Economic Rate of Return for the Potential Investment by the Millennium Challenge Corporation
In the Wastewater Collection and Transmission System in Zarqa Governorate, Jordan
Option 4a
Controls for Use By Project Evaluator

Analysis by MWH
Patrick Ray and Keith Burwell
July 22, 2010

ERR = 8.1%
NPV = 13.0 MJD

CONTROLS RELATED TO POPULATION PROJECTIONS AND CESSPITS

	Zarqa	Amman	
number of wastewater subscribers per connection	3.0	3.0	

default value = 3, range = 1-5, example: A single-family home has 1 sewer subscriber and 1 sewer connection; however, while each household within an 8-unit apartment building is an independent water/wastewater service subscriber, all 8 share a single conneciton to the sewer.

	Zarqa	Amman	
Cost to build a cesspit, JD	1,400	1,400	

defalut value = 1400 JD, range = 1000-3500 JD, example: 4 concrete walls, no bottom slab = approx. 1,400 JD

	Zarqa	Amman	
Cost to connect to the sewer network, JD	1,200	1,200	

defalut value = 1200 JD, range = 500 JD to 1500 JD

	Zarqa	Amman	
Benefit attributable to MCC of new sewer to communities outside the MCC network	60%	60%	

defalut value = 60%, range, example: 60% of the costs are for pumping stations and trunk sewers

	Zarqa	Amman	
saturation density before WAJ will extend network to new community	40%	40%	

defalut value = 40%, range, example: a small community grows from a single homestead to a density 40% before WAJ offers network

	Zarqa	Amman	
portion of growth within the MCC network area	25%	0%	

defalut value = 25%, range = 20%-30%

	Zarqa	Amman	
average annual cost of cesspit maintenance (saved when cesspits taken offline), JD	60	60	

defalut value = 60 JD, range = 20-150 JD, example: empty twice per year at 30 JD per empty

	Zarqa	Amman	
average annual wastewater tariff, JD	14	14	

defalut value = 14 JD, range = 10-50 JD, example: see sewer charge sheet

	Zarqa	Amman	
scenario for growth in wastewater connections in absence of MCC funds	0	0	

*two scenarios: scenario **0** , current year 2007 **ratio** perpetuates - WAJ makes new connections, maintaining ratio of ww connections to water connections at 72%; scenario **1** , current year 2007 **connections** perpetuate - WAJ makes no new ww connections, causing ratio of ww connections to water connections to fall from current 72%*

	Zarqa	Amman	
unit value of land in area with no current sewer service, JD/m^2	35	50	

CONTROLS RELATED TO PUBLIC HEALTH AND LABOR BENEFITS

portion of population affected by a waterborne disease each year	15%	

defalut value = 10%, range 10%-15%

portion of cases of waterborne disease attributable to inadequate sanitation network (& entirely fixable)	50%	

defalut value = 50%, range 25%-75%

average duration of waterborne illness	2	days

defalut value = 2, range 1-10, example: some waterborne illnesses may last a week, while others last only one day

value of a lost day of work/school for calculation of public health benefit	29	JD

defalut value = 29, range 20-50, example: we choose the average of the value of a day of skilled and unskilled labor

value of a day of unskilled labor	18	JD

defalut value = 18, range 10-20

value of a day of skilled labor	40	JD

defalut value = 40, range 30-50

shadow price - skilled labor	90%	

defalut value = 90%

shadow price - unskilled labor	50%	

defalut value = 50%

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ERR = 8.1%
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CONTROLS RELATED TO WASTEWATER FLOWS AND WATER/WASTEWATER EXCHANGE

efficiency of transformation of raw ww to treated ww	87%	
default value = 87%, this is the portion influent to the WWTP leaving as effluent, after losses in sludge removal and other treatment processes		
portion of wwtp effluent taken by upstream farmers	20%	
default value = 20%, this is the portion of effluent from the WWTP taken by non-JVA farmers in Zarqa before it enters the King Talal Reservoir		
portion of wwtp effluent lost to seepage and evaporation	20%	
default value = 20%, this is the portion of effluent from the WWTP lost as it flows in the Zarqa River and into the King Talal Reservoir		
cost to extract fresh water and pump it to Amman	0.6	JD/m^3
default value = 0.6		
value of water to agricultural sector	0.25	JD/m^3
default value = 0.25		
value of water to municipal sector	2.35	JD/m^3
default value = 2.35, this value from Haddadin (2006) "Water Resources in Jordan"		
exchange ratio - amount of freshwater released per unit treated wastewater provided	50%	
defalut value = 50%, this is the amount of fresh water available for exchange from the Yarmouk River through the King Abdulla Canal		
unit tariff charged in the As-Samra BOT contract for treatment of wastewater (understood to include capital & O&M)	0.16	JD/m^3
defalut value = 0.16		
portion of costs of wastewater treatment assigned to this wastewater collection project (the rest assigned to the wastewater	100%	
defalut value 0%, range 0-100%, example: this being the network collection portion of the analysis, we acknowledge the cost of additional wastewater treatment resulting from the expansion of the network, but assign those costs to the analysis of the expansion of As-Samra		

CONTROLS RELATED TO LAND ACQUISITION

value of land acquisition, litigation, and other expenses involved in the establishment of a new down-gradient wwtp	0	JD
defalut value in Option 1 = 5,000,000; in Option 2-4 = 0, example: only that in addition to what was normal for establishment of the As-Samra WWTP, and also what will be incurred constructing pumping stations in the same region.		
value of land acquired relative to the cost paid to acquire it	50%	
defalut value = 50%, range 25%-400%, example: the Utility may pay far more for land than its actual economic value, after litigation and other difficulties. Alternatively, the land may be worth much more than the Utility pays for it. We assume the Utility pays twice the value.		

