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### **1.7.3 Reuse of Effluent (Ma'an)**

#### **1.7.3.1 Present Reuse Practice**

Presently part of the treated effluent is used to irrigate the trees and fodder in the vicinity of the treatment plant. Another part is given to areas located within the borders of the treatment plant for irrigation of some olive trees. The remaining part is discharged into the wadi close to the treatment plant site. Around 50 donums outside the treatment plant area are registered to use treated effluent for irrigation of barley and alfalfa (forage). Actually, the beneficiary (Abu Darwish Ag. Society) cultivate only 20 % of the area. This beneficiary has a pump with a discharge capacity of around 180 m<sup>3</sup>/h at 160 m head. The irrigation method used is surface irrigation.

In the future there is a great potential for more beneficiaries to be benefited from the treated effluent for new cultivation. One farmer has just signed an agreement with WAJ in order to supply him with treated effluent sufficient for 135 donums. Most of this area will be planted by fodder and barley. Total area that benefit from the treated effluent through WAJ is therefore 185 donums.

Some farmers downstream of the treatment plant have built a barrier across the wadi (conducting treated effluent) in order to impound the water and pump it to their farms to supplement the deficit in irrigation demand from their groundwater wells.

Another 15 or 16 farms, which are distributed along the course of the Wadi are not able to use this water due to the fact that their farms are far from the water source and they have to pay for the piping and the pumping whenever necessary. Shepherds are also using this water to water their goats and sheeps in the direct vicinity of the treatment plant.

#### **1.7.3.2 Proposed Cropping Pattern**

If the water quality and quantity were not limiting factors, there would be no restrictions on the cropping pattern that might be adopted in Ma'an area. The soils are saline and the weather is hot and the climate is characterized as an arid climate. That means the potential evaporation is very high. So, in order to use and manage such type of soils, a combination of water, soil, and crop management practices must be adopted.

Existing cropping pattern in the area is comprised of fodders (Alfalfa), forest trees, barley and olives. According to the water quality of the effluent for Ma'an WWTP and the JS 893/ 95 the above mentioned crops are still an option together with the introduction of Date Palm, which is strongly tolerant to salinity as well as sorghum, and sudan grass.

However, the following water demand calculation takes into account a crop pattern composed of olive trees, date palms, wheat and barley as well as alfalfa (fodder).

### **1.7.3.3 Water Demand and Supply**

Proposed Ma'an reuse areas are located in agro-zone 10 as defined by the Ministry of Water and Irrigation.

Tables 1.7.3-1 and 1.7.3-2 show the proposed cropping pattern to be applied in Ma'an area and the irrigation demand (agro-zone 10) for the years 2010 and 2020. The table also illustrates the balance of required water and supplied water from the treatment plant for the year 2010. Whole proposed area for olives, date palms, wheat and barley is about 285 donums. Up to additional 800 donums of alfalfa may be irrigated to fit best the seasonal available treated effluent. Figure 1.7.3-1 shows the comparison between irrigation demand and available treated effluent. A strict management may bring closer the demand and supply curve by refining the extend of areas to be irrigated.

Storage capacity might be needed for operational purposes only, because land is plenty in the area and the future wastewater generated even after the expansion can be reused completely. In addition, it has to be noted that the wastewater stabilization pond system as available in Ma'an offers a certain capacity to store water: If the water level in the new ponds would be raised by 10 cm only for, let's say one month, a water volume of 10,000 m<sup>3</sup> could be stored taking into account a total surface of the ponds of about 10 ha as proposed for 2010. Such a change of the water level would not influence the treatment efficiency of the pond system.

**Table 1.7.3-1 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Ma'an Wastewater Treatment Plant (in 2010)**

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
<b>Available wastewater</b>													
Seasonal factor of treated effluent (wastewater)	0.81	0.75	0.81	0.88	1.00	1.12	1.22	1.25	1.22	1.12	1.00	0.88	-
Total wastewater effluent (m <sup>3</sup> /month) 2)	58.320	54.000	58.320	63.360	72.000	80.640	87.840	90.000	87.840	80.640	72.000	63.360	868.320
<b>1 OLIVES</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	51	51	78	126	150	151	154	135	112	29	-	-	1.038
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	61	60	93	150	179	180	183	161	133	34	0	0	1.235
Chosen area (donum)	55	55	55	55	55	55	55	55	55	55	55	55	
Demand (m <sup>3</sup> /month) 1)	3.372	3.324	5.094	8.266	9.826	9.897	10.082	8.872	7.338	1.868	0	0	67.938
<b>2 WHEAT &amp; BARLEY</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	40	63	99	174	23	-	-	-	-	100	54	36	588
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	66	104	166	290	38	0	0	0	0	167	89	60	980
Chosen area (donum)	150	150	150	150	150	150	150	150	150	150	150	150	
Demand (m <sup>3</sup> /month) 1)	9.949	15.628	24.851	43.468	5.734	0	0	0	0	25.000	13.381	8.992	147.003
<b>3 DATE PALM</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	35	50	81	145	193	206	209	184	152	107	66	42	1.469
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	42	60	96	173	230	245	249	219	181	127	79	50	1.749
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m <sup>3</sup> /month) 1)	3.327	4.787	7.720	13.805	18.365	19.575	19.901	17.513	14.485	10.171	6.310	3.971	139.929
<b>Total demand for crops no 1 - 3 (m<sup>3</sup>/ month)</b>	<b>16.647</b>	<b>23.739</b>	<b>37.665</b>	<b>65.539</b>	<b>33.924</b>	<b>29.472</b>	<b>29.983</b>	<b>26.384</b>	<b>21.823</b>	<b>37.038</b>	<b>19.692</b>	<b>12.963</b>	<b>354.869</b>
Remaining effluent (m <sup>3</sup> /month)	41.673	30.261	20.655	-2.179	38.076	51.168	57.857	63.616	66.017	43.602	52.308	50.397	
<b>4 ALFALFA</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	27	41	67	127	179	201	209	184	152	106	64	37	1.393
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	45	68	112	211	298	335	348	306	253	176	107	62	2.322
Required area of alfalfa (donum)	921	443	185	-10	128	153	166	208	260	248	489	818	
Selected area of alfalfa (donum)	800	500	150	0	150	150	150	200	250	250	500	800	
Demand for selected area of alfalfa (m <sup>3</sup> /month)	36.185	34.118	16.773	0	44.656	50.303	52.241	61.295	63.374	43.995	53.539	49.317	505.796
<b>Water Balance</b>													
Total demand (m <sup>3</sup> /month)	52.832	57.857	54.438	65.539	78.580	79.775	82.223	87.679	85.197	81.033	73.230	62.280	860.665
Total wastewater effluent (m <sup>3</sup> /month) 2)	58.320	54.000	58.320	63.360	72.000	80.640	87.840	90.000	87.840	80.640	72.000	63.360	868.320
Excess+/deficit- (m <sup>3</sup> /month)	5.488	-3.857	3.882	-2.179	-6.580	865	5.617	2.321	2.643	-393	-1.230	1.080	7.655

