Supporting Report for Chapter 1
"Rehabilitation and Extension of Ma'an Wastewater Treatment Plant and Treated Wastewater Reuse of Five Existing Treatment Plant"

ANNEX to 1.13.2

Economic and Financial Analysis

Financial/Economic Analysis of Tafielah Wastewater Reuse Project

Hydraulic Analysis (m^3/yr)

Item	Allocation		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Water Produced				463,460	516,867	518,602	520,343	522,089	523,842	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600
Industrial Water	0.00		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physical Losses (%)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Administrative/Managerial Losses (%)			0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Delivered			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Whose Bills are Collected			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigation Water	1.00		0	463,460	516,867	518,602	520,343	522,089	523,842	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600
Physical Losses (%)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Administrative/Managerial Losses (%)			0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses			0	56,264	51,687	46,674	41,627	36,546	31,431	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280	26,280
Quantity Delivered			0	463,460	516,867	518,602	520,343	522,089	523,842	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600
Quantity Whose Bills are Collected			0	407,196	465,180	471,928	478,715	485,543	492,411	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320

Financial Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components	83%	358,328	358,326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foreign Components	17%	75,948	75,948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs		434,275	434,275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Costs			434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275	434,275
O & M Costs			0	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080
Total Costs			434,275	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080
Revenues																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial Tariff (JD/m^3)			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Industrial Revenues (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	407,196	465,180	471,928	478,715	485,543	492,411	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320
Irrigation Tariff (JD/m^3)			0.010	0.013	0.016	0.020	0.024	0.031	0.038	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Irrigation Revenues (JD)			0	5,098	7,260	9,217	11,687	14,818	18,784	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809
Total Revenues (JD)			0	5,098	7,260	9,217	11,687	14,818	18,784	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809	23,809
Net Cash Flow (JD)			-434,275	18	2,180	4,137	6,607	9,738	13,704	18,729	18,729	18,729	18,729	18,729	18,729	18,729	18,729	18,729	18,729	18,729
Discounting (DR=5%)			0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552
Total Qty Whose Bills are Collected (m^3)			0	407,196	465,180	471,928	478,715	485,543	492,411	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320	499,320
FIRR	0.4%																			
NPV (JD)	-286,568		-413,595	16	1,890	3,404	5,177	7,266	9,739	12,677	12,073	11,498	10,951	10,429	9,933	9,460	9,009	8,580	8,172	7,782
PV of Total Costs (JD)	486,349		413,595	4,608	4,388	4,179	3,980	3,791	3,610	3,438	3,275	3,119	2,970	2,829	2,694	2,566	2,444	2,327	2,216	2,111
PV of Total Bills Collected Qty (m^3)	7,033,308		0	369,338	401,840	388,258	375,088	362,328	349,947	337,959	321,866	306,539	291,942	278,040	264,800	252,191	240,181	228,744	217,852	207,478
Unit Water Price (Fils/m^3)	69																			

Economic Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components			319,904	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319
Foreign Components			75,948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs			395,852	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319	319
Cumulative Costs			395,852	396,170	396,489	396,807	397,126	397,444	397,763	398,081	398,400	398,718	399,037	399,355	399,674	399,992	400,311	400,629	400,948	401,266
O & M Costs			0	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080	5,080
Total Costs			395,852	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399	5,399
Benefits																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unit Benefits of Industrial Water (JD/m^3)			2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740
Industrial Benefits (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	463,460	516,867	518,602	520,343	522,089	523,842	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600
Unit Benefits of Irrigation Water (JD/m^3)			0.030	0.034	0.034	0.034	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Irrigation Benefits (JD)			0	15,854	17,681	17,740	52,074	52,249	52,424	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600
Total Benefits (JD)			0	15,854	17,681	17,740	52,074	52,249	52,424	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600	52,600
Net Cash Flow (JD)			-395,852	10,455	12,282	12,341	46,675	46,850	47,025	47,201	47,201	47,201	47,201	47,201	47,201	47,201	47,201	47,201	47,201	47,201
Discounting (DR=10%)			0.90909	0.82645	0.75131	0.68301	0.62092	0.56447	0.51316	0.46651	0.42410	0.38554	0.35049	0.31863	0.28966	0.26333	0.23939	0.21763	0.19784	0.17986
Total Qty Delivered (m^3)			0	463,460	516,867	518,602	520,343	522,089	523,842	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600	525,600
EIRR	8.9%																			
NPV (JD)	-38,843		-359,865	8,641	9,228	8,429	28,981	26,445	24,131	22,020	20,018	18,198	16,544	15,040	13,672	12,429	11,300	10,272	9,338	8,490
PV of Total Costs (JD)	405,940		359,865	4,462	4,056	3,687	3,352	3,047	2,770	2,518	2,289	2,081	1,892	1,720	1,564	1,422	1,292	1,175	1,068	971
PV of Total Qty Delivered (m^3)	4,488,121		0	383,025	388,330	354,212	323,092	294,706	268,814	245,196	222,906	202,642	184,220	167,473	152,248	138,407	125,824	114,386	103,987	94,534
Unit Water Price (Fils/m^3)	91																			

Financial/Economic Analysis of 4 Wastewater Reuse Projects Combined

Hydraulic Analysis (m^3/yr)

Item	Allocation	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Water Produced		0	2,404,664	2,600,371	2,721,116	2,836,637	2,955,073	3,076,566	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268
Industrial Water	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physical Losses (%)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Administrative/Managerial Losses (%)		0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Delivered		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Whose Bills are Collected		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigation Water	1.00	0	2,404,664	2,600,371	2,721,116	2,836,637	2,955,073	3,076,566	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268
Physical Losses (%)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Administrative/Managerial Losses (%)		0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses		0	291,926	252,837	244,901	227,931	206,855	184,594	160,063	160,063	160,063	160,063	160,063	160,063	160,063	160,063	160,063	160,063	160,063
Quantity Delivered		0	2,404,664	2,600,371	2,721,116	2,836,637	2,955,073	3,076,566	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268
Quantity Whose Bills are Collected		0	2,112,738	2,347,534	2,476,215	2,608,706	2,748,217	2,891,972	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205

Financial Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components	74%	871,531	871,531	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foreign Components	26%	304,920	304,920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs		1,176,451	1,176,451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Costs			1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451	1,176,451
O & M Costs			0	23,171	23,196	23,221	23,247	23,273	23,298	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324
Total Costs			1,176,451	23,171	23,196	23,221	23,247	23,273	23,298	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324
Revenues																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial Tariff (JD/m^3)			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Industrial Revenues (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	2,112,738	2,347,534	2,476,215	2,608,706	2,748,217	2,891,972	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205
Irrigation Tariff (JD/m^3)			0.010	0.013	0.016	0.020	0.024	0.031	0.038	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Irrigation Revenues (JD)			0	26,408	36,680	48,364	63,714	83,869	110,320	145,006	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793
Total Revenues (JD)			0	26,408	36,680	48,364	63,714	83,869	110,320	145,006	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793	146,793
Net Cash Flow (JD)			-1,176,451	3,238	13,484	25,143	40,467	60,596	87,022	121,682	123,469	123,469	123,469	123,469	123,469	123,469	123,469	123,469	123,469	123,469
Discounting (DR=5%)			0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552
Total Qty Whose Bills are Collected (m^3)			0	2,112,738	2,347,534	2,476,215	2,608,706	2,748,217	2,891,972	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205	3,041,205
FIRR	6.4%																			
NPV (JD)	235,990		-1,120,430	2,938	11,648	20,684	31,707	45,218	61,845	82,360	79,589	75,799	72,190	68,752	65,478	62,360	59,391	56,563	53,869	51,304
PV of Total Costs (JD)	1,456,312		1,120,430	21,016	20,038	19,104	18,215	17,366	16,558	15,787	15,035	14,319	13,637	12,988	12,369	11,780	11,219	10,685	10,176	9,692
PV of Total Bills Collected Qty (m^3)	41,285,421		0	1,916,316	2,027,888	2,037,189	2,044,773	2,050,763	2,055,270	2,058,407	1,960,380	1,867,036	1,778,129	1,693,457	1,612,816	1,536,015	1,462,871	1,393,211	1,326,867	1,263,683
Unit Water Price (Fils/m^3)	35																			

Economic Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components			779,044	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763
Foreign Components			304,920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs			1,083,964	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763	763
Cumulative Costs			1,083,964	1,084,727	1,085,490	1,086,253	1,087,016	1,087,779	1,088,542	1,089,305	1,090,068	1,090,831	1,091,594	1,092,357	1,093,120	1,093,883	1,094,646	1,095,409	1,096,172	1,096,935
O & M Costs			0	23,171	23,196	23,221	23,247	23,273	23,298	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324	23,324
Total Costs			1,083,964	23,934	23,959	23,984	24,010	24,036	24,061	24,087	24,087	24,087	24,087	24,087	24,087	24,087	24,087	24,087	24,087	24,087
Benefits																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unit Benefit of Industrial Water (JD/m^3)			2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740
Industrial Benefits (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	2,404,664	2,600,371	2,721,116	2,836,637	2,955,073	3,076,566	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268
Unit Benefits of Irrigation Water (JD/m^3)			0.000	0.026	0.026	0.026	0.065	0.065	0.065	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
Irrigation Benefits (JD)			0	62,451	67,737	70,347	184,864	191,830	198,899	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169
Total Benefits (JD)			0	62,451	67,737	70,347	184,864	191,830	198,899	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169	206,169
Net Cash Flow (JD)			-1,083,964	38,517	43,778	46,363	160,854	167,794	174,838	182,082	182,082	182,082	182,082	182,082	182,082	182,082	182,082	182,082	182,082	182,082
Discounting (DR=10%)			0.90909	0.82645	0.75131	0.68301	0.62092	0.56447	0.51316	0.46651	0.42410	0.38554	0.35049	0.31863	0.28966	0.26333	0.23939	0.21763	0.19784	0.17986
Total Qty Delivered (m^3)			0	2,404,664	2,600,371	2,721,116	2,836,637	2,955,073	3,076,566	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268	3,201,268
EIRR	12.2%																			
NPV (JD)	225,284		-985,422	31,832	32,891	31,666	99,877	94,689	89,719	84,943	77,221	70,201	63,819	58,017	52,743	47,948	43,589	39,626	36,024	32,749
PV of Total Costs (JD)	1,150,200		985,422	19,780	18,001	16,382	14,908	13,567	12,347	11,237	10,215	9,287	8,442	7,675	6,977	6,343	5,766	5,242	4,765	4,332
PV of Total Qty Delivered (m^3)	25,486,711		0	1,987,326	1,953,684	1,858,559	1,761,329	1,668,061	1,578,765	1,493,415	1,357,650	1,234,227	1,122,025	1,020,023	927,293	842,994	766,358	696,689	633,354	575,776
Unit Water Price (Fils/m^3)	47																			