CONTROLS ON COST MULTIPLIERS

capital cost multiplier for sensitivity analysis on capital cost estimation	1.0
defalut value = 1.0, range 0.5-3, example: the project evaluator may apply a quick multiplier to capital costs in order to explore the effect of a lower or higher estimate on the ERR	
Inflation rate of energy prices relative to all others	0.0%
default value = 0%, range -3 to 3%, example: value of 3 a relative inflation rate to energy prices of 3%; value used for projection of pumping cost in engineering analysis = approximately 2%	
discount rate for preliminary calculation of Net Present Value (NPV)	7.0%
defalut value = 7%	

Economic Rate of Return

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
COSTS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Land Acquisition Costs	2,500,000	2,500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2,500,000
Capital Costs	0	20,461,455	40,922,910	40,922,910	0	0	0	0	0	0	0	0	0	803,908	0	0	0	0	6,431,267	-96,765,666
Engineering Costs	3,055,375	1,425,841	2,851,683	2,851,683	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingencies	5,115,364	5,115,364	5,115,364	5,115,364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M Costs	0	0	238,279	476,558	953,116	1,057,297	1,136,215	1,215,134	1,294,052	1,372,971	1,452,611	1,532,250	1,611,890	1,691,530	1,771,170	1,853,099	1,935,028	2,016,958	2,098,887	2,180,817
Connection Costs	0	0	10,473,445	10,473,445	370,580	370,580	370,580	370,580	370,580	366,266	366,266	366,266	366,266	366,266	385,922	385,922	385,922	385,922	385,922	362,782
Land for constructiion of new down-gradient wwtp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional WW Treatment Costs	0	0	546,250	1,092,501	2,185,002	2,367,862	2,550,723	2,733,584	2,916,444	3,099,305	3,279,507	3,459,710	3,639,912	3,820,114	4,000,316	4,188,431	4,376,545	4,564,660	4,752,774	4,940,889
Additional WW Tariffs	0	0	366,571	733,141	751,442	769,743	788,043	806,344	824,645	842,478	860,312	878,146	895,980	913,813	932,561	951,308	970,056	988,803	1,007,551	1,025,288
TOTAL COSTS	10,670,738	29,502,660	60,514,501	61,665,601	4,260,139	4,565,482	4,845,562	5,125,642	5,405,722	5,681,021	5,958,697	6,236,372	6,514,048	7,595,632	7,089,968	7,378,760	7,667,551	7,956,343	14,676,401	-90,755,891
BENEFITS																				
Savings on cesspits not constructed	0	0	0	0	308,953	308,953	308,953	308,953	308,953	309,151	309,151	309,151	309,151	309,151	326,386	326,386	326,386	326,386	326,386	305,116
Savings on cesspits no longer requiring maintenance	0	0	523,672	1,047,344	1,073,488	1,099,632	1,125,776	1,151,920	1,178,064	1,203,541	1,229,017	1,254,494	1,279,971	1,305,447	1,332,230	1,359,012	1,385,794	1,412,576	1,439,359	1,464,698
Value of Reclaimed Land (Land Value)	0	0	0	0	15,558,689	399,570	399,570	399,570	399,570	399,570	425,524	425,524	425,524	425,524	425,524	453,557	453,557	453,557	453,557	453,557
Improved Health of Zarqa Residents	0	0	0	0	4,382,392	4,489,357	4,596,322	4,703,288	4,810,253	4,917,218	5,036,398	5,155,579	5,274,759	5,393,939	5,513,120	5,640,151	5,767,183	5,894,215	6,021,247	6,148,278
Employment Opportunities	0	0	472,144	472,144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Improved Health of Zarqa River	0	0	0	8,202,167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Value of water/wastewater exchange	0	0	0	0	7,722,616	8,368,914	9,015,212	9,661,510	10,307,808	10,954,106	11,591,009	12,227,911	12,864,813	13,501,715	14,138,618	14,803,485	15,468,352	16,133,219	16,798,086	17,462,953
Additional WW Tariffs	0	0	366,571	733,141	751,442	769,743	788,043	806,344	824,645	842,478	860,312	878,146	895,980	913,813	932,561	951,308	970,056	988,803	1,007,551	1,025,288
Reduction in ww system emergency response	0	0	0	0	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	800,000	600,000	400,000	200,000	0	0	0	0	0	0	0
TOTAL BENEFITS	0	0	1,362,387	10,454,797	30,797,579	16,436,168	17,233,876	18,031,584	18,829,292	19,426,065	20,051,412	20,650,805	21,250,198	21,849,590	22,668,438	23,533,899	24,371,328	25,208,757	26,046,186	26,859,891
TOTAL NET ECONOMIC BENEFIT	-10,670,738	-29,502,660	-59,152,115	-51,210,805	26,537,440	11,870,686	12,388,314	12,905,942	13,423,570	13,745,044	14,092,715	14,414,432	14,736,150	14,253,959	15,578,469	16,155,140	16,703,777	17,252,414	11,369,785	117,615,782

