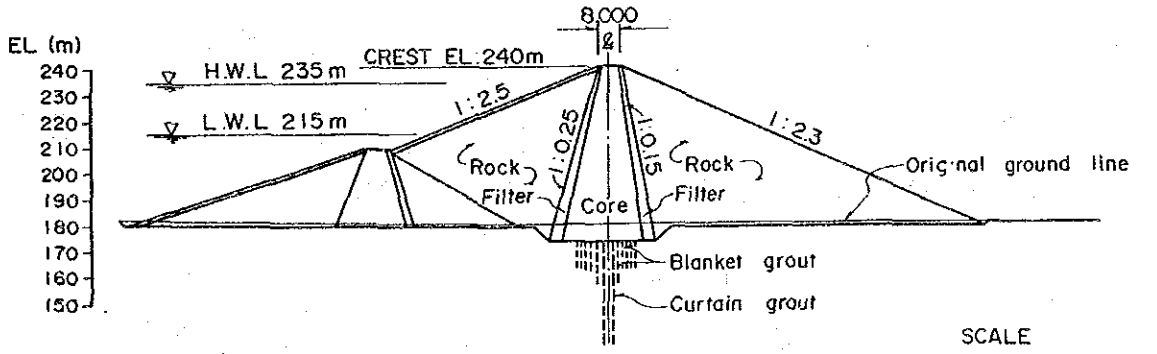
SCALE 0 100 200m

NUKHEILA DAM PLAN



SCALE 0 50 100m

UPSTREAM VIEW OF DAM

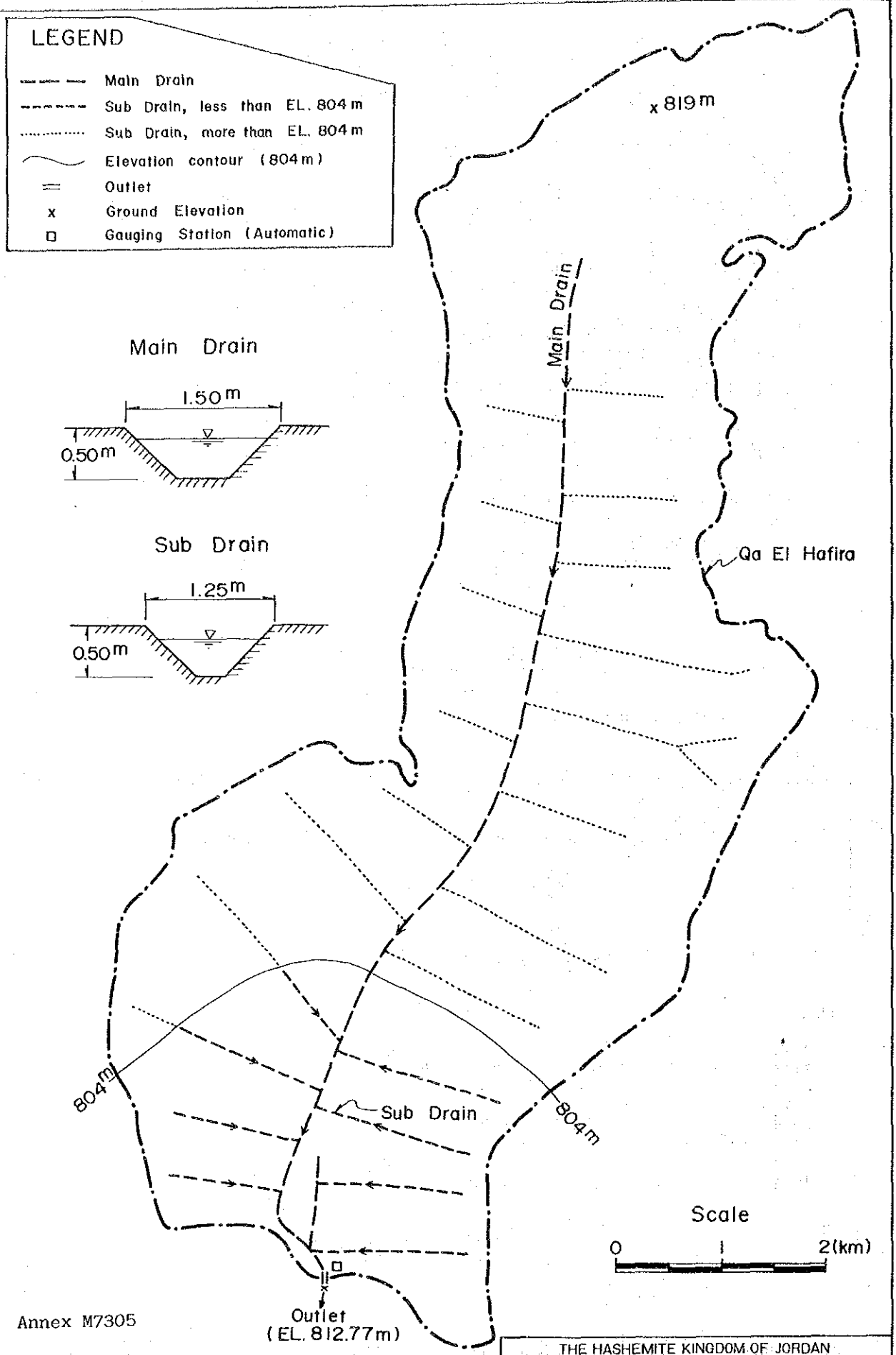


SCALE 0 50 100m

TYPICAL SECTION OF DAM

Annex M6319-6 Proposed Nukheila Dam

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



Annex M7305

Schematic of Qa El Hafira Drainage Improvement

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex M7319 PROPOSED SURFACE WATER DEVELOPMENT PLANS

Proposed Plan	Main Purpose	Available Potential Water	Direct Cost (JD.1,000)
1. Wala	Compensation for irrigation water and water supply	1) 5 MCM/y: Shallow aquifer (base flow) 2) 6 MCM/y: Deep aquifer by injection 3) 6 MCM/y: Seepage to channel (Total 17 MCM/y)	1) Dam & Water facilities:8,080 2) Injection wells (11 Nos.): 338 3) O&M for wells: 6.4/year
2. Hammam	Irrigation	0.8 MCM/y: Storage water	Dam & water facilities:4,180
3. Siwaga C	Water supply	0.6 MCM/y: Storage water (Injection to deep aquifer)	1) Dam and water facilities: 250 2) Injection wells (2 Nos.) : 66 3) O & M for wells: 1.2/year
4. Khabra	Undefined purpose	2.7 MCM/y: Storage water	Dam & water facilities:2,550
5. Nukheila	Undefined purpose	1) 8.8 MCM/y: Storage water 2) 4.4 MCM/y: Seepage to channel (Total 13.2 MCM/y)	Dam & water facilities:3,690