Financial/Economic Analysis of Ma'an Wastewater Treatment Plant Extension Project

Hydraulic Analysis (m^3/yr)

Item	Allocation	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Water Produced				349,000	379,702	413,104	449,446	488,984	532,000	575,778	623,157	674,436	729,935	790,000	790,000	790,000	790,000	790,000	790,000
Industrial Water	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physical Losses (%)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Administrative/Managerial Losses (%)		0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Delivered		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quantity Where Bills are Collected		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Irrigation Water	1.00	0	0	349,000	379,702	413,104	449,446	488,984	532,000	575,778	623,157	674,436	729,935	790,000	790,000	790,000	790,000	790,000	790,000
Physical Losses (%)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physical Losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Administrative/Managerial Losses (%)		0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Administrative/Managerial Losses		0	0	34,900	34,173	33,048	31,461	29,339	26,600	28,789	31,158	33,722	36,497	39,500	39,500	39,500	39,500	39,500	39,500
Quantity Delivered		0	0	349,000	379,702	413,104	449,446	488,984	532,000	575,778	623,157	674,436	729,935	790,000	790,000	790,000	790,000	790,000	790,000
Quantity Where Bills are Collected		0	0	314,100	345,529	380,056	417,984	459,645	505,400	546,989	592,000	640,714	693,438	750,500	750,500	750,500	750,500	750,500	750,500

Financial Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components	84%	2,670,191	1,335,096	1,335,096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foreign Components	16%	506,222	253,111	253,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs		3,176,413	1,588,207	1,588,207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Costs			1,588,207	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413	3,176,413
O & M Costs			0	0	24,000	25,578	27,260	29,053	30,964	33,000	34,631	36,342	38,138	40,022	42,000	42,000	42,000	42,000	42,000	42,000
Total Costs			1,588,207	1,588,207	24,000	25,578	27,260	29,053	30,964	33,000	34,631	36,342	38,138	40,022	42,000	42,000	42,000	42,000	42,000	42,000
Revenues																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial Tariff (JD/m^3)			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Industrial Revenues (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	0	314,100	345,529	380,056	417,984	459,645	505,400	546,989	592,000	640,714	693,438	750,500	750,500	750,500	750,500	750,500	750,500
Irrigation Tariff (JD/m^3)			0.147	0.173	0.205	0.242	0.285	0.336	0.397	0.468	0.468	0.468	0.468	0.468	0.468	0.468	0.468	0.468	0.468	0.468
Irrigation Revenues (JD)			0	0	64,291	83,454	108,316	140,568	182,403	236,661	256,135	277,312	300,834	324,712	351,433	351,433	351,433	351,433	351,433	351,433
Total Revenues (JD)			0	0	64,291	83,454	108,316	140,568	182,403	236,661	256,135	277,312	300,834	324,712	351,433	351,433	351,433	351,433	351,433	351,433
Net Cash Flow (JD)			-1,588,207	-1,588,207	40,291	57,876	81,056	111,515	151,439	203,661	221,505	240,971	261,886	284,690	309,433	309,433	309,433	309,433	309,433	309,433
Discounting (DR=5%)			0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552
Total Qty Whose Bills are Collected (m^3)			0	0	314,100	345,529	380,056	417,984	459,645	505,400	546,989	592,000	640,714	693,438	750,500	750,500	750,500	750,500	750,500	750,500
FIRR	5.3%																			
NPV (JD)	177,944		-1,512,578	-1,440,558	34,805	47,615	63,509	83,214	107,625	137,846	142,784	147,934	153,119	158,526	164,099	156,285	148,842	141,755	135,004	128,576
PV of Total Costs (JD)	3,444,888		1,512,578	1,440,558	20,732	21,043	21,359	21,680	22,005	22,336	22,323	22,311	22,298	22,286	22,273	21,213	20,203	19,241	18,324	17,452
PV of Total Bills Collected Qty (m^3)	8,185,953		0	0	271,331	284,267	297,784	311,908	326,661	342,075	352,594	363,436	374,612	386,132	398,006	379,055	361,005	343,813	327,441	311,848
Unit Water Price (Fils/m^3)	420																			

Economic Analysis (JD at 2001 Prices)

Item	Percent	Amount	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Costs																				
Local Components			1,290,236	1,290,236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foreign Components			253,111	253,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Duty & Taxes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Capital Costs			1,543,347	1,543,347	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Costs			1,543,347	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695	3,086,695
O & M Costs			0	0	24,000	25,578	27,260	29,053	30,964	33,000	34,631	36,342	38,138	40,022	42,000	42,000	42,000	42,000	42,000	42,000
Total Costs			1,543,347	1,543,347	24,000	25,578	27,260	29,053	30,964	33,000	34,631	36,342	38,138	40,022	42,000	42,000	42,000	42,000	42,000	42,000
Benefits																				
Industrial Usage Qty (m^3)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unit Benefits of Industrial Water (JD/m^3)			2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740	2.740
Industrial Benefits (JD)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation Usage Qty (m^3)			0	0	349,000	379,702	413,104	449,446	488,984	532,000	575,778	623,157	674,436	729,935	790,000	790,000	790,000	790,000	790,000	790,000
Unit Benefits of Irrigation Water (JD/m^3)			0.000	0.000	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368	0.368
Irrigation Benefits (JD)			0	0	128,258	139,540	151,816	165,171	179,702	195,510	211,598	229,010	247,855	268,251	290,325	290,325	290,325	290,325	290,325	290,325
Total Benefits (JD)			0	0	128,258	139,540	151,816	165,171	179,702	195,510	211,598	229,010	247,855	268,251	290,325	290,325	290,325	290,325	290,325	290,325
Net Cash Flow (JD)			-1,543,347	-1,543,347	104,258	113,962	124,555	136,118	148,738	162,510	176,968	192,668	209,718	228,229	248,325	248,325	248,325	248,325	248,325	248,325
Discounting (DR=10%)			0.90909	0.82645	0.75131	0.68301	0.62092	0.56447	0.51316	0.46651	0.42410	0.38554	0.35049	0.31863	0.28966	0.26333	0.23939	0.21763	0.19784	0.17986
Total Qty Delivered (m^3)			0	0	349,000	379,702	413,104	449,446	488,984	532,000	575,778	623,157	674,436	729,935	790,000	790,000	790,000	790,000	790,000	790,000
EIRR	4.5%																			
NPV (JD)	-1,271,569		-1,403,043	-1,275,494	78,330	77,838	77,339	76,835	76,326	75,812	75,052	74,282	73,505	72,721	71,931	65,392	59,447	54,043	49,130	44,663
PV of Total Costs (JD)	2,943,222		1,403,043	1,275,494	18,032	17,470	16,927	16,400	15,889	15,395	14,687	14,011	13,367	12,752	12,166	11,060	10,054	9,140	8,309	7,554
PV of Total Qty Delivered (m^3)	4,548,715		0	0	262,209	259,341	256,505	253,700	250,926	248,182	244,186	240,254	236,386	232,580	228,835	208,032	189,128	171,927	156,297	142,088
Unit Water Price (Fils/m^3)	647																			

Calculation of SCF (Standard Conversion Factor)

(Unit: Million JD)

Year	Imports	Exports	Import Duties	SCF
1999	3,589.8	2,416.5	274.0	0.9564
1998	3,608.7	5,215.7	288.2	0.9684
1997	3,676.7	5,232.8	240.0	0.9738
1996	3,839.9	2,597.2	219.3	0.9671
4 Year Average				0.9664

Source: Statistical Yearbook of Jordan 1996 to 1999

SCF=(M+X)/((M+Tm)+(X-Tx+SB))

where M: Imports (CIF Prices), X: Exports (FOB Prices), Tm: Import Duties, Tx: Export Taxes, SB: Export Subsidies