NPV at economic discount rate	**13,037,581**
EIRR	**8.14%**

COSTS TO MCC (capital replacement costs to Utility)

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

		Year																		
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Costs																					
Collection Networks	*53,691,908*		10,738,382	21,476,763	21,476,763																-53,691,908
Force Main	*26,505,442*		5,301,088	10,602,177	10,602,177																-26,505,442
Transmission and Trunk Sewers	*6,031,758*		1,206,352	2,412,703	2,412,703																-6,031,758
Pumping Stations	*16,078,167*		3,215,633	6,431,267	6,431,267										803,908					6,431,267	-10,536,559
TOTAL	***102,307,275***		***20,461,455***	***40,922,910***	***40,922,910***										***803,908***					***6,431,267***	***-96,765,666***
Engineering and others	*10,184,582*	3,055,375	1,425,841	2,851,683	2,851,683																
Contingencies	*20,461,455*	5,115,364	5,115,364	5,115,364	5,115,364																
Land Acquisition	*5,000,000*	2,500,000	2,500,000																		-2,500,000
TOTAL	***137,953,312***	***10,670,738***	***29,502,660***	***48,889,957***	***48,889,957***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***803,908***	***0***	***0***	***0***	***0***	***6,431,267***	***-99,265,666***

design life		
civil works	50	years
mechanical	15	years
electrical	25	years
instrumentation	10	years
civil works - pipelines	*maintained in perpetuity*	

pumping stations	
20%	civil
40%	mechanical
35%	electrical
5%	instrument
*conservative, as could be 25%, 40%, 35%	

COSTS TO ZARQA UTILITY *(passed on in part to households through tariffs)*

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Connection Cost			10,473,445	10,473,445	370,580	370,580	370,580	370,580	370,580	366,266	366,266	366,266	366,266	366,266	385,922	385,922	385,922	385,922	385,922	362,782
Increased Tariff (paid by hh's, credited to Utility)			366,571	733,141	751,442	769,743	788,043	806,344	824,645	842,478	860,312	878,146	895,980	913,813	932,561	951,308	970,056	988,803	1,007,551	1,025,288
Collection System O&M Costs																				
Collection Networks			8,389	16,779	33,557	81,796	114,305	146,814	179,323	211,831	244,340	276,849	309,358	341,866	374,375	406,884	439,393	471,902	504,410	536,919
Force Main			4,141	8,283	16,566	40,379	56,428	72,476	88,524	104,572	120,620	136,669	152,717	168,765	184,813	200,862	216,910	232,958	249,006	265,054
Transmission and Trunk Sewers			942	1,885	3,770	9,189	12,841	16,493	20,145	23,797	27,449	31,101	34,753	38,405	42,057	45,709	49,361	53,013	56,666	60,318
Pumping Stations			224,806	449,611	899,222	925,932	952,642	979,351	1,006,061	1,032,770	1,060,201	1,087,632	1,115,062	1,142,493	1,169,924	1,199,644	1,229,364	1,259,085	1,288,805	1,318,525
Net O&M Cost of Decentralized WWTPs			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL			***238,279***	***476,558***	***953,116***	***1,057,297***	***1,136,215***	***1,215,134***	***1,294,052***	***1,372,971***	***1,452,611***	***1,532,250***	***1,611,890***	***1,691,530***	***1,771,170***	***1,853,099***	***1,935,028***	***2,016,958***	***2,098,887***	***2,180,817***
Cost of Land Acquistion for New WWTP in Valley	0	0																		
Additional WW Treatment O&M Costs																				
additional ww flow to wwtp, MCM/yr			3.41	10.24	13.66	14.80	15.94	17.08	18.23	19.37	20.50	21.62	22.75	23.88	25.00	26.18	27.35	28.53	29.70	30.88
cost of additional treatment (JD/yr)			546,250	1,092,501	2,185,002	2,367,862	2,550,723	2,733,584	2,916,444	3,099,305	3,279,507	3,459,710	3,639,912	3,820,114	4,000,316	4,188,431	4,376,545	4,564,660	4,752,774	4,940,889
portion of this cost attributed to network project			546,250	1,092,501	2,185,002	2,367,862	2,550,723	2,733,584	2,916,444	3,099,305	3,279,507	3,459,710	3,639,912	3,820,114	4,000,316	4,188,431	4,376,545	4,564,660	4,752,774	4,940,889

baseline O&M for pump stations - labor, mostly	20,000	JD/yr
capital depreciation per additoinal unit ww treated:	0.16	JD/m^3
portion of costs of ww treatment attributed to ww collection project	100%	