Remarks:

1) Based on irrigation time:24 hours/day

2) Wastewater effluents of treatment plant **2.400** m<sup>3</sup>/day in 2010 and 876.000 m<sup>3</sup>/annum

3) Irrigation surface (donums):

	OLIVES	WHEAT & BARLEY	DATE PALM	ALFALFA
Total (min.):	55	150	80	0
Total (max.):	55	150	80	800

**Table 1.7.3-2 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Ma'an Wastewater Treatment Plant (in 2020)**

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
<b>Available wastewater</b>													
Seasonal factor of treated effluent (wastewater)	0.81	0.75	0.81	0.88	1.00	1.12	1.22	1.25	1.22	1.12	1.00	0.88	-
Total wastewater effluent (m <sup>3</sup> /month) 2)	82,620	76,500	82,620	89,760	102,000	114,240	124,440	127,500	124,440	114,240	102,000	89,760	1,230,120
<b>1 OLIVES</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	51	51	78	126	150	151	154	135	112	29	-	-	1,038
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	61	60	93	150	179	180	183	161	133	34	0	0	1,235
Chosen area (donum)	80	80	80	80	80	80	80	80	80	80	80	80	
Demand (m <sup>3</sup> /month) 1)	4,904	4,835	7,409	12,024	14,292	14,396	14,664	12,904	10,674	2,717	0	0	98,819
<b>2 WHEAT &amp; BARLEY</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	40	63	99	174	23	-	-	-	-	100	54	36	588
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	66	104	166	290	38	0	0	0	0	167	89	60	980
Chosen area (donum)	210	210	210	210	210	210	210	210	210	210	210	210	
Demand (m <sup>3</sup> /month) 1)	13,928	21,879	34,791	60,855	8,027	0	0	0	0	35,000	18,734	12,589	205,804
<b>3 DATE PALM</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	35	50	81	145	193	206	209	184	152	107	66	42	1,469
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	42	60	96	173	230	245	249	219	181	127	79	50	1,749
Chosen area (donum)	110	110	110	110	110	110	110	110	110	110	110	110	
Demand (m <sup>3</sup> /month) 1)	4,575	6,582	10,614	18,981	25,251	26,915	27,364	24,080	19,918	13,984	8,677	5,460	192,402
<b>Total demand for crops no.1 - 3 (m<sup>3</sup>/ month)</b>	<b>23,407</b>	<b>33,296</b>	<b>52,815</b>	<b>91,860</b>	<b>47,571</b>	<b>41,311</b>	<b>42,028</b>	<b>36,984</b>	<b>30,591</b>	<b>51,701</b>	<b>27,411</b>	<b>18,049</b>	<b>497,024</b>
Remaining effluent (m <sup>3</sup> /month)	59,213	43,204	29,805	-2,100	54,429	72,929	82,412	90,516	93,849	62,539	74,589	71,711	
<b>4 ALFALFA</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	27	41	67	127	179	201	209	184	152	106	64	37	1,393
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	45	68	112	211	298	335	348	306	253	176	107	62	2,322
Required area of alfalfa (donum)	1,309	633	267	-10	183	217	237	295	370	355	697	1,163	
Selected area of alfalfa (donum)	1,300	600	300	0	200	200	250	300	350	350	700	1,200	
Demand for selected area of alfalfa (m <sup>3</sup> /month)	58,801	40,942	33,547	0	59,541	67,070	87,068	91,942	88,723	61,593	74,954	73,976	738,158
<b>Water Balance</b>													
Total demand (m <sup>3</sup> /month)	82,208	74,238	86,362	91,860	107,112	108,381	129,096	128,926	119,314	113,294	102,365	92,025	1,235,183
Total wastewater effluent (m <sup>3</sup> /month) 2)	82,620	76,500	82,620	89,760	102,000	114,240	124,440	127,500	124,440	114,240	102,000	89,760	1,230,120
Excess+/deficit- (m <sup>3</sup> /month)	412	2,262	-3,742	-2,100	-5,112	5,859	-4,656	-1,426	5,126	946	-365	-2,265	-5,063

Remarks:

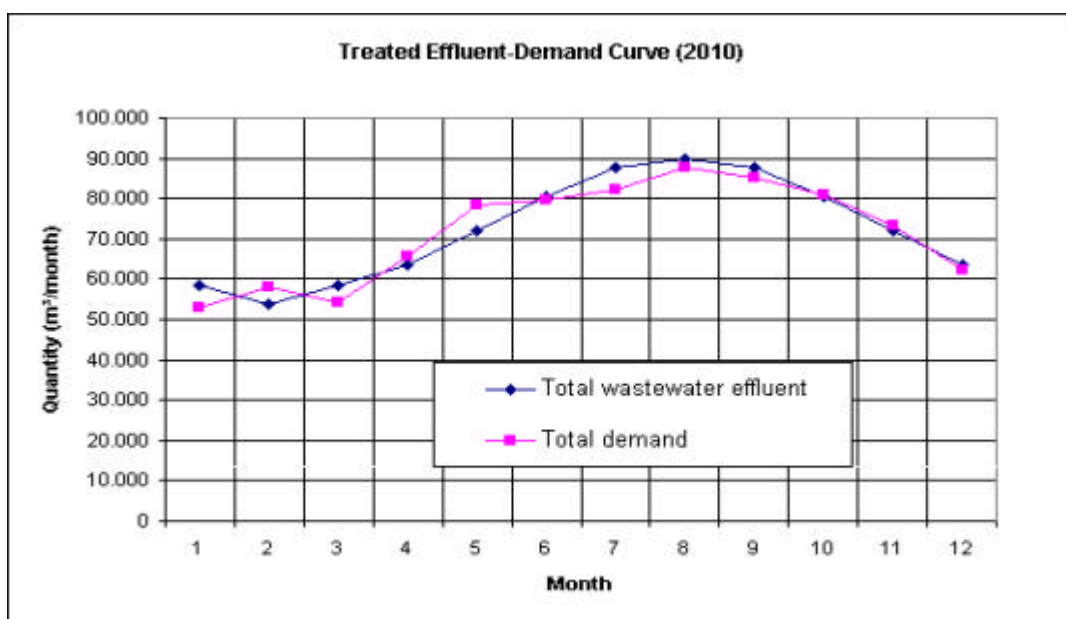
1) Based on irrigation time:24 hours/day