Farm Budget of Major Crops Grown in Jordan

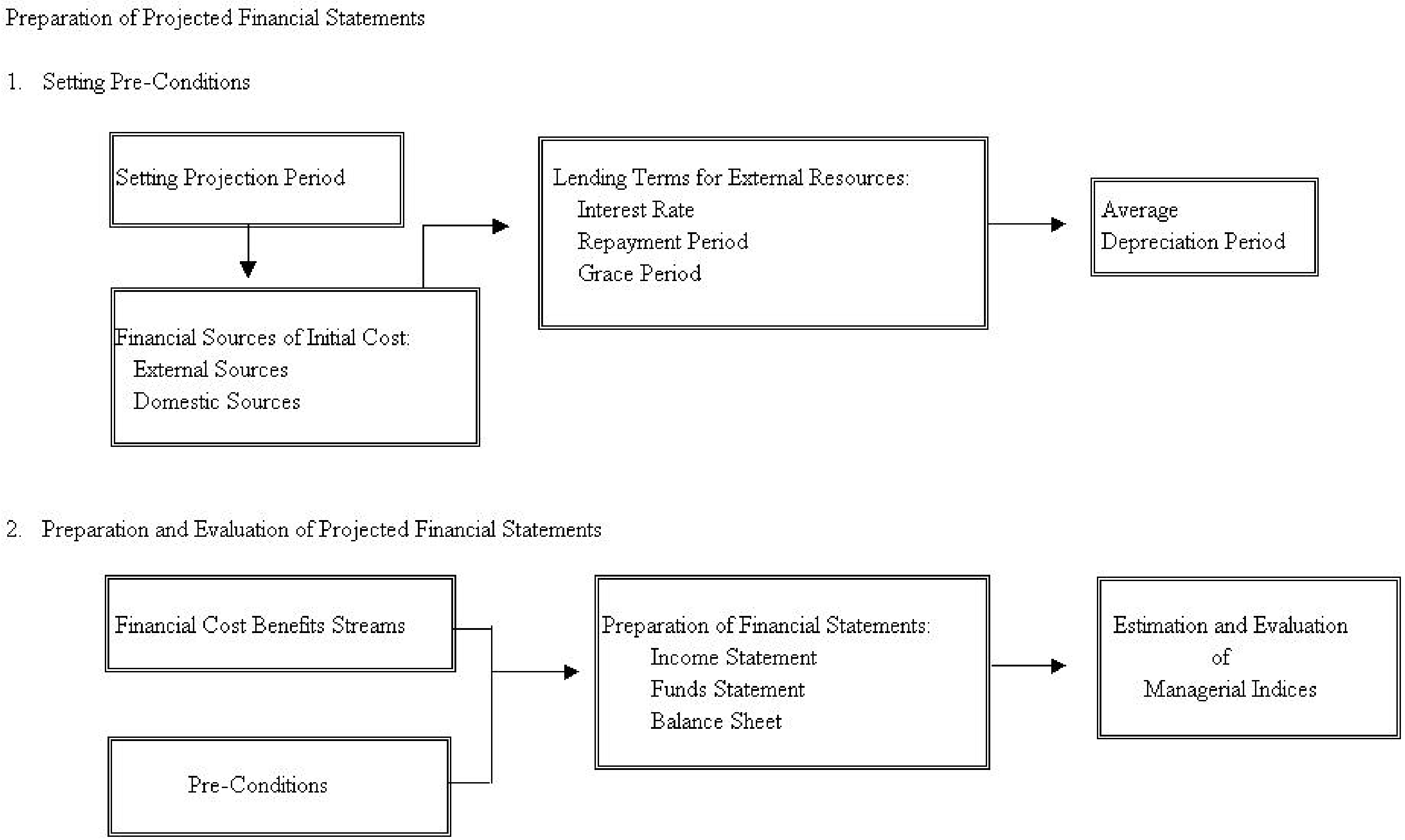
(Unit: JD/dunum)

Crop	Variable Cost														Ave. Yields (tons/dunum)	Selling Price (JD/ton)	Total Value	Gross Margin
	Plowing	Seeds & Seedlings	Organic Fertilizers	Chemical Fertilizers	Mulch	Pesticides	Water	Labor	Strings	Fuels	Transportation	Interest	Others	Total				
Tomato	5	24	18	15	20	10	8	20	0	2	2	2	3	129	4.5	90	405	276
Egg Plant	5	20	15	14	20	12	8	15	0	2	2	3	2	118	3.5	110	385	267
Squash	5	8	15	13	15	14	5	12	0	2	2	2	2	95	2.5	140	350	255
Bean	5	7	15	10	18	12	6	12	0	2	2	2	2	93	1.5	210	315	222
Cucumber	5	9	15	16	15	15	7	10	0	2	2	2	2	100	2	185	370	270
Potato	9	150	15	15	17	15	8	12	0	2	2	2	2	249	2	280	560	311
Cabbage	5	25	15	10	15	10	7	10	0	2	2	2	2	105	3.5	70	245	140
Cauliflower	5	25	15	10	15	10	6	10	0	2	2	2	2	104	3.5	85	297.5	193.5
Malok	4	15	0	8	0	5	4	8	1	2	2	2	2	53	2	90	180	127
Sweet Pepper	5	22	15	12	15	10	7	12	0	2	2	2	2	106	2	200	400	294
Hot Pepper	5	22	15	12	15	10	7	12	0	2	2	2	2	106	2	195	390	284
Broad Bean	5	5	10	5	13	6	4	8	0	2	2	2	2	64	0.75	300	225	161
Green Onion	6	20	15	13	0	8	5	12	1	2	2	2	2	88	2	145	290	202
Dry Onion	6	20	15	15	0	10	7	17	1	2	2	2	2	99	2	160	320	221
Garlic	6	22	15	13	0	8	5	13	1	2	2	2	2	91	0.95	285	270.75	179.75
Carrot	5	5	15	10	0	7	6	10	1	2	2	2	2	67	2	125	250	183
Lettuce	5	10	15	12	0	7	6	12	1	2	2	2	2	76	1.5	150	225	149
Yellow Melon	5	8	15	10	12	8	6	10	0	2	2	2	2	82	1.5	180	270	188
Water Melon	5	10	20	15	12	10	8	12	0	2	2	2	2	100	2	185	370	270
Pea	3	3	3	3	8	3	4	5	0	1	1	1	1	36	0.3	500	150	114
Cow Pea	3	4	4	4	8	3	4	6	0	1	1	1	1	40	0.45	350	157.5	117.5
Okra	3	3	4	4	8	3	4	6	1	1	1	1	1	40	0.35	400	140	100
Beat	4	4	8	7	0	6	8	9	1	1	1	1	1	51	2	100	200	149
Parseley	3	2	4	4	0	3	4	6	1	1	1	1	1	31	0.7	190	133	102
Radish	3	2	4	4	0	3	4	6	1	1	1	1	1	31	1.5	100	150	119
Spinach	3	2	4	4	0	3	4	6	1	1	1	1	1	31	1.4	100	140	109
Cucumber (Long)	4	3	5	5	8	3	4	6	0	1	1	1	1	42	0.6	250	150	108
Wheat	4	3	0	0	0	0	5	3	0	1	1	1	1	19	0.35	200	70	51
Barley	4	2.5	0	0	0	0	4	3	0	1	1	1	1	17.5	0.3	180	54	36.5
Maize	4	4	0	3	10	0	5	6	0	1	1	1	1	36	2	120	240	204
Other Cereals	4	5	0	5	10	4	6	7	0	1	1	1	1	45	1.5	150	225	180
Citrus	15	0	25	15	0	14	15	10	0	4	4	7	3	112	2.2	200	440	328
Banana	15	0	30	20	0	12	20	13	1	5	5	7	4	132	1.75	450	787.5	655.5
Olive	6	0	6	4	0	4	5	7	0	2	2	4	3	43	4	50	200	157
Grape	10	0	15	10	0	8	6	8	0	4	4	6	4	75	1.75	250	437.5	362.5
Date Palm	15	0	15	10	0	5	5	9	0	3	4	4	5	75	0.78	300	234	159
Guava	10	0	15	5	0	6	8	8	0	3	4	4	4	67	1.35	200	270	203
Other Trees	10	0	20	10	0	7	6	9	0	3	5	6	5	81	1.5	200	300	219
Total/Average	224	464.5	435	345	254	274	241	360	12	74	78	85	79	77	1.7	197	279	202

Source: MWI

ANNEX to 1.13.3

Financial Statements



Methodology for Preparation of Financial Statements for Wastewater Reuse/Treatment Projects

ANNEX to 1.15

Impacts of Wastewater Reuse on the Social and Natural Environment

Annex to 1.15 "Impacts of Wastewater Reuse on the Social and Natural Environment"

Contents

1. Objectives and Methodologies of EIA

1.1 Objectives

As part of the Study on Water Resources Management in the Hashemite Kingdom of Jordan, being implemented by Japan International Cooperation Agency (JICA), five Wastewater Treatment Plants (WWTPs) in the kingdom have been selected with respect to the possible reuse of their treated effluent for irrigation. These WWTPs are Ma'an, Abu-Nuseir, Fuhis, Tafila, and Wadi Essir. A local consultant was contracted to carry out this Environmental Impact Assessment (EIA) at pre-feasibility level for each of the five schemes.

The EIA investigated the existing social and natural environments at each scheme and assessed the impact of the scheme at each site. This EIA included collection of the existing data; water quality sampling of the surface water, groundwater, and wastewater effluents; social study including interviews, focus groups, and quantitative assessment; site investigations for natural and social environment; data analysis of the collected and acquired information.

The objectives of this EIA study are:

- To understand the present condition of the environment in each of the project areas
- To identify the particular activities of the projects which may induce significant impact on the social and natural environment
- To predict the environmental impacts and evaluate their magnitudes
- To propose environmental management countermeasures in order to control and mitigate the adverse effects and impacts induced by the project activities.

1.2 Guidelines

For the environmental impact assessment (EIA), the JICA Guideline of Environmental Consideration (JICA, 1992) was followed. In this guideline, the EIA is considered to be a comprehensive study of the environmental impacts regarding some selected environmental elements on which certain impacts are anticipatable from the projects. Table 1.2-1 is the checklist for the EIA based on the guideline.