BENEFITS TO ZARQA UTILITY *(passed on to households through reduction of tariffs)*

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reduction in ww system emergency response					1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	800,000	600,000	400,000	200,000	0	0	0	0	0	0	0
Increased Tariff (paid by hh's, credited to Utility)			366,571	733,141	751,442	769,743	788,043	806,344	824,645	842,478	860,312	878,146	895,980	913,813	932,561	951,308	970,056	988,803	1,007,551	1,025,288

**reduced o&m requirements because pipes have been rehabbed*

BENEFITS TO ZARQA HOUSEHOLDS

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Improved Health of Zarqa Residents	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
value of days of work/school saved					4,382,392	4,489,357	4,596,322	4,703,288	4,810,253	4,917,218	5,036,398	5,155,579	5,274,759	5,393,939	5,513,120	5,640,151	5,767,183	5,894,215	6,021,247	6,148,278

Additional Employment	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
skilled labor			328,652	328,652																
unskilled labor			143,492	143,492																
total			472,144	472,144																

Savings on Not-Constructed Cesspits	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			0	0	267,712	267,712	267,712	267,712	267,712	285,101	285,101	285,101	285,101	285,101	303,883	303,883	303,883	303,883	303,883	276,478

Savings on Existing Cesspits No Longer Requiring Maintenance	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			444,534	889,068	910,302	931,536	952,771	974,005	995,239	1,017,853	1,040,466	1,063,080	1,085,693	1,108,307	1,132,410	1,156,513	1,180,617	1,204,720	1,228,823	1,250,753

Value of Reclaimed Land	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Value of increase in usable land where cesspits taken out of service	0	0	0	0	15,558,689	399,570	399,570	399,570	399,570	399,570	425,524	425,524	425,524	425,524	425,524	453,557	453,557	453,557	453,557	453,557

BENEFITS TO AMMAN HOUSEHOLDS

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Savings on Not-Constructed Cesspits	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			0	0	41,241	41,241	41,241	41,241	41,241	24,051	24,051	24,051	24,051	24,051	22,503	22,503	22,503	22,503	22,503	28,638

Savings on Existing Cesspits No Longer Requiring Maintenance	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			79,138	158,277	163,186	168,096	173,005	177,915	182,825	185,688	188,551	191,414	194,277	197,141	199,820	202,499	205,178	207,857	210,535	213,945

Value of Reclaimed Land	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Value of increase in usable land where cesspits taken out of service	0	0	0	0	3,956,913	122,741	122,741	122,741	122,741	122,741	71,579	71,579	71,579	71,579	71,579	66,974	66,974	66,974	66,974	66,974

Improved Quality of Zarqa River

Option 4a

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Pumping stations fixed and operating properly																				
capital costs of pumping stations				8,202,167																
O&M costs of pumping stations																				
TOTAL		***0***	***0***	***8,202,167***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

Option 4a
Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Water/Wastewater Exchange	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
incremental ww collected and treated (MCM/yr)	0	0	0	0	13.7	14.8	15.9	17.1	18.2	19.4	20.5	21.6	22.7	23.9	25.0	26.2	27.4	28.5	29.7	30.9
incremental treated wwtp effuent (MCM/yr)	0	0	0	0	11.9	12.9	13.9	14.9	15.9	16.9	17.8	18.8	19.8	20.8	21.8	22.8	23.8	24.8	25.8	26.9
incremental irrigation water taken by upstream farmers (MC	0	0	0	0	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4
incremental irrigation water available to King Talal Res. (MC	0	0	0	0	7.1	7.7	8.3	8.9	9.5	10.1	10.7	11.3	11.9	12.5	13.1	13.7	14.3	14.9	15.5	16.1
value of incremental irrigation water to farmers (MJD/yr)	0	0	0	0	1.5	1.6	1.7	1.9	2.0	2.1	2.2	2.4	2.5	2.6	2.7	2.8	3.0	3.1	3.2	3.4
amount of fresh water transferred to the city	0	0	0	0	3.6	3.9	4.2	4.5	4.8	5.1	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.8	8.1
value of incremental municipal water (MJD/yr)	0	0	0	0	6.2	6.8	7.3	7.8	8.3	8.8	9.4	9.9	10.4	10.9	11.4	12.0	12.5	13.0	13.6	14.1
total incremental value water/wastewater exchange (MJD/y	0	0	0	0	7.7	8.4	9.0	9.7	10.3	11.0	11.6	12.2	12.9	13.5	14.1	14.8	15.5	16.1	16.8	17.5

efficiency of transformation of raw ww to treated ww	87%	
portion taken by upstream farmers	20%	
portion of wwtp effluent lost to seepage and evaporation	20%	
portion of collected ww available for irrigation	0.70	
cost to extract fresh and pump it to Amman	0.6	JD/m^3
value of water to agricultural sector	0.25	JD/m^3
value of water to municipal sector	2.35	JD/m^3
exchange ratio - amount of fresh water per unit treated ww	50%	