2) Wastewater effluents of treatment plant **3,400** m<sup>3</sup>/day in 2020 and 1,241,000 m<sup>3</sup>/annum

3) Irrigation surface (donums):

Total (min.): 400  
Total (max.): 1,700

OLIVES	WHEAT & BARLEY	DATE PALM	ALFALFA
80	210	110	0
80	210	110	1,300



**Figure 1.7.3-1 Seasonal Treated Effluent and Demand for irrigation (Ma'an)**

### 1.7.3.3 Area Proposed for Irrigation

Enough arable land is available for reuse of the treated effluent from Ma'an's Wastewater Treatment Plant. In particular these lands are distributed in the Northern, Eastern and Southern sides of the treatment plant. Figure 1.7.3-2 depicts the proposed area that might be used for future irrigation. The land areas that could be exploited till the year 2010 depending on the quantity of effluent that might be available in the future are about 1,100 donums in a first phase until 2010, given that the water demand is estimated in Table 1.7.3-1.

### 1.7.4 Preliminary Design of Facilities (Ma'an)

A preliminary design is set for the required reuse facilities for Ma'an Wastewater Treatment Plant. The facilities include a transmission main line from the exit of the treatment plant to the reservoir. The reservoir will be built in an area higher in elevation than the surrounding area and the exit point of the treatment plant. Therefore, pumping is necessary to convey the water to the proposed storage reservoir. In this case pumping to the farms is not necessary because effluent will flow from the reservoir through the distribution lines by gravity. Figure 1.7.3-2 shows the arrangement of main elements of the proposed reuse system.

#### Pump station

A pump station is required to pump the treated effluent from the treatment plant to the storage reservoir. The capacity is roughly estimated to 40 l/s and a pumping head of about 10 m.

#### Transmission Facilities

The preliminary selection of the pipeline indicates that the length of the transmission line will be around 700 m, and the inside diameter of the pipe is 200 mm (8") in order to convey the effluent to the storage reservoir.



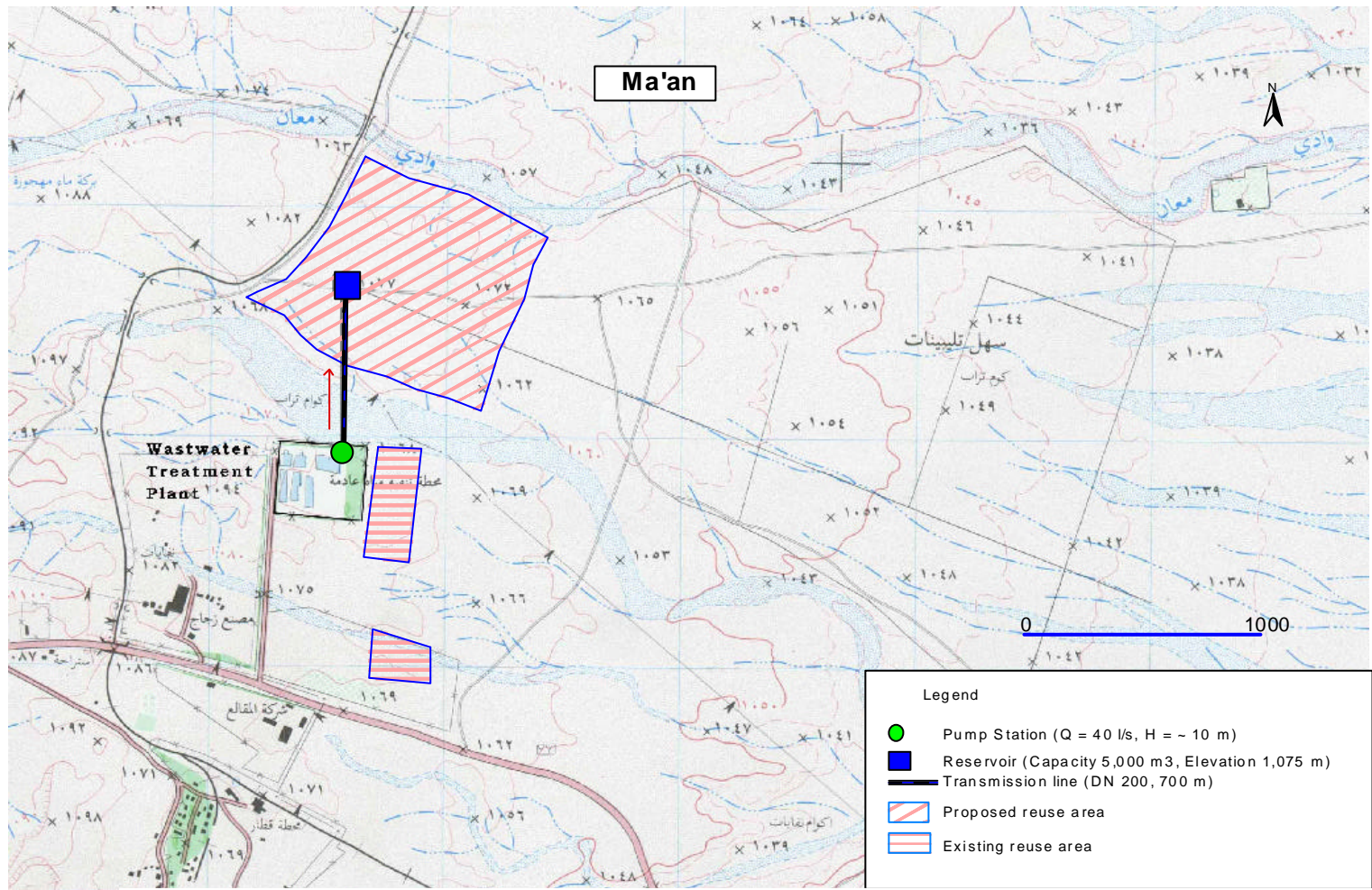


Figure 1.7.3-2 Location of Ma'an Wastewater Treatment Plant and Proposed Site for Effluent Reuse

## **Storage Facilities**

The storage volume of the reservoir is selected to facilitate operation of the reuse schemes. According to the design criteria the reservoir volume should contain around 5,000 m<sup>3</sup> in a first phase. The proper location for the storage reservoir is about 700 m far from the treatment plant outlet on a hilly area where the difference in elevation is about 20 m from which the surrounded area is supplied by water by gravity.

## **1.8 Reuse of Effluent in Abu Nuseir**

### **1.8.1 Existing System of Wastewater Collection, Treatment and Disposal (Abu Nuseir)**

Abu Nuseir housing is the only service area served by Abu Nuseir Wastewater Treatment Plant. Figure 1.8.2-1 depicts the existing sewerage system in Abu Nuseir.