As a result of the preliminary screening of the environmental elements which might be under the impacts of the project (Interim Report of JICA Study Team, 2001.1), it was decided that the EIA should mainly stress the following parameters:

(1) Natural environment and environmental hazards regarding water quality, soil quality, groundwater, flora and fauna, landscape, noise, vibration and offensive odor;

(2) Social environment regarding the attitudes or willingness of farmers toward wastewater reuse, benefits and disadvantages of wastewater reuse upon farming activities, and other related social issues.

The terms of reference (TOR) were formulated by the Study Team as the baseline of the EIA study (Progress Report (2) of JICA Study Team, 2001. 5).

Table 1.2-1 Checklist of Environmental Elements

(1) Social Environment	(2) Natural Environment	(3) Environmental Hazards
Resettlement	Topography & Geography	Air Pollution
Economic Activity	Soil Erosion	Water Pollution
Traffic & public Facilities	Groundwater	Soil Pollution
Community Separation	Lake & Rivers	Noise & Vibration
Archaeological & Cultural Properties	Coastal Area	Ground Subsidence
Water Right / Right of Common	Flora & Fauna	Offensive Odor
Public Health & Sanitation	Meteorology	
Solid Wastes	Landscape	
Risk of Disaster		

Source: JICA Guideline for Environmental Consideration (1992)

1.3 Methodologies

(1) Social Environment Survey and Assessment

The main objective of the social survey is to assess the socio-economic conditions of the farmers in each study area and their attitude and willingness to use the treated wastewater as a source to irrigate their plants, and to investigate the attitude of the residents toward wastewater reuse as consumers of irrigated products or possible users of treated wastewater. In addition the social survey aims at investigating the land use conditions in the vicinity of the WWTP in each area.

Two target groups were identified within the study areas - the farmers and non-agricultural residents. The area covered by the survey is confined to a circle of 2-3 km in radius in the vicinity of the WWTP depending on the agricultural and residential land use of each area. The survey was carried out through the use of a questionnaire, interviews and discussions with focus groups. Site investigation, data collection and analysis of the collected information were also carried out.

The social questionnaire was designed for the farmers of each study area. The questionnaire elicited information concerning the farm and the farmer, water supply and quality for irrigation, and farmers' expenses. In addition to this farmers were asked about the awareness of water supply problems in each study area and the kingdom, the cropping patterns and irrigation practices and profitability. A significant part of the questionnaire was allocated for the issue of the farmers' willingness to use and to pay for the treated wastewater.

The survey was carried out given the conditions on the ground and the accessibility to the residents and farmers. The investigation team investigated the issue and decided to collect as much as possible of questionnaires and to carry out focus group meetings with the people in the areas.

Interviews, gatherings and meetings were conducted at each site with concerned agencies, governmental institutions and agricultural and non-agricultural residents in the areas to make general evaluation of the their attitude toward wastewater reuse, the cropping patterns they recommend to irrigate and the willingness of consumers towards this new water resource. As an introduction to the discussions the interviewing team

provided general information about wastewater applications and legislation both in Jordan and other countries.

Site reconnaissance and existing data collection were carried out for land ownership and land use conditions in the vicinity of the WWTPs. Local institutions and societies provided lists of land ownership of each site, and inventory of ownerships was collected through the interviews with farmers and residents of the areas. The investigation team collected geographic information of maps and recent aerial photos before investigating the land conditions of the study areas. Digital photos were taken during the site reconnaissance.

Obstacles and drawbacks concerning the social survey are taken into consideration in the analysis of acquired information. The following are the main obstacles/drawbacks faced on the ground:

- Inaccuracy of answers obtained, especially those related to irrigation quantities and expenses, economic status and profitability of the farmers
- The actual numbers of farmers found in the vicinities of the WWTPs were less than anticipated. Numbers were insufficient to run a quantitative analysis as anticipated in the original plan.
- Difficulty to find some farmers because in many cases they are not fulltime workers in their farms.

The information and impressions regarding the social environment were reflected in the social environment sections of each area. The analysis focused on:

- Description of the area, the farms and farmers
- Water Supply for irrigation
- Cropping Patterns
- Irrigation Techniques and Practices
- Irrigation Expenses and Profitability
- Social Attitudes to Wastewater Reuse

(2) Natural Environment Survey and Assessment

Ecological Assessment Methodology

A baseline ecological evaluation was conducted for the five wastewater treatment plants and their surroundings. Data concerning the floral and faunal ecosystems of each area were collected by two methods:

- Fieldwork at each location, during which data was collected by direct observation, interviews with local people and workers in the area.
- A review of the existing literature on each area, including the documentation and updating of the current status of species and habitats.

Existing ecological data was critically reviewed and updated or validated, as appropriate, following the fieldwork. Additional data relevant to the significant issues were collected from recently published documents and reports.

The criteria used with relation to species and habitat status were defined in accordance to national and international criteria, in particular the International Union for Conservation of Nature Red Lists of Species and Bird Life International Important Areas criteria, and the Jordan Biodiversity Country Study and Jordan Environmental Strategy.

The study area for each location is defined as follows:

- The Ma'an study area included the plant and its ponds, irrigated farms at the output of the plant and the main wadis surrounding the plant.
- The Abu-Nuseir study area included the plant and its ponds, the adjacent hillsides and wadi, the irrigation area and wadis adjacent to the treatment plants.
- The Fuhis study area included the treatment plant and hillsides adjacent to the plants, the main two wadis flowing west and east side of the treatment plant, the anticipated irrigation areas, the area downstream of the two wadis (NAMES) and the Wadi Shuaib area.
- The Tafila study area included the Tafila farms, the treatment plant, Wadi Tafila, and the areas upstream and downstream of where the treated effluent is discharged.
- The Wadi Essir study area included the Wadi Eseir itself wadi with its permanent water flow, the Iraq Al Amir area and adjacent wadi, the treatment plant, the main wadi flowing from the treatment plant towards the Jordan Valley opposite of Adassiya on the main Naur Ghor Highway.

Water Quality Sampling and Analysis

Table 1.3-1 shows the water sampling for each site.

Analysis on the required water quality parameters was carried out by the Department of Geology at the University of Jordan in accordance with internationally accepted practice and guidelines. Table 1.3-2 presents the analytical method used for the main parameters.

Table 1.3-1 Summary of Water Sampling

Scheme	Effluent	Surface Water		Groundwater	
		Location	Date	Location	Date
Ma'an	WWTP 17/04/01	No surface water flows	17/04/01	Abu Danish Well Ahmad Radiya Well Shamiya Spring	17/04/01 17/04/01 17/04/01
Abu Nuseir	WWTP 11/04/01 WWTP 25/04/01	In Wadi 2 km Downstream of WWTP	11/04/01 25/04/01	Abu Nuseir Spring Um El Uruq	11/04/01 25/04/01 11/04/01 25/04/01
Fuhis	WWTP 09/04/01 WWTP 26/04/01	Wadi Mahis Downstream of confluence between Wadi Mahis and WWTP	09/04/01 26/04/01 09/04/01 26/04/01	Marmala Spring	09/04/01 26/04/01
Tafila	WWTP 17/04/01	Wadi Tafila	17/04/01	Shalha Spring	17/04/01
Wadi Essir	WWTP 09/04/01 WWTP 26/04/01	Wadi Essir upstream of WWTP Wadi Essir dnstream of WWTP	09/04/01 26/04/01 09/04/01 26/04/01	Safra Spring	09/04/01 26/04/01

Table 1.3-2 Water Quality - Analytical Methods

Parameter	Analytical Method
Temperature	Field thermometer of 0.1 ^{o}C accuracy
pH	Field pH – meter WTW - instrument
Electrical conductivity (EC at 25°C)	Field EC – meter
Calcium (Ca)	Titration with 0.02 N Na – EDTA salt (Titriplex III) using murexide indicator
Calcium & Magnesium (Ca + Mg)	Titration with 0.02 N Na_2 – EDTA salt (TitriplexIII) using crichorome black T indicator
Chloride (Cl)	Titration with 0.02 $AgNO_3$ using diphonyl carbazone indicator
Bicarbonate (HCO_3)	Titration with 0.02 H_2SO_4 and bromocrysol indicator
Carbonate (CO_3)	Titration by using 0.02 H_2SO_4 and phenonoaphthalic indicator
Nitrate (NO_3)	Spectrophotometer, wavelength 206 nm
Orthophosphate (PO_4)	Spectrophotometer, wavelength 700nm
Sulphate (SO_4)	Spectrophotometer, wavelength 492nm
Sodium, potassium, Lithium (Na, K, Li)	Flame photometer
Fluoride, Iodide & Bromide (F, I, Br)	Ion selective electrodes using microprocessor, orion model 901
Trace elements (Cu, Sn, pb, Fe, Mn, Cd, Ni, Sr)	Atomic Absorption
Chemical Oxygen Demand	Titration by using potassium dichromat
Total Organic Carbon	Titration by using 0.02 KM O4

Groundwater and Soils Investigation

The investigation of the surface water, groundwater and soils was carried out by conducting visits to each site, sampling and analysis of water quality parameters as detailed above, and conducting a literature search into the particular environment of each area.

In order to investigate historical and special aspects of groundwater flow and quality, water quality information on the springs and wells in each area was obtained from the Water Authority of Jordan. However, this was of limited use for the present study because:

- The spring or well sites lay too far away from the treatment works or the proposed reuse site to be of relevance.
- The analyzed parameters are restricted to normal chemical analysis, where as the study requires a larger variety of parameters.