ERR 8.14%

Economic Rate of Return for the Potential Investment by the Millennium Challenge Corporation
In the Wastewater Collection and Transmission System in Zarqa Governorate, Jordan
Option 4a Phase I
Controls for Use By Project Evaluator

Analysis by MWH
Patrick Ray and Keith Burwell
July 22, 2010

ERR = 14.2%
NPV = 47.8 MJD

CONTROLS RELATED TO POPULATION PROJECTIONS AND CESSPITS

	Zarqa	Amman	
number of wastewater subscribers per connection	3.0	3.0	

default value = 3, range = 1-5, example: A single-family home has 1 sewer subscriber and 1 sewer connection; however, while each household within an 8-unit apartment building is an independent water/wastewater service subscriber, all 8 share a single conneciton to the sewer.

	Zarqa	Amman	
Cost to build a cesspit, JD	1,400	1,400	

defalut value = 1400 JD, range = 1000-3500 JD, example: 4 concrete walls, no bottom slab = approx. 1,400 JD

	Zarqa	Amman	
Cost to connect to the sewer network, JD	1,200	1,200	

defalut value = 1200 JD, range = 500 JD to 1500 JD

	Zarqa	Amman	
Benefit attributable to MCC of new sewer to communities outside the MCC network	60%	60%	

defalut value = 60%, range, example: 60% of the costs are for pumping stations and trunk sewers

	Zarqa	Amman	
saturation density before WAJ will extend network to new community	40%	40%	

defalut value = 40%, range, example: a small community grows from a single homestead to a density 40% before WAJ offers network

	Zarqa	Amman	
portion of growth within the MCC network area	25%	0%	

defalut value = 25%, range = 20%-30%

	Zarqa	Amman	
average annual cost of cesspit maintenance (saved when cesspits taken offline), JD	60	60	

defalut value = 60 JD, range = 20-150 JD, example: empty twice per year at 30 JD per empty

	Zarqa	Amman	
average annual wastewater tariff, JD	14	14	

defalut value = 14 JD, range = 10-50 JD, example: see sewer charge sheet

	Zarqa	Amman	
scenario for growth in wastewater connections in absence of MCC funds	0	0	

*two scenarios: scenario **0**, current year 2007 **ratio** perpetuates - WAJ makes new connections, maintaining ratio of ww connections to water connections at 72%; scenario **1**, current year 2007 **connections** perpetuate - WAJ makes no new ww connections, causing ratio of ww connections to water connections to fall from current 72%*

	Zarqa	Amman	
unit value of land in area with no current sewer service, JD/m2	35	50	

CONTROLS RELATED TO PUBLIC HEALTH AND LABOR BENEFITS

portion of population affected by a waterborne disease each year	15%	

defalut value = 10%, range 10%-15%

portion of cases of waterborne disease attributable to inadequate sanitation network (& entirely fixable)	50%	

defalut value = 50%, range 25%-75%

average duration of waterborne illness	2	days

defalut value = 2, range 1-10, example: some waterborne illnesses may last a week, while others last only one day

value of a lost day of work/school for calculation of public health benefit	29	JD

defalut value = 29, range 20-50, example: we choose the average of the value of a day of skilled and unskilled labor

value of a day of unskilled labor	18	JD

defalut value = 18, range 10-20

value of a day of skilled labor	40	JD

defalut value = 40, range 30-50

shadow price - skilled labor	90%	

defalut value = 90%

shadow price - unskilled labor	50%	

defalut value = 50%

Economic Rate of Return for the Potential Investment by the Millennium Challenge Corporation
In the Wastewater Collection and Transmission System in Zarqa Governorate, Jordan
Option 4a Phase I
Controls for Use By Project Evaluator

Analysis by MWH
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July 22, 2010

ERR = 14.2%
NPV = 47.8 MJD

CONTROLS RELATED TO WASTEWATER FLOWS AND WATER/WASTEWATER EXCHANGE

efficiency of transformation of raw ww to treated ww	87%	
default value = 87%, this is the portion influent to the WWTP leaving as effluent, after losses in sludge removal and other treatment processes		
portion of wwtp effluent taken by upstream farmers	20%	
default value = 20%, this is the portion of effluent from the WWTP taken by non-JVA farmers in Zarqa before it enters the King Talal Reservoir		
portion of wwtp effluent lost to seepage and evaporation	20%	
default value = 33%, this is the portion of effluent from the WWTP lost as it flows in the Zarqa River and into the King Talal Reservoir		
cost to extract fresh and pump it to Amman	0.6	JD/m^3
default value = 0.6		
value of water to agricultural sector	0.25	JD/m^3
default value = 0.25		
value of water to municipal sector	2.35	JD/m^3
default value = 2.35, this value from Haddadin (2006) "Water Resources in Jordan"		
exchange ratio - amount of freshwater released per unit treated wastewater provided	50%	
defalut value = 50%, this is the amount of fresh water available for exchange from the Yarmouk River through the King Abdulla Canal		
unit tariff charged in the As-Samra BOT contract for treatment of wastewater (understood to include capital & O&M)	0.16	JD/m^3
defalut value = 0.16		
portion of costs of wastewater treatment assigned to this wastewater collection project (the rest assigned to the wastewater	100%	
defalut value 0%, range 0-100%, example: this being the network collection portion of the analysis, we acknowledge the cost of additional wastewater		