Since its operation in 1986, Abu-Nuseir Wastewater Treatment Plant is still operating below its design capacity.

The existing WWTP adopts the extended aeration activated sludge treatment process. The treated effluent is disinfected and discharged into the Wadi el Marbat. Finally, effluent is discharged via Wadi Zarqa into the King Talal Reservoir (KTR). The design criteria for Abu Nuseir Wastewater Treatment Plant are as follows:

Influent		Effluent
Inflow (m <sup>3</sup> /d)	BOD <sub>5</sub> (mg/l)	BOD <sub>5</sub> (mg/l)
4,000	780	30

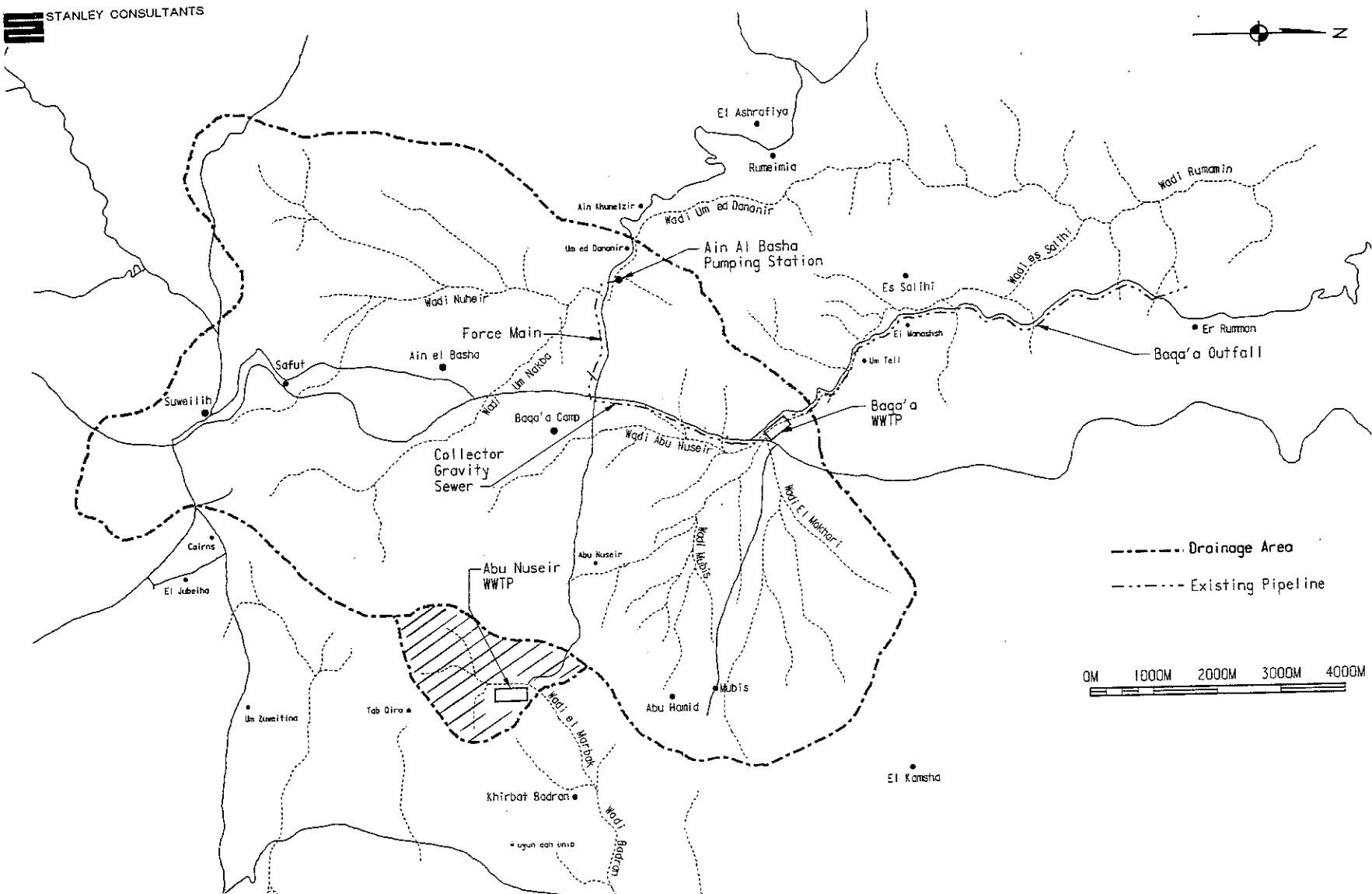
At the moment only one of the two aeration carrousel is operating. The other train and the two rotating biological cylinders (RBC) units haven't yet been put into service. Abu-Nuseir WWTP is currently producing an effluent of reasonable quality. The low content of fecal coliforms are certainly due to the continuous chlorination of the effluent. The mechanical sludge dewatering system is out of service. At present, sludge is digested, thickened and tankered to Ain Ghazal Pre-treatment Plant.

Since the treatment plant is working within the design capacity, so there is no need for an extension most probably for the coming years (compare Table 1.8.2-1). Figure 1.8.2-2 shows the existing treatment system of Abu Nuseir WWTP.

### **1.8.2 Wastewater Quantity and Quality (Abu Nuseir)**

In terms of wastewater quantity, the inflow to Abu Nuseir WWTP has reached more than 1,600 m<sup>3</sup>/day in 2000. The reason for the reduction in the inflow to the treatment plant in 1999 is the draught phenomenon (low rainfall and limited water resources), which lowered available water for domestic use. Table 1.8.2-1 shows the development in the quantity of influent to the treatment plant since 1988.