2. Present Environmental Settings

2.1 Description of WWTPs and Effluents

Table 2.1-1 summarizes the general condition of the WWTPs at Ma'an, Abu-Nuseir, Fuhis, Tafila and Wadi Essir. The 5 WWTPs are using different biological processes for wastewater treatment. The effluent from each WWTP is discharged to wadis except for small scale reuse in the vicinity of the WWTP for irrigation of crops, olive and fruit trees. All these WWTPs are equipped with chlorination facilities for final disinfection of the treated effluent, but only that at Fuhis WWTP is currently operational.

Table 2.1-2 shows the analysis results of the effluent quality from each WWTP with comparison with the standard values as specified in the Jordanian Standard for Treated Domestic Wastewater (JS 893). For Ma'an and Tafila, one sample was collected in April, 2001 and for Abu-Nuseir, Fuhis and Wadi Essir, two samples were collected in the same month but different date. In this case, the values shown in Table 2.1-2 are average of the two samples. From this table, it is understand that the quality of the effluent from most of the WWTPs is acceptable for irrigation of fruit trees, fodder crops and even vegetables. The effluent from the Fuhis WWTP has the best quality regarding COD, BOD, nitrate and ammonia nitrogen, and above all, the zero value of fecal coliform as a result of chlorination at end of the treatment train. However, the quality of the effluent from the Ma'an WWTP shows unfavorable values regarding COD, BOD, nutrient substances (ammonia and phosphate) and fecal coliform. The poor effluent quality is thought to be resulted from the poor operational condition of the WWTP. The anaerobic ponds at Ma'an WWTP were only cleaned once in 1996, and need to be rehabilitated again. Only from the appearance of the water color in the ponds, it can be judged that the effective volume is no longer enough for performing good biological treatment. Existing data of effluent quality analysis in 2000 show about the same condition but with much higher fecal coliform count than our measurement.

Table 2.1-1 General Condition of the 5 WWTPs

WWTP	Ma'an	Abu-Nuseir	Fuhis	Tafila	Wadi Essir
Treatment Method	Stabilization Pond System: 2 anaerobic ponds, 3 facultative ponds, 1 maturation pond	Activated sludge process: screens, aerated grit chambers, primary settling tanks, rotating biological cylinders (not in opration), activated sludge tanks, secondary settling tanks	Activated sludge process: screens, grit chambers, activated sludge tanks (extended aeration), secondary settling tanks, with maturation ponds for additional treatment	Biological filtration process: screens, Imhoff tanks, trickling filters, secondary settling	Stabilization pond system: screens, anaerobic ponds, aerated ponds (by jetting using submersible pumps), maturation ponds
Sludge Disposal	Not available	Digested, thickened and tanked to the As Samra WWTP, sometimes via Ain Ghazal pre-treatment plant; mechanical sludge dewatering system available but not in operation currently	Thickened and dried on site in summer but trucked to the As Samra WWTP via Ain Ghazal pre-treatment plant in winter	Drying beds provided and the dried sludge is transported by trucks to the solid waste dumping ground of Jorf Al Darawesh	Not available
Installed Capacity	1,600 m^3/d at present and 5,100 m^3/d in 2020	4,000 m^3/d at present and no plan of extension by 2020	2,400 m^3/d at present and no plan of extension by 2020	1,600 m^3/d at present and 3,500 m^3/d by 2020	Installed capacity 4,000 m^3/d but currently operating at less than 1/4
Effluent Discharge	To Wadi Al Hamam, a seasonal wadi	To Wadi Bereen which flows into the Wadi Zarqa	To Deir Al-Sabeel Wadi which flows into Wadi Shua'ab	To Wadi Al Ghweir which flows into the Jordan Rift Valley	To Wadi Essir and finally into the Kafrein Reservoir
Present Effluent Reuse	About 500 m^3/d used in summer and 200 m^3/d in winter for irrigation of 5 ha farming land within the WWTP and 7 ha outside the WWTP; farmers paying 2 fils/m^3 for the effluent reuse.	Only small scale use of effluent for irrigation in the vicinity of the WWTP	Effluent unofficially taken from the wadi by farmers for irrigation of trees	Currently used to irrigate about 1.5 ha of land inside the treatment plant	Almost no application

Table 2.1-2 Analysis Results of Effluent Quality

Parameter	Analysis Value					Jordanian Standard (JS 893)		
	Ma'an	Abu Nuseir	Fuhis	Tafila	Wadi Essir	Vegetables	Fruit Trees, Rorestation, Crops & Grains	Fodder
EC S/cm	2050	1661.5	1669	1680	1788.5	-	-	-
TDS mg/L	883	908	939.5	1092	1001.5	2000	2000	2000
Temp.	18.8	20	20.25	19.8	24.75	-	-	-
pH	8.25	6.85	7.345	7.86	8.83	6 - 9	6 - 9	6 - 9
Ca mg/L	117.6	77.3	59.3	78.4	78.2	400	400	400
Mg mg/L	47.04	55.92	43.2	58.8	34.92	60	60	60
Na mg/L	224.02	151.685	215.74	109.94	234.6	230	230	230
K mg/L	51.2	41	28.8	61.2	45.6	-	-	-
Cl mg/L	204.4	236.6	320.25	153.3	212.975	350	350	350
SO_4 mg/L	168	133.2	117.744	108.96	114.72	1000	1000	1000
HCO_3 mg/L	620	428.11	302.622	527.62	542.5	520	520	520
NO_3 mg/L	3.4	18.145	12.5	6.5	8.9	-	-	-
PO_4 mg/L	28	36.045	30.98	43	11.55	-	-	-
NH_4 mg/L	122	21.53	5.77	61	33.15	-	-	-
COD mg/L	440	117.5	57.25	151.06	223	500	500	700
BOD_5 mg/L	210	47	28.25	75	95	150	150	250
CN mg/L	nn	nn	nn	nn	nn	0.1	0.1	0.1
Br mg/L	0.36	0.178	0.33	0.38	0.875	-	-	-
F mg/L	0.43	0.345	0.525	0.55	0.62	1.0	1.0	1.0
Fe mg/L	0.08	0.044	0.1415	0.065	0.074	5.0	5.0	1.0
Mn mg/L	0.021	0.042	0.0435	0.023	0.0425	0.2	0.2	0.2
Zn mg/L	0.23	0.34	0.865	0.18	0.49	2.0	2.0	2.0
Sr mg/L	0.21	0.28	0.375	0.25	0.525	-	-	-
B mg/L	0.44	0.12	0.225	0.38	0.58	1.0	1.0	3.0
Hg mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001
Ni mg/L	<0.002	0.003	0.01	<0.002	0.01	0.2	0.2	0.2
Cr mg/L	0.02	0.032	0.025	0.02	0.0555	0.1	0.1	0.1
Se mg/L	0.003	0.01	0.02	0.005	0.015	0.02	0.02	0.02
Pb mg/L	0.003	0.012	0.017	<0.001	0.023	0.5	0.5	0.5
As mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0.1	0.1	0.1
Nematodes	no	no	Dead larvae	no	no	<1	-	<1
Total Fecal MPN /100mL	5228	261	0	1272	775	1000	-	-
SAR	4.9	2.3	3.8	2.3	5.6	9	9	9
SS	225	32	23	35	200	200	250	-

2.2 The Social Environment

(1) Ma'an WWTP Area

Despite the fact that the WWTP is located in an arid environment, some private agricultural activities are going on in its vicinity area. Due to the low rainfall in the area, the agricultural lands need irrigation in all seasons. The sole source of fresh water is the shallow wells, but during the last five years the yields from the wells decreased by 60% or more.

Most of the farmers are cultivating their lands in the south and east of the WWTP especially around the wadi where the effluent is discharged. They are self-financed farmers with land side ranging between 5 –15 ha. Among them two farms have signed contracts to receive treated effluent from the WWTP at a nominal fee about 0.002 JD/m^3. The others convey and pump the treated effluent from the wadi without contracts.

Olive, fruit and forest trees and fodder crops (such as alfalfa and barley) are the main irrigated products in this area. Most of the farmers use irrigation networks for the groundwater wells and also the treated effluent. One farmer pumps water from the wadi and then stores it in a reservoir at an elevated location for irrigation. Flood irrigation and drip irrigation are the main methods, and sprinklers are used on a limited scale.

All the farms pay capital expenses for water pumping, storage and irrigation networks, as well as recurring expenses for maintenance, labors etc. The capital expenses for large farms are 8000 – 13000 JD while the recurring expenses are 2000 – 4000 JD annually. For the medium farms the capital and recurring expenses are about 4000 and 500 JD, respectively.

(2) Abu-Nuseir WWTP Area

No major agricultural activities are noticed in the vicinity of the Abu-Nuseir WWTP. There are a few farms at the downstream side, but the landowners do not depend only on agriculture as their main income source. The land owners near the WWTP expect their lands to be transformed to residential or urban uses in the future.

Al Rafah Society Residential Project has 120 Dunums of lands distributed to more than 25 owners. The project area is about 500 m north of the WWTP near the wadi where the treated effluent is discharged.

Most of the cultivated crops are rain-fed grains. A few farms near the wadi use water from springs or directly from the wadi. Some farms away from the wadi buy freshwater from water tanks for irrigation. During site visits, it was noticed that some livestock forms were using the wadi water for their herds.

Wheat and barley are the main rain-fed crops in this area; olive and fruit trees are the main irrigated pants, while legumes are also planted in limited scale. Most farmers use surface irrigation method. The water consumption is about 10 m^3/dunum for grown trees, and about 25 m^3/dumum for young trees in this area. The WAJ is conducting wastewater reuse experiment on fodder crops using drip irrigation in this area as a pilot

project.

