WATER REUSE AND ENVIRONMENTAL CONSERVATION PROJECT

CONTRACT NO. EDH–I–00–08–00024–00 ORDER NO. 04

TASK 4
SITE SELECTION REPORT
JULY 2011

IMPLEMENTED BY AECOM

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JULY 2011

Submitted to:

USAID Jordan

Prepared by:

AECOM

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LIST OF ACRONYMS

ASEZA	Aqaba Special Economic Zone Authority
AWC	Aqaba Water Company
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EIA	Environmental impact assessment
FOG	Fat, oil and grease
GAM	Greater Amman Municipality
ha	Hectar (10,000 m^2)
HFDB	Hashemite Fund for Development of Jordan Badia
JD	Jordanian Dinar
JUST	Jordan University for Science and Technology
JVA	Jordan Valley Authority
m^3/d	Cubic meter per day
MBAS	Methylene blue active substances (surfactants)
MCM	Million Cubic Meter
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MoH	Ministry of Health
MWI	Ministry of Water and Irrigation
NCARE	National Center for Agricultural Research and Extension
O&M	Operation and Maintenance
RFP	Request for proposal
RIAL	Reuse for Industry, Agriculture and Landscaping Project
TDS	Total dissolved solids
TN (or T-N)	Total nitrogen
TOR	Terms of reference
TSS	Total suspended solids
UNDP	United Nations Development Program
WAJ	Water Authority of Jordan
WREU	Water Re-use and Environment Unit
WRIP	Water Reuse Implementation Project
WUA	Water User Association
WWTP	Wastewater Treatment Plant

1 Introduction

Jordan is one of the most water scarce countries in the world. According to the Jordan Water Strategy 2008-2022 (MWI, 2009) an annual water resources (i.e., extracted volume from various water sources) was 867 Million Cubic Meter (MCM) per year in 2007, which corresponds to a water share per capita of approximately 145 m^3/capita/year (MWI, 2009), far below the international water poverty line of 1,000 m^3 per capita per year (UNDP). Currently, water allocation by sector is 64% to agriculture, 30% for municipal, 5% for industry, and 1% for tourism (MWI, 2009).

Water resources consist primarily of surface and groundwater, with reclaimed water being used on a significant scale for irrigation, mostly in the Jordan Valley via the King Talal dam. According to the Water Strategy, the total water resources is projected to increase from 867 MCM in 2007 to 1632 MCM in 2022. To achieve the projected increase, water conveyance from Disi aquifer to Amman is planned to be operational by 2013 and the Red-Dead project (hydroelectric power generation coupled with sea water desalination to supply fresh water and replenishment of Dead Sea) should be operational by 2022. The water resources development plan also includes full utilization of reclaimed water.

The USAID Water Reuse and Environmental Conservation Project (Project) is tasked to provide continued support for wastewater reuse activities around USAID funded wastewater treatment plants (WWTPs) for community livelihood enhancement. The assistance by the Project will include extended technical support at the Wadi Mousa site and development of new sustainable water reuse pilot programs that can generate income for local communities in Jordan.

1.1 Objective of the Report

The objective of this report is to document the information collected for the selection of new pilot project sites and present the process and outcome of the site selection. Detailed plans for each selected site will be developed following the agreement among the stakeholders and USAID on the site selection. It should be noted that the development of new pilot projects is subject to the availability of the grant to be awarded through a separate USAID procurement procedure. Preferred pilot sites are prioritized in this report but the number of pilot projects was not determined.

1.2 Site Selection Process Overview

The project team first reviewed previous USAID water reuse pilot projects to understand the success and lessons learned from the previous projects. The team also conducted a review of wastewater treatment plants in Jordan, based on the available documents, and visited USAID-funded wastewater treatment plants to collect information necessary for the site selection. A brief summary of the wastewater treatment plants in Jordan is presented in Section 2. The outcome of the review of previous USAID water reuse pilot projects was documented in the *Comprehensive Review Report* (Task 4, May 2011), and findings are described briefly in Sections 3 and 4. Based on the collected information, a set of criteria for site selection was developed, and a multi-criteria analysis was conducted with key stakeholders' inputs to determine the preferred pilot project sites.