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Figure 1.8.2-1

General Layout of Abu Nuseir Sewerage System

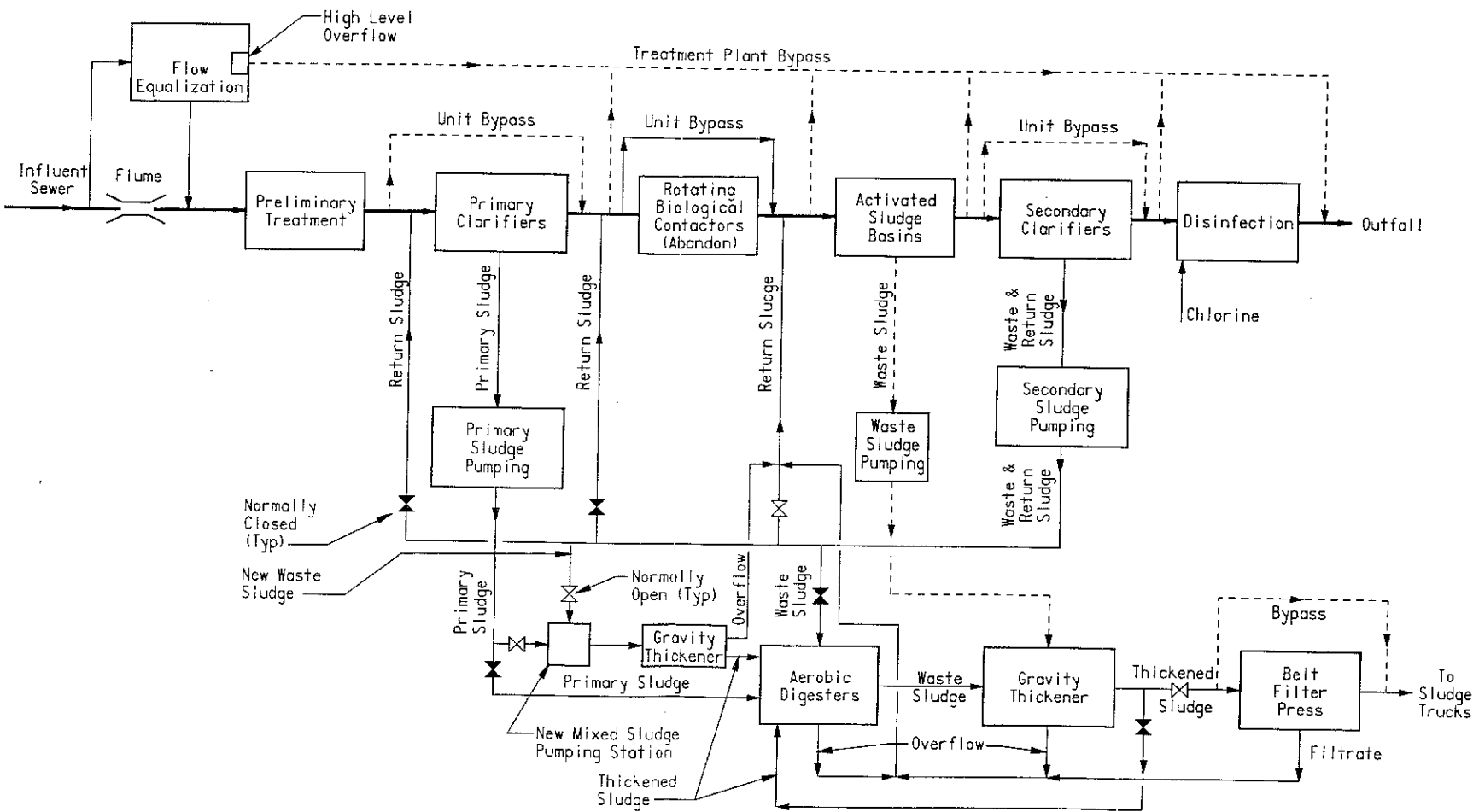


Figure 1.8.2-2

Schematic Layout of Abu Nuseir Wastewater Treatment Plant

**Table 1.8.2-1 Development of Influent Quantity of Abu Nuseir Wastewater Treatment Plant**

Year	Influent (m <sup>3</sup> /day)
1988	1,360
1989	1,311
1990	1,325
1991	1,316
1992	1,431
1993	1,514
1994	1,532
1995	1,497
1996	1,463
1997	1,486
1998	1,499
1999	1,411
2000	1,617

The current coverage percentage for Abu Nuseir WWTP is around 65 %. This value is expected to increase to around 85 % in the year 2010 due to extension measures of the sewerage system and will continue to keep the same coverage till 2020. So, by 2020 the treatment plant will reach its maximum design capacity of 4,200 m<sup>3</sup>/day, which equals an annual inflow of 1.54 MCM/a. Table 1.8.2-2 shows the development in the inflow to the treatment plant till the year 2020.

**Table 1.8.2-2 Projection of the Influent to Abu Nuseir Wastewater Treatment Plant**

**SCENARIO 0 "Consultants' Study"**

(acc. to Consultant's Study Report, TYP SA)

**Basic data:**

Population in 1994: 18,879

	Unit	1994	2000	2005	2010	2015	2020
Growth rate (previous period)	%	-	3.24	3.24	3.24	3.24	3.24
Spec. water demand	l/c/d	130	120	143	143	143	143
Commercial demand	m <sup>3</sup> /d						
Small industrial demand	m <sup>3</sup> /d						
Pastoral demand	m <sup>3</sup> /d						
Coverage	%	65	65	75	85	85	85
Return factor	-	0.8	0.8	0.8	0.8	0.8	0.8
Losses/inflow	%	0	0	0	0	0	0
Specific pollutional load	gBOD <sub>5</sub> /c/d	65	65	65	65	65	65

	Unit	1994	2000	2005	2010	2015	2020
<b>Population</b>	c	18,879	22,860	26,811	31,445	36,880	43,254
Connected (sewerage)	c	12,271	14,859	20,108	26,728	31,348	36,766
Not connected (sewerage)	c	6,608	8,001	6,703	4,717	5,532	6,488
<b>Water demand</b>							
Domestic demand	l/c/d	130	120	143	143	143	143
	m <sup>3</sup> /d	2,454	2,743	3,834	4,497	5,274	6,185
Commercial demand	m <sup>3</sup> /d						
Small industrial demand	m <sup>3</sup> /d						
Pastoral demand	m <sup>3</sup> /d						
Total	m <sup>3</sup> /d	2,454	2,743	3,834	4,497	5,274	6,185
<b>Wastewater production</b>							
Return flow (w. demand)	m <sup>3</sup> /d	1,276	1,426	2,300	3,058	3,586	4,206
Losses/inflow	m <sup>3</sup> /d	0	0	0	0	0	0
Total	m <sup>3</sup> /d	1,276	1,426	2,300	3,058	3,586	4,206
	m <sup>3</sup> /month	38,287	42,793	69,011	91,730	107,585	126,181
	m <sup>3</sup> /a	465,820	520,648	839,628	1,116,053	1,308,955	1,535,199
<b>Pollutional load</b>							
Poll. load (dom. demand)	kgBOD <sub>5</sub> /d	798	966	1,307	1,737	2,038	2,390
Poll. load (com. demand)	kgBOD <sub>5</sub> /d						
Poll. load (small ind.)	kgBOD <sub>5</sub> /d						
Others	kgBOD <sub>5</sub> /d						
Total load	kgBOD <sub>5</sub> /d	798	966	1,307	1,737	2,038	2,390
<b>Reuse of wastewater</b>							
Inflow to the treatment plant	m <sup>3</sup> /a	465,820	520,648	839,628	1,116,053	1,308,955	1,535,199
Losses in treatment plant	%	5	5	5	5	5	5
(due to infiltr./evap.)	m <sup>3</sup> /a	23,291	26,032	41,981	55,803	65,448	76,760
<b>Effluent of treatment plant</b>	m <sup>3</sup> /a	<b>442,529</b>	<b>494,616</b>	<b>797,647</b>	<b>1,060,250</b>	<b>1,243,507</b>	<b>1,458,439</b>

Table 1.8.2-3 shows the quality of influent and effluent for Abu Nuseir WWTP for the period 1988-2000.