For the farmers using tanker water for farming, they pay about one JD for per cubic meter of freshwater, while the farmers who access to the wadi or spring water pay only for the irrigation capital cost (pipelines and pumps). However, forming in this area is not the main source of income and formers use their land to produce crops and fruits for their own needs. Most of them noted that they do not make any profit from farming.

(3) Fuhis WWTP Area

The agricultural lands are located south and southwest of the WWTP along the wadis. Most of the farms depend on rainfall for crop cultivation and use spring water as supplementary irrigation water source. Some farms located around the wadi where the treated effluent is discharged also pump water for irrigation of olive and forest trees. The farm side can be categorized into three groups: small farm with land area of 4 – 12 dunums; medium farm with land area of 15 – 4 dumums; and a few large-size farms of about 100 dunums.

Olive trees and fruit trees such as citrus, guava, grapes, and figs are cultivated in a large scale in this area. These trees are seldom irrigated except for the very dry season. Some farms also cultivate summer vegetables such as cucumber, eggplants, sweat and chili peppers, and winter vegetables such as cauliflower, but only in small scales. Spring water is the main source for their irrigation. All farmers utilize gravity system for supplementary irrigation, mostly from May to October. Some farmers have storage reservoir for fresh water and sometimes the treated effluent. Drip irrigation is common practice in this area due to its higher efficiency and suitability to the soil condition. Flood irrigation is also practiced for its lower expenses and suitability to small areas.

Based on the interview survey, the small landowners often spend about 450 JD as capital cost and 800 JD as annual recurring cost, and the medium farms' owners pay 2700 JD for capital cost and 2200 JD as recurring cost. As for the large size farms, the capital cost and recurring cost are 6000 JD and 4800 JD, respectively. The profit from agriculture is unclear in this area.

(4) Tafila WWTP Area

The Tafila WWTP is located in an agricultural area and is surrounded by Roman olive trees. The agricultural activity is concentrated at the upstream side of the treatment plant. Spring water is the main source for freshwater irrigation. Only some farms downstream the treatment plant receive treated effluent from the wadi. The farm size in this area range between 5 dunums and 25 dumums, most being inherited land. They don't have permanent laborers working in their farms.

Spring water is abundant in this area. It is said that there had existed 360 springs in the past time but nowadays freshwater is mainly supplied by 3 large springs with good quality water. However, the quantity of spring water has been decreasing and there exists the problem of chronic water shortage for irrigation.

In addition to the olive trees, fruit trees such as grape, fig and apple trees are also cultivated around the treatment plant. Fodder crops are planted but in a small scale. All the farms use gravity systems for irrigation during the dry season but depend on rainfall

in winter time. Surface irrigation is the common practice and the annual water consumption is estimated to be about 20m^3/dunum for olive trees as well as fruit trees. With the simple irrigation method, the farmers pay 500 – 1500 JD of capital cost and 200 – 600 JD of recurring cost annually for irrigation. The profit from agriculture is unclear, but some farmers estimated their annual profit as 1000 – 5000 JD.

(5) Wadi Essir Area

In Wadi Essir area, agricultural lands are located west, east and south of the WWTP. Farm sizes are comparatively small in a range between 10 to 30 dumums. The landowners and their families are working on their farms and temporary labors are only hired in the busy seasons. The farms are mostly rain-fed, with supplementary irrigation using spring water during the summer period. Due to decreasing quantity of water from the available springs, the farmers are facing the problem of water shortage. Currently, they are not using surface water from the wadi where the treated effluent is discharged. High pumping and conveyance costs for water supply from the wadi to the elevated farms is considered to be the main reason, and perception of poor effluent quality may be another reason for this.

Most of the farms are planted with olive trees and fruit trees. The farmers believe that these crops need less water and have good marketing opportunities in this area. A few farms are cultivated with summer vegetables such as chili peppers and eggplants and winter vegetables such as green beans, fava beans, and peas. Spring water is conveyed to the farms by pipes or concrete channels and stored in small reservoirs for irrigation use. Surface irrigation and drip irrigation are utilized for the trees and furrow irrigation is utilized for the vegetables.

The farmers usually share the costs for irrigation. For each individual farmer, the average capital cost and maintenance cost are about 500 JD and 100 JD, respectively. Farmers complained about the low profit from agriculture and showed their willingness to sell their lands. For example, the Al Shahwan farmers said they do not have any profits from farming and the losses over the recent years are in the range of 2000 – 3000 JD.

2.3 The Natural Environment

(1) Ma'an WWTP Area

The Ma'an WWTP lies in the area northwest of Ma'an city. The area is located in the semi arid region and classified as part of the Saharo-Arabian bio-geographic zone. The annual precipitation is less than 100 mm but the evaporation rate is as high as 300 mm/ annum. Geologically, the area is covered by recent alluvial deposits overlying the bituminous marl formation (B3), which is an aquiclude with a very low permeability.

The local soil consists of a mixture of gavels, sands, silt and clay. The soil profiles are underdeveloped with a very thin humus layer. The soil begins at the surface wit ha regolith horizon covering the original bedrock. The amount and type of precipitation in the area does not cause the formation of significant soil profiles. There a few wells and springs in the vicinity of the WWTP. Water quality analysis results of this study (refer to Table 2.4-1) and historic data show a salinity level between 1100 – 2400 μS/cm as EC.

The area is divided into two main ecological zoons: (1) the wadi system orientated east-west and varying in width from several hundred meters to tens of meters; (2) the gravel and chert pebble Hammada with its particular flora and fauna. The old geological formation of Hammada desert and the soil coverage by gravel and chert pebble has created special habitats specific to the area. This type of Hammada is rich with reptilian and insect faunal communities. The flora is not expressed in all times of the year and has a very short flowering and flourishing season, sometimes creating the impression that the area is not rich in biological resources. The run-off wadis are particularly rich with floral communities and habitats. The site is regarded as semi-natural due to the proximity of the Ma'an-Mudawara highway, and the grazing activities practiced by local nomadic Bedouins.

The main flora of the area can be divided into two floral compositions: (1) run-off Hammada vegitation, which is confined to the wadi courses and areas of water accumulation and is the most ecologically important part of the area, and (2) the pebble and gravel Hammada which exists in the site. Of the major reptile species inhabiting the vicinity, the desert monitor, Spiny Tailed-Lizzard are very important and endangered reptiles which can be observed clearly near the road sides. The larger mammals of the area are Red Fox, Serhani Wolf, Striped Hyeana, Caracal, Sand Gazelles which are distributed 20 – 30 km east of the site towards the Saudi Borders.

There are no special protected areas in the vicinity of the project site. The Wadi Abu Rarfa Rangeland Reserve is located 30 km south of the site, close to the highway.

(2) Abu Nuseir WWTP Area

The area downstream of the Abu Nuseir WWTP is rural. Several villages and rural houses have been established on an ad-hoc basis. There is one main wadi that cuts across the area and intersects with other smaller wadis from the west and south of the area. The main wadi, which receives the treated effluent flow, has no permanent base flow and runs from the west to the northeast. This wadi is heavily vegetated by forest trees and eucalyptus.

Geologically, the area is covered by the Upper Cretaceous rocks consisting of

limestones, dolomites, shales and maris. Aquifers and aquicludes alternate in the general vicinity, but in the area around the wadi, the lower part of the Upper Cretaceous rocks underlies the area. The surrounding mountains are covered by the Hummar Formation Aquifer (A4). Springs are found mainly in this aquifer. With gentle slopes, the rede and brown types of Mediterranean soils have developed in this area. The thickness is generally 50 – 80 cm. Thicker soil profiles are found on both sides along the wadi and thin soils along the hills. The soil in this area is very suitable for plantation due to the presence of the humus layer covering almost the entire area.

There are several wells and springs in the vicinity of the WWTP. Water from most of these wells and springs are fresh with low or moderate salinity (EC as 500 – 1600 μS/cm) according the analysis results of this study (refer to Table 2.4-1) and historic data. The salinity of the water in the wadi course is about 1650 μS/cm, partially under the influence of the discharged effluent.

The Abu Nuseir area mainly belongs to the Mediterranean bio-geographic zone. The annual rainfall is about 300 – 350 mm. The area has been heavily subjected to rain-fed orchard farming. Certain floral indicators pinpoint the level of degradation of the natural habitats which have reached this area over the last several hundred years. The ecosystem in this area is an important type of habitat, characterized as a steppe type, and originally covered with oak, pistachio and other Mediterranean forest vegetation. Nowadays the forest has been cleared, and the land is formed and heavily grazed and degraded.

The topography of this area is characterized by high to medium elevation. Such altitudes created specific hillsides and wadis in which vegetation distribution is confined and determined. The area still maintains several natural and semi-natural forests composed of natural mixed oak and pine stands, shrubs and man-made afforested areas of pine and eucalyptus.

No protected areas exist within the vicinity of the Abu Nuseir WWTP.

(3) Fuhis WWTP Area

The area is hilly and has a Mediterranean landscape covered with semi-natural forests and vegetation. Downstream the treatment plant, the area is rural and predominantly agricultural land except for the sand mining site and the solid waste dumpsite near the WWTP. The area has a few wadis that are dry in summer period. Annual rainfall in this area is about 400 mm.

Geologically, the area is covered by Lower Cretaceous sandstones, which form a good aquifer. The direction of water discharge is from the east to the west. The lower sandstone aquifer becomes exposed at the downstream side and groundwater appears as springs there. The soil cover in the area consists of sandy soils developed over steep slopes of fine-grained quarts sandstone (Kurnub). The weathering products of such soil are easily removed by the erosion of the step topography of the area. Hence soils are generally thin with a humus layer of only a few centimeters.