CONTROLS RELATED TO LAND ACQUISITION

value of land acquisition, litigation, and other expenses involved in the establishment of a new down-gradient wwtp	0	JD
defalut value in Option 1 = 5,000,000; in Option 2-4 = 0, example: only that in addition to what was normal for establishment of the As-Samra WWTP, and also what will be incurred constructing pumping stations in the same region.		
value of land acquired relative to the cost paid to acquire it	50%	
defalut value = 50%, range 25%-400%, example: the Utility may pay far more for land than its actual economic value, after litigation and other difficulties.		

CONTROLS ON COST MULTIPLIERS

capital cost multiplier for sensitivity analysis on capital cost estimation	1.0	
defalut value = 1.0, range 0.5-3, example: the project evaluator may apply a quick multiplier to capital costs in order to explore the effect of a lower or higher estimate on the ERR		
Inflation rate of energy prices relative to all others	0.0%	
default value = 0%, range -3 to 3%, example: value of 3 a relative inflation rate to energy prices of 3%; value used for projection of pumping cost in engineering analysis = approximately 2%		
discount rate for preliminary calculation of Net Present Value (NPV)	7.0%	
defalut value = 7%		

Economic Rate of Return

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTF
some flows from small communities treated locally by two packaged decentralized wastewater treatment plant

	Year																			
COSTS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Land Acquisition Costs	1,000,000	1,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,000,000
Capital Costs	0	10,622,211	21,244,421	21,244,421	0	0	0	0	0	0	0	0	0	513,120	0	0	0	0	4,104,962	-49,573,945
Engineering Costs	1,521,625	710,092	1,420,184	1,420,184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingencies	2,732,553	2,732,553	2,732,553	2,732,553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M Costs	0	0	225,138	450,276	900,553	965,225	1,017,344	1,069,463	1,121,582	1,173,701	1,226,540	1,279,379	1,332,218	1,385,057	1,437,896	1,463,839	1,489,783	1,515,726	1,541,670	1,567,613
Connection Costs	0	0	10,022,152	10,022,152	592,634	592,634	592,634	592,634	592,634	386,387	386,387	386,387	386,387	386,387	0	0	0	0	0	0
Land for constructiion of new down-gradient wwtp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Additional WW Treatment Costs	0	0	480,930	961,860	1,923,720	2,101,526	2,279,332	2,457,138	2,634,943	2,812,749	2,987,985	3,163,221	3,338,457	3,513,693	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929
Additional WW Tariffs	0	0	350,775	701,551	731,548	761,546	791,543	821,541	851,538	871,217	890,896	910,575	930,253	949,932	949,932	949,932	949,932	949,932	949,932	949,932
TOTAL COSTS	5,254,178	15,064,855	36,476,153	37,532,997	4,148,455	4,420,931	4,680,853	4,940,775	5,200,698	5,244,054	5,491,808	5,739,561	5,987,315	6,748,189	6,076,756	6,102,700	6,128,643	6,154,587	10,285,492	-44,367,470
BENEFITS																				
Savings on cesspits not constructed	0	0	0	0	506,299	506,299	506,299	506,299	506,299	327,680	327,680	327,680	327,680	327,680	0	0	0	0	0	0
Savings on cesspits no longer requiring maintenance	0	0	501,108	1,002,215	1,045,069	1,087,922	1,130,776	1,173,630	1,216,483	1,244,596	1,272,708	1,300,821	1,328,933	1,357,046	1,357,046	1,357,046	1,357,046	1,357,046	1,357,046	1,357,046
Value of Reclaimed Land (Land Value)	0	0	0	0	14,229,556	685,917	685,917	685,917	685,917	685,917	429,069	429,069	429,069	429,069	429,069	0	0	0	0	0
Improved Health of Zarqa Residents	0	0	0	0	4,309,701	4,430,715	4,551,729	4,672,743	4,793,757	4,914,771	5,034,187	5,153,602	5,273,018	5,392,434	5,511,849	5,511,849	5,511,849	5,511,849	5,511,849	5,511,849
Employment Opportunities	0	0	245,105	245,105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Improved Health of Zarqa River	0	0	0	6,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Value of water/wastewater exchange	0	0	0	0	6,799,149	7,427,581	8,056,013	8,684,446	9,312,878	9,941,310	10,560,660	11,180,009	11,799,358	12,418,708	13,038,057	13,038,057	13,038,057	13,038,057	13,038,057	13,038,057
Additional WW Tariffs	0	0	350,775	701,551	731,548	761,546	791,543	821,541	851,538	871,217	890,896	910,575	930,253	949,932	949,932	949,932	949,932	949,932	949,932	949,932
Reduction in ww system emergency response	0	0	0	0	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	800,000	600,000	400,000	200,000	0	0	0	0	0	0	0
TOTAL BENEFITS	0	0	1,096,988	7,948,871	28,621,322	15,899,980	16,722,278	17,544,575	18,366,873	18,785,491	19,115,200	19,701,756	20,288,313	20,874,869	21,285,954	20,856,885	20,856,885	20,856,885	20,856,885	20,856,885
TOTAL NET ECONOMIC BENEFIT	-5,254,178	-15,064,855	-35,379,165	-29,584,126	24,472,867	11,479,050	12,041,425	12,603,800	13,166,175	13,541,437	13,623,392	13,962,195	14,300,998	14,126,680	15,209,198	14,754,185	14,728,241	14,702,298	10,571,392	65,224,355