The efficiency of Abu Nuseir WWTP is between 95 and 97 % - an acceptable range for the applied treatment process. In addition, the treatment plant doesn't need any further expansion in the near future. According to the projection of wastewater production (Table 1.8.2-2) an expansion would be needed around 2020.

**Table 1.8.2-3 Quality of Influent and Effluent of Abu Nuseir WWTP for 1988/2000**

Year	Influent (mg/l)			Effluent (mg/l)			
	BOD <sub>5</sub>	COD	TSS	BOD <sub>5</sub>	COD	TSS	TDS
1988	630	1,150	620	27	121	28	*
1989	633	1,204	621	23	71	26	*
1990	677	1,182	690	32	90	39	699
1991	711	1,060	709	24	86	25	807
1992	735	1,237	728	21	77	25	851
1993	656	1,212	657	22	80	22	792
1994	572	960	550	23	80	21	785
1995	533	518	518	19	76	20	650
1996	620	1,169	600	24	83	42	793
1997	884	1,390	617	45	107	91	857
1998	588	1,378	556	17	90	33	1,079
1999	634	1,233	601	17	79	29	823
2000	579	1,385	584	27	111	27	965

### **1.8.3 Reuse of Effluent (Abu Nuseir)**

#### **1.8.3.1 Present Reuse Practice**

With regard to Abu Nuseir WWTP there is no planned and only very little unplanned reuse irrigation around or in the vicinity of the treatment plant: There is one case of utilizing the treated effluent to irrigate some fruit trees, especially stone fruits and some olives, nearby. The other planted areas downstream of the treatment plant are planted to field crops (wheat and barley), which are considered as rainfed agriculture. So, there is a great potential for supplemental reuse of wastewater for all the rainfed agriculture in the area.

All the treated effluent is discharged to the Wadi Al Marbat, which ends up at Wadi Bereen. Then it discharges into Wadi Zarqa, which carries in particular effluent from As Samra WWTP, and mouths in King Talal Reservoir.

The Ministry of Agriculture has prepared recently a new pilot project of about 1 donum area, which is supervised by National Center for Agricultural Research and Technology Transfer (NCARTT) in order to test the possibility of adopting drip irrigation technique as a method of irrigation utilizing the treated effluent. The study area is downstream of the treatment plant and will be supplied by treated effluent through an open channel.

#### **1.8.3.2 Proposed Cropping Pattern**

Due to the steep topography and the high altitudes of Abu Nuseir area, it is recommended to follow the existing field crops farming (wheat and barley). Olive trees, date palms and fodder crops are also expected to supplement the irrigation activities within the availability of future treated effluent quantities.

### **1.8.3.3 Water Demand for Irrigation**

Downstream of the existing treatment plant there is plenty of arable land area appropriate for irrigation by the treated effluent.

Water demand and treated effluent were determined on the basis of net irrigation demand figures of the MWI (agro-zone 5). Results are summarized in Tables 1.8.3-1 and 1.8.3-2 for the target years 2010 and 2020. Figure 1.8.3-1 illustrates seasonal variation of available treated effluent and demand for irrigation of proposed irrigation areas of Abu Nuseir. During the period between April and September it is possible to reuse the entire effluent quantity. From October to March precipitation is so high that there is no requirement for additional irrigation. Therefore about 280,000 m<sup>3</sup>/a is expected as excess water. This quantity will flow via Wadi Al Marbat, Wadi Bereen and Wadi Zarqa and contribute finally to the stored volume in King Talal Reservoir.

**Table 1.8.3-1 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Abu Nuseir Wastewater Treatment Plant (2010)**

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
<b>Available wastewater</b>													
Seasonal factor of treated effluent (wastewater)	0.81	0.75	0.81	0.88	1.00	1.12	1.22	1.25	1.22	1.12	1.00	0.88	-
Total wastewater effluent (m <sup>3</sup> /month) 2)	70,470	65,250	70,470	76,560	87,000	97,440	106,140	108,750	106,140	97,440	87,000	76,560	1,049,220
<b>1 OLIVES</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	16	14	35	105	132	134	138	120	102	19	-	-	815
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	19	16	42	125	157	160	165	143	122	23	0	0	970
Chosen area (donum)	200	200	200	200	200	200	200	200	200	200	200	200	
Demand (m <sup>3</sup> /month) 1)	3,776	3,273	8,360	24,939	31,395	32,011	32,910	28,502	24,355	4,552	0	0	194,074
<b>2 WHEAT &amp; BARLEY</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	-	17	45	136	5	-	-	-	-	100	34	-	337
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	0	28	75	227	8	0	0	0	0	167	56	0	561
Chosen area (donum)	200	200	200	200	200	200	200	200	200	200	200	200	
Demand (m <sup>3</sup> /month) 1)	0	5,645	14,946	45,438	1,689	0	0	0	0	33,333	11,176	0	112,227
<b>3 DATE PALM</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	-	13	39	127	178	187	188	162	139	95	44	-	1,171
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	0	15	46	151	212	222	223	193	165	113	53	0	1,394
Chosen area (donum)	100	100	100	100	100	100	100	100	100	100	100	100	
Demand (m <sup>3</sup> /month) 1)	0	1,505	4,587	15,074	21,240	22,249	22,332	19,341	16,527	11,331	5,261	0	139,446
<b>Total demand for crops no.1 - 3 (m<sup>3</sup>/ month)</b>	<b>3,776</b>	<b>10,423</b>	<b>27,894</b>	<b>85,451</b>	<b>54,325</b>	<b>54,260</b>	<b>55,242</b>	<b>47,842</b>	<b>40,882</b>	<b>49,217</b>	<b>16,437</b>	<b>0</b>	<b>445,748</b>
Remaining effluent (m <sup>3</sup> /month)	66,694	54,827	42,576	-8,891	32,675	43,180	50,898	60,908	65,258	48,223	70,563	76,560	
<b>4 ALFALFA</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	16	14	35	105	132	134	138	120	102	19	-	-	815
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	26	23	59	175	220	224	230	200	170	32	0	0	1,359
Required area of alfalfa (donum)	2,524	2,393	728	-51	149	193	221	305	383	1,513	0	0	
Selected area of alfalfa (donum)	500	500	500	0	150	200	200	300	400	500	500	500	
Demand for selected area of alfalfa (m <sup>3</sup> /month)	13,214	11,457	29,262	0	32,965	44,816	46,074	59,854	68,194	15,934	0	0	321,768
<b>Water Balance</b>													
Total demand (m <sup>3</sup> /month)	16,990	21,880	57,156	85,451	87,290	99,075	101,316	107,696	109,075	65,151	16,437	0	767,517
Total wastewater effluent (m <sup>3</sup> /month) 2)	70,470	65,250	70,470	76,560	87,000	97,440	106,140	108,750	106,140	97,440	87,000	76,560	1,049,220
Excess+/deficit- (m <sup>3</sup> /month)	53,480	43,370	13,314	-8,891	-290	-1,635	4,824	1,054	-2,935	32,289	70,563	76,560	281,703