The water discharged from the Kurnub sandstones in this area has generally low salinity ranging from 550 – 700 μS/cm as EC. Water quality analysis of this study shows

similar results (refer to Table 2.4-1). Wadi Mahis shows elevated salinities of more than 800 μS/cm. This is thought to be a result of irrigation return flows and seepages of cesspool contents into the wadi.

The area is situated in a region where the Mediterranean Bio-geographic region intersects with a small element of Irano-Turanian Bio-geographic zone. Mediterranean hillside forests in the area are dominated by natural oak and pistachio trees along with introduced Aleppo pines. Mediterranean zone forest habitats, steppe and hills, are mainly dominated by Mediterranean vegetation. There are seasonal wadi systems in the area. There is a permanent base flow in Wadi Fuhis, which intersects with Wadi Mahis to form a bigger wadi rich with vegetation such as oleander, phragmitys and other wetland types. The Irano-Turanian steppe below the Mediterranean non-forest areas is dominated with astaragalus, artemisia and other typical steppe vegetation. Elements of Afro-subtropical vegetation, such as ziziphus, arabian date palm, procera and other african types are scattered below the Irano-Turanian zone.

No protected areas exist in the vicinity of the WWTP plant although the Mediterranean forests of oak, pistachio and pine are protected by forestry law.

(4) Tafila WWTP Area

Tafila WWTP is located in a hilly area with dense vegetation. This area consists of two zones – the arid Mediterranean zone and the Irano-Turanian zone. The Mediterranean zone is at the upstream of the WWTP and is characterized by having an annual rainfall of 400 – 600 mm, an altitude range of 700-1700 m, a relatively low summer temperature, and the most diverse vegetation in Jordan. This ecozone is well expressed and dominant in the Tafila WWTP area. the Irano-Turanian zone is a less expressed ecozone but nevertheless certain ecological features which indicate its existence in the area of the Tafila WWTP. It surrounds the entire Mediterranean region, and forms a narrow strip in some places which may interrupt the Mediterranean region.

Geologically the area is covered by Upper Cretaceous rocks consisting of marls, shales, limestones and dolomites. The treatment plant was constructed over the upper parts of the Upper Cretaceous rock sequences consisting of shales, marls and partly sandy limestones. The upper layers of the Lower Cretaceous sandstones are unsaturated and hence effluents and other waters may infiltrate into them and discharge with water discharged further downstream along the wadis from the Lower Cretaceous sandstones. The fact that the permeabilities of the lower Upper Cretaceous and Lower Cretaceous are small will allow for a major self-purification mechanism to take place, through the physical destruction of microorganisms and natural oxidation/reduction processes. The area is underlain by the Um Ghudran Formation – an aquifer partly covered by weathering products of the same formation. Towards the west, basalt rocks cover a part of the area. The Um Ghudran formation in the area consists of chalks at the bottom overlain by phosphatic cherts and sandstones, which form the middle part and chalks which form the upper most parts. The rocks are fissured and fragmented possessing relatively high porosities and permeabilities. The thickness of the Um Ghudran here is 85 m. The underlying unit is the Wadi Essir Formation – an aquifer consisting of massive limestones with some chert modules and chert bands with a total thickness of 80m. The Wadi Essir Formation forms a good aquifer from which many springs issue,

both in this area and in other areas in Jordan. The groundwater in the Tafila area is generally of moderate salinity of 500 – 1000 μS/cm as can be seen from the analysis result of this study (refer to Table 2.4-1) and historical data.

Three main habitats are in found in the study area: (1) Mediterranean non-forest habitat - mainly nowadays farmed with orchards and olive trees, heavily grazed and eroded; (2) Irano-Turanian steppe - on hillsides and steep slope adjacent to the Tafila wadi system, rich with ratem, artemisia, astragulus and other such steppe vegetation, and surrounded by a Mediterranean strip; and (3) Wadi and canyon system with permanent water from different springs, rich with wadi vegetation, aquatic wild life such as frogs, dragon flies and crustaceans but no fish. Mediterranean flora are the most dominant flora in the site. This is a non-forest Mediterranean type of landscape due overgrazing and intensive wood cutting over the millennia. This type of vegetation is obvious around the water channel, stone terraces, and sidewalks and in steep areas. It has been heavily degraded due to human agricultural activities and overgrazing. The main features of the Irano-Turanian flora of Tafila are the steppe type of vegetation, which has intruded into the Mediterranean region. The composition of this vegetation varies according to soil and slope. The vegetation in the Tafila area is also affected by tropical conditions of Wadi Araba and the Rift Valley.

In terms of fauna, the site did not appear rich with reptiles, probably due to the intensive human activities. However it was diverse with different reptilian species. The area was also rich in bird species, mainly resident and summer visitors. This is due to the rich natural and man made vegetation located in the site. As mentioned, the site appears to be without any records of higher mammals, these having disappeared from the area a long time ago due to intensive human activities.

In the site there are no protected areas, although the Wadi Dana Wildlife Reserve is situated around 20km to the south. The Tafila wadi system could be defined as a special habitat in that area since it flows all the way into Wadi Araba, which is an important ecosystem in Jordan.

(5) Wadi Essir WWTP Area

The treatment plant lies at the right hand side of Wadi Essir valley downstream of Iraq El Amir historic site at an elevation of about 100m above the wadi bottom. Many years ago, the wadi had continuous base flow throughout the year. However, the development of Wadi Essir Spring, upstream the wadi, for municipal supply has affected its flow to the downstream.

Geologically, the area is covered by the lower parts of the Upper Cretaceous rocks; the Na'ur and Fuhis formations, which consist of marls, shales dolomites and limestones. As a whole the rock sequence is considered as an aquiclude but the limestone and dolomite beds within it form low yield underdeveloped aquifers. In the downstream area of the confluence of the treatment plant effluents, and the Wadi Essir stream, Lower Cretaceous sandstones crop out. They form a good aquifer in this area and elsewhere in Jordan due to their high primary and secondary permeability and porosity. The geological formation from which the soil developed in this area is the Fuhis – Na'ur formation which consists of marls shales and limestones. The slopes along the wadi are steep and do not allow for appreciable soil horizons to develop. In depressions and flat

areas there is a humus layer of a few centimeters thickness covering marly soils. The steep slopes are covered by weathered rocks forming a type of regolith.

Groundwater including springs and wells in this area is moderate in salinity (800 – 1300 μS/cm) as indicted by the results of water quality analysis of this study (refer to Table 2.4-1) and historical data.

This area falls into two distinctive bio-geographic zones – the Mediterranean and Irano-Turanian zones. A small afro-tropical element is also evident in the area but is less expressed. The following habitat types are located in the vicinity of the site: (1) Mediterranean non-forest – hillsides and slopes which are mainly vegetated with scattered oak trees, amygdalus, carub and other Mediterranean shrubs and vegetation; (2) Steppe – vegetated with mixed Irano-Turanian and Mediterranean vegetation such as artemisia , ferula, ratema and others; and (3) Seasonal wadis rich with aquatic and wetland vegetation such as Phragmitys, oleander, arabian date palms, juncus and others.

There are no protected areas in the site or its vicinity.

2.4 Water Quality and Environmental Hazard

(1) Quality of Groundwater and Surface Water at the Project Sites

Water samples were collected from existing wells, springs and wadi flows in the vicinity of each project site. Table 2.4-1 summarizes the analysis results.

Ma'an

Three groudwater samples were collected in the vicinity of the Ma'an WWTP, two from wells and one from a spring. No surface sample was collected because the wadi was dry. The groundwater is slightly brackish for the Abu Darwish well and Shamiya spring with TDS about 1200 mg/L. The comparatively high total fecal coliform count (TFCC) as about 2000 per 100 mL for all these samples indicates pollution of groundwater from human or animal sources. Of the three sampling locations, only the Abu Rakhiya well is downstream the WWTP and about 500 m from the wadi where the effluent is discharged, but this well is not high in salinity or high in nitrate concentration. Therefore, the WWTP may not contribute to the groundwater pollution in this area.

Abu Nuseir

Water samples were collected from 3 locations and repeated twice on different days. The Abu Nuseir spring is about 500 m upstream the WWTP and the Um Le'rouq spring is about 6 km downstream. The third sample was from the Wadi Bereen 2 km downstream the WWTP. The two spring samples are fresh with low salinity, but with high nitrate concentration, especially for the Um Le'rouq spring which shows NO_3 as high as 1.6 meq/L or 99.2 mg/L. The sample collected from the wadi is no doubt the effluent from the WWTP because it shows about the same salinity level, but its NO_3 concentration is only 0.1 meq/L. Therefore, the source of the high NO_3 of the spring water is not the WWTP but other pollution sources.

Fuhis

At Fuhis, samples were collected from two locations along Wadi Mahis, one before the mixing of the wadi flow with the discharged effluent from the WWTP, another after the mixing. The groundwater sample was from Marmala spring on the hill side with elevation higher than the WWTP. All samples were collected twice on different days. Before mixing with the treated effluent, the wadi water is fresh with TDS less than 500 mg/L. However, the NO_3 concentration is about 0.9 meq/L or 56 mg/L. Because TFCC is not found from the wadi water, it is considered that the nitrate source may be from irrigation return flow but not human or animal feces. After mixing, the salinity level is elevated to about 900 mg/L, but NO_3 and TFCC remain the previous values. Good performance of the treatment process in the Fuhis WWTP results in good quality of the discharged effluent. Chlorination as the final stage of the treatment has effectively prevented the water from pollution by fecal coliform. The groundwater from Marmala spring is fresh and free from fecal contamination.