6. Qatrana (Exist.)	Water supply or irrigation	3.2 MCM/y: Deep aquifer by injection	1) Drainage work:4 2) Injection wells (7 Nos.): 311 3) O&M for drainage and wells: 10.4/y
7. Sultani (Exist.)	Water supply	0.7 MCM/y: Deep aquifer by injection	1) Excavation work: 450 2) O&M for excavation and wells: 19.2/year

Annex M8304 (1/2) ECONOMIC BENEFIT AND COST FLOW

(I) Hammam Irrigation Scheme

Unit : JD 1,000

Year in Order	Economic Cost			Benefit
	Construction Cost	OM-cost	Total	
1	220	-	220	-
2	29	-	29	-
3	185	-	185	-
4	2,240	-	2,240	-
5	3,182	-	3,182	-
6	1,591	-	1,591	-
7	-	-	-	-
8	-	93	93	203
9	-	149	149	324
10	-	186	186	405
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
50	-	186	186	405

(II) Qatrana Irrigation Scheme

Unit : JD 1,000

Year in Order	Economic Cost			Benefit
	Construction Cost	OM-cost	Total	
1	13	-	13	-
2	2	-	2	-
3	11	-	11	-
4	425	-	425	-
5	11	-	11	-
6	6	3	9	71
7	-	4	4	113
8	-	5	5	142
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
50	-	5	5	142

Annex M8304 (2/2) ECONOMIC BENEFIT AND COST FLOW

(III) Hamman and Qatran Irrigation Schemes

Unit : JD 1,000

Year in Order	Economic Cost			Benefit
	Construction Cost	OM-cost	Total	
1	233	-	233	-
2	31	-	31	-
3	196	-	196	-
4	2,665	-	2,665	-
5	3,193	-	3,193	-
6	1,597	3	1,600	71
7	-	4	4	113
8	-	98	98	345
9	-	154	154	466
10	-	191	191	547
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
50	-	191	191	547