Remarks:

- 1) Based on irrigation time:24 hours/day  
2) Wastewater effluents of treatment plant **2,900** m<sup>3</sup>/day in 2010 and 1,058,500 m<sup>3</sup>/annum  
3) Irrigation surface (donums):  

OLIVES  
Total (min.): 500  
Total (max.): 1,000

WHEAT & BARLEY  
200  
200

DATE PALM  
100  
100

ALFALFA  
0  
500



**Table 1.8.3-2 Water Demand for Irrigation of Proposed Crops and Treated Effluent Supplied from Abu Nuseir Wastewater Treatment Plant (2020)**

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
<b>Available wastewater</b>													
Seasonal factor of treated effluent (wastewater)	0.81	0.75	0.81	0.88	1.00	1.12	1.22	1.25	1.22	1.12	1.00	0.88	-
Total wastewater effluent (m <sup>3</sup> /month) 2)	97,200	90,000	97,200	105,600	120,000	134,400	146,400	150,000	146,400	134,400	120,000	105,600	1,447,200
<b>1 OLIVES</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	16	14	35	105	132	134	138	120	102	19	-	-	815
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	19	16	42	125	157	160	165	143	122	23	0	0	970
Chosen area (donum)	280	280	280	280	280	280	280	280	280	280	280	280	
Demand (m <sup>3</sup> /month) 1)	5,286	4,583	11,705	34,915	43,953	44,816	46,074	39,903	34,097	6,373	0	0	271,704
<b>2 WHEAT &amp; BARLEY</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	-	17	45	136	5	-	-	-	-	100	34	-	337
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	0	28	75	227	8	0	0	0	0	167	56	0	561
Chosen area (donum)	200	200	200	200	200	200	200	200	200	200	200	200	
Demand (m <sup>3</sup> /month) 1)	0	5,645	14,946	45,438	1,689	0	0	0	0	33,333	11,176	0	112,227
<b>3 DATE PALM</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	-	13	39	127	178	187	188	162	139	95	44	-	1,171
Irrigation efficiency	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	0	15	46	151	212	222	223	193	165	113	53	0	1,394
Chosen area (donum)	140	140	140	140	140	140	140	140	140	140	140	140	
Demand (m <sup>3</sup> /month) 1)	0	2,107	6,422	21,104	29,737	31,148	31,265	27,077	23,137	15,864	7,366	0	195,225
<b>Total demand for crops no.1 - 3 (m<sup>3</sup>/ month)</b>	<b>5,286</b>	<b>12,334</b>	<b>33,073</b>	<b>101,457</b>	<b>75,379</b>	<b>75,964</b>	<b>77,339</b>	<b>66,979</b>	<b>57,234</b>	<b>55,571</b>	<b>18,541</b>	<b>0</b>	<b>579,157</b>
Remaining effluent (m <sup>3</sup> /month)	91,914	77,666	64,127	4,143	44,621	58,436	69,061	83,021	89,166	78,829	101,459	105,600	
<b>4 ALFALFA</b>													
Net irrigation demand (m <sup>3</sup> / donum/ month)	16	14	35	105	132	134	138	120	102	19	-	-	815
Irrigation efficiency	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
Gross irrigation demand (m <sup>3</sup> / donum/ month)	26	23	59	175	220	224	230	200	170	32	0	0	1,359
Required area of alfalfa (donum)	3,478	3,390	1,096	24	203	261	300	416	523	2,474	0	0	
Selected area of alfalfa (donum)	1,000	1,000	1,000	0	200	300	300	400	500	1,000	1,000	1,000	
Demand for selected area of alfalfa (m <sup>3</sup> /month)	26,429	22,913	58,523	0	43,953	67,223	69,111	79,805	85,242	31,867	0	0	485,067
<b>Water Balance</b>													
Total demand (m <sup>3</sup> /month)	31,714	35,248	91,597	101,457	119,332	143,187	146,450	146,785	142,476	87,438	18,541	0	1,064,224
Total wastewater effluent (m <sup>3</sup> /month) 2)	97,200	90,000	97,200	105,600	120,000	134,400	146,400	150,000	146,400	134,400	120,000	105,600	1,447,200
Excess+/deficit- (m <sup>3</sup> /month)	65,486	54,752	5,603	4,143	668	-8,787	-50	3,215	3,924	46,962	101,459	105,600	382,976

Remarks:

- 1) Based on irrigation time:24 hours/day  
2) Wastewater effluents of treatment plant **4,000** m<sup>3</sup>/day in 2020 and 1,460,000 m<sup>3</sup>/annum  
3) Irrigation surface (donums):  