NPV at economic discount rate	**47,844,972**
EIRR	**14.22%**

COSTS TO MCC (capital replacement costs to Utility)

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

		Year																		
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Costs																					
Collection Networks	*36,358,810*		7,271,762	14,543,524	14,543,524																-36,358,810
Force Main	*4,012,800*		802,560	1,605,120	1,605,120																-4,012,800
Transmission and Trunk Sewers	*2,477,038*		495,408	990,815	990,815																-2,477,038
Pumping Stations	*10,262,405*		2,052,481	4,104,962	4,104,962										513,120					4,104,962	-6,725,296
TOTAL	***53,111,053***		***10,622,211***	***21,244,421***	***21,244,421***										***513,120***					***4,104,962***	***-49,573,945***
Engineering and others	*5,072,084*	1,521,625	710,092	1,420,184	1,420,184																
Contingencies	*10,930,211*	2,732,553	2,732,553	2,732,553	2,732,553																
Land Acquisition	*2,000,000*	1,000,000	1,000,000																		-1,000,000
TOTAL	***71,113,348***	***5,254,178***	***15,064,855***	***25,397,158***	***25,397,158***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***513,120***	***0***		***0***	***0***	***4,104,962***	***-50,573,945***

design life		
civil works	50	years
mechanical	15	years
electrical	25	years
instrumentation	10	years
civil works - pipelines	*maintained in perpetuity*	

pumping stations	
20%	civil
40%	mechanical
35%	electrical
5%	instrument
*conservative, as could be 25%, 40%, 35%	

COSTS TO ZARQA UTILITY *(passed on in part to households through tariffs)*

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Connection Cost			10,022,152	10,022,152	592,634	592,634	592,634	592,634	592,634	386,387	386,387	386,387	386,387	386,387	0	0	0	0	0	0
Increased Tariff (paid by hh's, credited to Utility)			350,775	701,551	731,548	761,546	791,543	821,541	851,538	871,217	890,896	910,575	930,253	949,932	949,932	949,932	949,932	949,932	949,932	949,932
Collection System O&M Costs																				
Collection Networks			5,681	11,362	22,724	55,390	77,404	99,419	121,433	143,447	165,461	187,475	209,489	231,503	253,517	275,532	297,546	319,560	341,574	363,588
Force Main			627	1,254	2,508	6,113	8,543	10,973	13,402	15,832	18,261	20,691	23,121	25,550	27,980	30,410	32,839	35,269	37,698	40,128
Transmission and Trunk Sewers			387	774	1,548	3,774	5,273	6,773	8,273	9,773	11,272	12,772	14,272	15,772	17,272	18,771	20,271	21,771	23,271	24,770
Pumping Stations			218,443	436,886	873,772	899,948	926,123	952,299	978,474	1,004,650	1,031,545	1,058,441	1,085,336	1,112,231	1,139,127	1,139,127	1,139,127	1,139,127	1,139,127	1,139,127
Net O&M Cost of Decentralized WWTPs			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL			***225,138***	***450,276***	***900,553***	***965,225***	***1,017,344***	***1,069,463***	***1,121,582***	***1,173,701***	***1,226,540***	***1,279,379***	***1,332,218***	***1,385,057***	***1,437,896***	***1,463,839***	***1,489,783***	***1,515,726***	***1,541,670***	***1,567,613***
Cost of Land Acquistion for New WWTP in Valley	0	0																		
Additional WW Treatment O&M Costs																				
additional ww flow to wwtp, MCM/yr			3.01	9.02	12.02	13.13	14.25	15.36	16.47	17.58	18.67	19.77	20.87	21.96	23.06	23.06	23.06	23.06	23.06	23.06
cost of additional treatment (JD/yr)			480,930	961,860	1,923,720	2,101,526	2,279,332	2,457,138	2,634,943	2,812,749	2,987,985	3,163,221	3,338,457	3,513,693	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929
portion of this cost attributed to network project			480,930	961,860	1,923,720	2,101,526	2,279,332	2,457,138	2,634,943	2,812,749	2,987,985	3,163,221	3,338,457	3,513,693	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929	3,688,929

baseline O&M for pump stations - labor, mostly	20,000	JD/yr
capital depreciation per additoinal unit ww treated:	0.16	JD/m^3
portion of costs of ww treatment attributed to ww collection project	100%	