Tafila

Two samples were collected in the vicinity of the Tafila WWTP, one from the wadi where the treated effluent is discharged and another from Shalha spring. Apparently the wadi water quality is under the influence of the treated effluent with higher salinity. The spring water is fresh with low salinity. However, its NO_3 concentration of 0.7 meq/L (42 mg/L) and TFCC of 1050 per 100 mL show the influence from human and animals. The WWTP may have on influence on this spring because it is on the other side of the hill.

Wadi Essir

Totally six samples were collected from three locations in the vicinity of the Wadi Essir WWTP. The Safra spring may not be influenced by the WWTP although it is only at a distance of 500 m. This is because its elevation is higher and the analysis result shows much lower salinity than the wadi water and the treated effluent. The salinity does not change much in Wadi Sir before and after the mixing with the WWTP effluent. The other water quality parameters are within the range for common surface water.

(2) Offensive Odors and Other Salinity Problems

Residents in the vicinity have complained about the offensive odor from most of the WWTPs and the discharged wadis. The problem seems to be the most serious at Ma'an WWTP site. The main reason is that the pond system is not working well and need to be rehabilitated. The survey team has experienced this problem during site visiting and the poor quality of the treated effluent also explains this fact. The source of the offensive odors is H_2S generated from the ponds as at Ma'an WWTP or other treatment facinities, and also from the sludge. No complaints on offensive odors were from the Wadi Essir area. This may be because of the short period of the WWTP's operation from its start a few years ago or the better condition of operation at present.

Related to the WWTPs and the discharge of the treated effluent to the wadis, farmers and residents complained about the problem of mosquitoes which made their life uncomfortable especially in the hot summer season.

Among the five WWTPs, the Tafila WWTP is very closed to the residential area of

Tafila Town. Therefore the above mentioned problems may affect more people than at the other sites.

(3) Vibration and Noise

Operation of the wastewater treatment plants does not generate much vibration or noise, therefore, this problem is not serious at present and no complaints are raised in all the five project sites.

Table 2.4-1 Quality of Groundwater and Surface Water at the Project Sites

(1) Ma'an and Tafila Groundwater and Surface Water Quality

Parameter	Maan 17/4/01			Tafila 17/4/01	
	Abu Darwish well	Ahmad Radiya well	Shamiya spring	Shalha spring	Wadi Tafilah
EC *S*/cm	2340.0	1320.0	2090.0	711.0	1680.0
TDS mg/L	1226.0	816.0	1157.0	396.0	953.0
Temp.	21.4	23.0	20.2	19.3	17.5
pH	7.4	7.5	7.2	7.9	8.2
Ca meq/L	6.8	3.9	6.5	3.9	4.9
Mg meq/L	5.9	7.7	7.9	1.2	1.0
Na meq/L	8.2	3.6	5.6	1.6	8.9
K meq/L	1.0	0.4	0.6	0.5	1.3
Cl meq/L	11.2	5.4	8.8	2.0	4.9
SO_4 meq/L	5.4	4.8	5.4	1.0	3.4
HCO_3 meq/L	4.2	5.0	5.8	3.5	7.7
NO_3 meq/L	0.2	0.2	0.6	0.7	0.3
COD mg/L	160.0	120.0	100.0	60.0	76.0
BOD_5 mg/L	62.0	47.0	45.0	27.0	31.0
Br mg/L	0.1	0.3	0.2	0.2	0.5
Nematodes	no nematodes	no nematodes	no nematodes	no nematodes	no nematodes
Total Fecal /100cc	2110.0	2001.0	1980.0	1050.0	1110.0
SAR	4.3	1.6	2.3	1.0	5.2
Turbidity NTU	6.0	11.0	12.0	11.0	15.0
Color	4.0	8.0	5.0	6.0	8.0

(2) Abu-Nuseir Groundwater and Surface Water Quality

1.7.3.1.1 Pa	Ab Nsr spring		Ab Nsr 2km dnstm of WWTP		Um el Urug	
ra	11/4/01	25/4/01	11/4/01	25/4/01	11/4/01	25/4/01
EC *S*/cm	846.0	865.0	1572.0	1650.0	1161.0	1175.0
TDS mg/L	456.0	467.0	970.0	984.0	602.3	630.0
Temp.	18.6	17.7	18.6	18.3	18.7	18.6
pH	7.6	7.8	7.8	8.1	7.4	7.4
Ca meq/L	3.9	3.6	3.1	2.9	4.0	4.8
Mg meq/L	2.0	1.9	2.1	2.9	3.9	3.1
Na meq/L	2.3	2.4	8.7	10.4	3.9	4.4
K meq/L	0.3	0.1	0.9	0.7	0.3	0.1
Cl meq/L	2.6	2.7	9.1	9.7	4.4	4.4
SO_4 meq/L	0.1	0.1	3.0	3.2	2.4	2.0
HCO_3 meq/L	4.1	4.3	3.9	4.0	4.1	4.2
NO_3 meq/L	0.9	0.7	0.1	0.1	1.6	1.6
COD mg/L	98.0	120.0	100.1	120.0	140.0	170.0
BOD_5 mg/L	45.0	56.0	45.0	62.0	69.0	81.0
Br mg/L	0.1	0.1	0.1	0.1	0.1	0.1
Nematodes	dead nematode larvae	dead nematode larvae	dead nematode larvae	dead nematode larvae	no nematodes	no nematodes
Total Fecal /100cc	200.0	250.0	350.0	300.0	10.0	7.0
SAR	1.3	1.4	5.9	6.1	3.0	2.2
Turbidity NTU	7.5	8.0	10.0	11.0	11.5	12.0
Color	6.3	6.0	3.3	3.9	4.4	5.0

Table 2.4-1 Quality of Groundwater and Surface Water at the Project Sites (cont'd)

(3) Fuhis Groundwater and Surface Water Quality						
Parameter	Wadi Mahis		Marmala spring		W Mhs+WWTP Effluent	
	9/4/01	26/4/01	9/4/01	2001/4/26	2001/4/9	26/4/01
EC *S*/cm	832.0	877.0	592.0	592.0	1454.0	1751.0
TDS mg/L	484.0	488.0	351.0	339.0	868.0	952.0
Temp.	20.4	19.9	20.0	20.9	21.8	19.9
pH	8.3	8.3	7.3	7.3	8.2	8.1
Ca meq/L	3.0	3.7	4.0	3.9	4.9	4.1
Mg meq/L	2.9	2.7	0.9	0.8	1.9	2.7
Na meq/L	2.2	1.9	1.2	1.1	6.5	8.0
K meq/L	0.3	0.3	0.1	0.1	1.0	0.8
Cl meq/L	2.6	2.3	2.2	2.1	5.8	7.7
SO_4 meq/L	1.5	1.7	0.9	1.0	4.4	3.1
HCO_3 meq/L	3.5	3.8	2.4	2.2	4.5	5.0
NO_3 meq/L	0.9	0.8	0.6	0.5	0.1	0.9
COD mg/L	75.0	65.0	100.0	107.2	142.0	153.0
BOD_5 mg/L	42.0	36.0	40.0	44.5	75.0	85.0
Br mg/L	0.7	0.6	0.5	0.5	0.6	0.5
Nematodes	no nematodes	no nematodes	no nematodes	no nematodes	no nematodes	no nematodes
Total Fecal /100cc	0.0	0.0	0.0	0.0	0.0	0.0
SAR	1.3	1.1	0.8	0.7	3.5	4.3
Turbidity NTU	12.4	11.6	15.0	12.0	13.9	15.0
Color	6.1	4.9	8.0	5.0	5.7	7.4
(4) Wadi Essir Groundwater and Surface Water Quality						
Parameter	Safra spring		Wadi Sir befor mixing		W Sir+WWTP Effluent	
	9/4/01	26/4/01	9/4/01	26/4/01	9/4/01	26/4/01
EC *S*/cm	961.0	964.0	1292.0	1290.0	1408.0	1350.0
TDS mg/L	535.0	554.0	839.8	838.5	915.2	877.5
Temp.	25.6	25.2	21.7	22.5	21.1	21.1
pH	7.5	7.6	8.2	8.2	8.1	8.2
Ca meq/L	4.2	4.4	3.9	3.9	3.9	3.8
Mg meq/L	2.7	2.9	3.8	3.9	3.8	3.3
Na meq/L	2.2	2.1	5.6	5.7	6.0	5.9
K meq/L	0.3	0.2	0.3	0.3	0.4	0.4
Cl meq/L	2.2	2.4	5.8	5.8	5.8	5.8
SO_4 meq/L	2.1	2.2	3.9	3.6	3.0	3.3
HCO_3 meq/L	4.4	4.5	4.3	4.4	5.0	4.7
NO_3 meq/L	0.6	0.5	0.2	0.3	0.3	0.3
COD mg/L	13.0	12.5	16.6	16.2	16.0	16.0
BOD_5 mg/L	160.0	152.0	126.0	135.0	142.0	170.0
Br mg/L	51.4	50.3	45.0	45.2	49.2	55.0
Nematodes	0.3	0.2	0.1	0.2	0.2	0.2
Total Fecal /100cc	no nematodes	no nematodes	no nematodes	no nematodes	no nematodes	no nematodes
SAR	294.0	289.0	320.0	309.0	570.0	564.0
Turbidity NTU	1.2	1.1	4.7	5.1	4.9	4.8
Color	18.0	15.0	12.0	14.1	14.0	16.2
EC *S*/cm	16.0	12.0	4.9	7.0	6.2	6.8