Total (min.): 700

Total (max.): 1,700

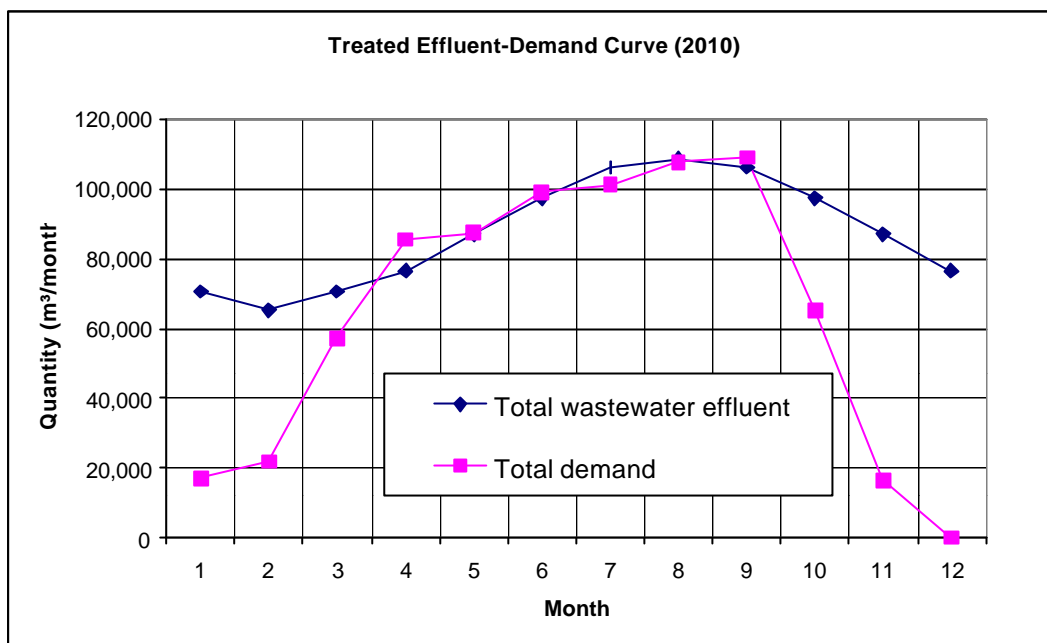
OLIVES 280

WHEAT & BARLEY 280

DATE PALM 140

ALFALFA 0

1,000



**Figure 1.8.3-1 Seasonal Treated Effluent and Demand for Irrigation (Abu Nuseir)**

#### **1.8.3.4 Area Proposed for Irrigation**

Figure 1.8.4-1 shows the location of Abu Nuseir Wastewater Treatment Plant and proposed site for effluent reuse. The areas to be exploited till the year 2010 depending on the quantity of effluent that might be available in the future are up to 1,000 donums.

Effluent will be discharged by gravity to the reuse areas. They are located in an area below the contour line of 890 m a.s.l..

#### **1.8.4 Preliminary Design of Facilities (Abu Nuseir)**

Required reuse facilities for Abu Nuseir reuse scheme are designed on available information of the area. The facilities include a transmission line from the exit of the treatment plant to the reservoir. The reservoir will be constructed in an elevation of 900 m. Pumping is not required to convey the water to the proposed storage reservoir (see Figure 1.8.4-1).

Those farmers who are willing to get treated effluent for supplementing their field crops should make contracts with WAJ in order to agree on the quantities required and on the conditions of reuse.

##### **Transmission Facilities**

Proposed transmission line (DN 300, 900 m) conveys the effluent from the treatment plant outlet to a storage reservoir. From there effluent is discharged to the reuse areas in northeastern direction of the Abu-Nuseir WWTP.

##### **Storage Facilities**

The storage reservoir is designed to accommodate two days flow (6,000 m³). It will be constructed in an elevation of 900 m to supply proposed reuse areas by gravity.

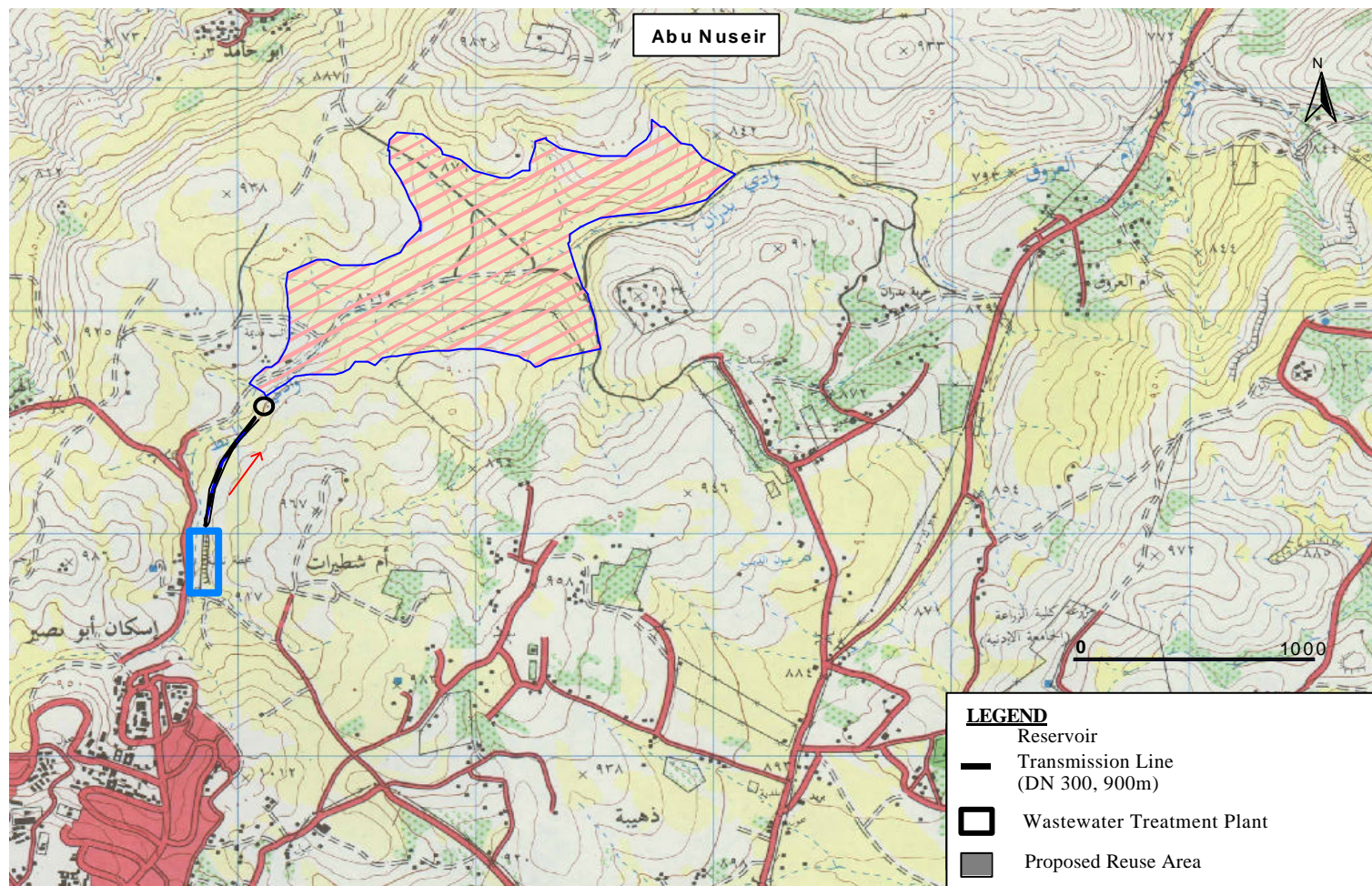


Figure 1.8.4-1 Location of Abu Nuseir Wastewater Treatment Plant and Proposed Site for Effluent Reuse