BENEFITS TO ZARQA UTILITY *(passed on to households through reduction of tariffs)*

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reduction in ww system emergency response					1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	800,000	600,000	400,000	200,000	0	0	0	0	0	0	0
Increased Tariff (paid by hh's, credited to Utility)			350,775	701,551	731,548	761,546	791,543	821,541	851,538	871,217	890,896	910,575	930,253	949,932	949,932	949,932	949,932	949,932	949,932	949,932

**reduced o&m requirements because pipes have been rehabbed*

BENEFITS TO ZARQA HOUSEHOLDS

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Improved Health of Zarqa Residents	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
value of days of work/school saved					4,309,701	4,430,715	4,551,729	4,672,743	4,793,757	4,914,771	5,034,187	5,153,602	5,273,018	5,392,434	5,511,849	5,511,849	5,511,849	5,511,849	5,511,849	5,511,849

Additional Employment	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
skilled labor			170,614	170,614																
unskilled labor			74,491	74,491																
total			245,105	245,105																

Savings on Not-Constructed Cesspits	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			0	0	475,569	475,569	475,569	475,569	475,569	297,488	297,488	297,488	297,488	297,488	0	0	0	0	0	0

Savings on Existing Cesspits No Longer Requiring Maintenance	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			406,559	813,117	852,313	891,508	930,703	969,898	1,009,094	1,033,612	1,058,130	1,082,649	1,107,167	1,131,685	1,131,685	1,131,685	1,131,685	1,131,685	1,131,685	1,131,685

Value of Reclaimed Land	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Value of increase in usable land where cesspits taken out of service	0	0	0	0	14,229,556	685,917	685,917	685,917	685,917	685,917	429,069	429,069	429,069	429,069	429,069	0	0	0	0	0

BENEFITS TO AMMAN HOUSEHOLDS

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Savings on Not-Constructed Cesspits	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			0	0	30,730	30,730	30,730	30,730	30,730	30,192	30,192	30,192	30,192	30,192	0	0	0	0	0	0

Savings on Existing Cesspits No Longer Requiring Maintenance	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			94,549	189,098	192,756	196,414	200,073	203,731	207,390	210,984	214,578	218,172	221,767	225,361	225,361	225,361	225,361	225,361	225,361	225,361

Value of Reclaimed Land	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Value of increase in usable land where cesspits taken out of service	0	0	0	0	4,727,444	91,459	91,459	91,459	91,459	91,459	89,857	89,857	89,857	89,857	89,857	0	0	0	0	0

Improved Quality of Zarqa River

Option 4a Phase I

Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Pumping stations fixed and operating properly																				
capital costs of pumping stations				6,000,000																
O&M costs of pumping stations																				
TOTAL		***0***	***0***	***6,000,000***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

Option 4a Phase I
Conveyance of all flows generated in the study area to As Samra WWTP
some flows from small communities treated locally by two packaged decentralized wastewater treatment plants

Water/Wastewater Exchange	Year																			
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
incremental ww collected and treated (MCM/yr)	0	0	0	0	12.0	13.1	14.2	15.4	16.5	17.6	18.7	19.8	20.9	22.0	23.1	23.1	23.1	23.1	23.1	23.1
incremental treated wwtp effuent (MCM/yr)	0	0	0	0	10.5	11.4	12.4	13.4	14.3	15.3	16.2	17.2	18.2	19.1	20.1	20.1	20.1	20.1	20.1	20.1
incremental irrigation water taken by upstream farmers (MC	0	0	0	0	2.1	2.3	2.5	2.7	2.9	3.1	3.2	3.4	3.6	3.8	4.0	4.0	4.0	4.0	4.0	4.0
incremental irrigation water available to King Talal Res. (MC	0	0	0	0	6.3	6.9	7.4	8.0	8.6	9.2	9.7	10.3	10.9	11.5	12.0	12.0	12.0	12.0	12.0	12.0
value of incremental irrigation water to farmers (MJD/yr)	0	0	0	0	1.3	1.4	1.5	1.7	1.8	1.9	2.0	2.2	2.3	2.4	2.5	2.5	2.5	2.5	2.5	2.5
amount of fresh water transferred to the city	0	0	0	0	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.4	5.7	6.0	6.0	6.0	6.0	6.0	6.0
value of incremental municipal water (MJD/yr)	0	0	0	0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	10.5	10.5	10.5	10.5	10.5
total incremental value water/wastewater exchange (MJD/y	0	0	0	0	6.8	7.4	8.1	8.7	9.3	9.9	10.6	11.2	11.8	12.4	13.0	13.0	13.0	13.0	13.0	13.0

efficiency of transformation of raw ww to treated ww	87%	
portion taken by upstream farmers	20%	
portion of wwtp effluent lost to seepage and evaporation	20%	
portion of collected ww available for irrigation	0.70	
cost to extract fresh and pump it to Amman	0.6	JD/m^3
value of water to agricultural sector	0.25	JD/m^3
value of water to municipal sector	2.35	JD/m^3
exchange ratio - amount of fresh water per unit treated ww	50%	

ERR 14.22%