The activities undertaken for the selection of pilot sites are summarized as follows:

- Review and analysis of previous USAID pilot projects and compilation of lessons learned from prior USAID agricultural reuse activities, focusing on the pilot at Wadi Mousa
- Collection of operational data about the wastewater treatment plants
- Field visits to the wastewater treatment plants funded by USAID to assess the current conditions
- Development of selection criteria based on the collected information
- Gaining stakeholder input through a Water Reuse Pilot Project Workgroup.
- Evaluation of the data to identify the preferred sites

1.3 Stakeholder Engagement – Water Reuse Pilot Workgroup

The Project team recognized that engagement of key stakeholders would be the most critical element in the site selection process. The project team reached out to potential stakeholders while reviewing the lessons learned from the previous water reuse pilot projects to identify participants in the "Water Reuse Pilot Workgroup," a group formed of representatives from the key stakeholders. Activities by the Workgroup are expected to include:

- Providing inputs to the site selection
- Scoping of activities at each of selected pilot projects
- Facilitating community engagement for planning the pilot project
- Coordinating with government agencies concerning requirements in assessments and approval processes
- Facilitating the coordination between stakeholders during the implementation of the project
- Public outreach

A range of stakeholders was invited to form the Workgroup including:

- Ministry of Water and Irrigation (MWI)
- Water Authority of Jordan (WAJ)
- Jordan Valley Authority (JVA)
- Ministry of Agriculture (MoA)
- National Center for Agriculture Research and Extension (NCARE)
- Ministry of Environmental (MoEnv)
- Ministry of Health (MoH)
- Hashemite Fund for the Development of Jordan Badia (HFDB)

2 Wastewater Treatment and Reuse in Jordan

Four wastewater treatment plants constructed with support by USAID have been identified by USAID as primary candidate sites for the new pilot projects: Ma'an, Mafraq, Shobak and North Shouneh. To help understand the conditions of these four plants and to evaluate potential inclusion of other plants in the list of candidate sites, the project team conducted a review of ALL wastewater treatment plants in Jordan. This section presents a brief overview of wastewater treatment plants in Jordan and the current status of water reuse.

2.1 Wastewater Treatment Plants

There are twenty five municipal WWTPs serving major cities and towns of Jordan. Design capacities, average inflow and outflow quantities, types of treatment as well as the end use of the reclaimed water from WWTPs are summarized in Table 1. In summary, fifteen facilities are activated sludge WWTPs; six employ trickling filters (of which two plants also have an activated sludge process); and four utilize waste stabilization ponds, one with aerated lagoons, and one with anaerobic/facultative lagoons. Five WWTPs are under

construction as of July 2011. The total inflow to these treatment plants was around 118 MCM per year in 2010, and the total effluent flow was estimated at about 111 MCM per year (WAJ, 2011a). The population in Jordan is currently about 6.1 million and projected to reach about 8 million by 2022 (Department of Statistics, 2011). According to the Jordan Water Strategy (MWI, 2009), the total wastewater flow is expected to reach 247 MCM by 2022, and reclaimed water is recognized as a perennial water source that would be an integral part of the water resources management.

Table 1: Jordan's Wastewater Treatment Plants' Design Capacities, Flow, Treatments and End Uses in 2010

No.	Plant[a]	Avg. Design Flow m^3/day	Avg. Inflow (Actual,2010) m^3/day	Avg. Outflow (2010) m^3/day	Type of treatment	End use
1	**Kherbet As-Samra**	267000	230606	217977	Activated sludge	Flow
2	**Aqaba 1**	12000	9845.5	10410.3	Extended Aeration	Irrigation and Potash industry(2.5 MCM/Yr)
3	**Aqaba 2**	9000	6730.6	6716.6	Water stabilization ponds	Irrigation
4	**Irbid**	11023	8132.1	7171.8	Biological filter and Activated Sludge	Discharged to the Wadies
5	Salt	7700	5290.7	4938.3	Extended Aeration	Discharged to Wadi Jerash
6	Jarash East	3250	3680.8	3477.8	Oxidation Ditch	Discharged to Wadi Jerash, it is being diluted then reused
7	**Mafraq**	1800	2008.8	1643	Waste stabilization ponds	Irrigation
8	Baqa'a	14900	10208.6	9654.7	Biological filter	Discharged to Wadi, then reaches King Talal Dam
9	**Karak**	785	1753.4	1674.3	Biological filter/and maturation pond	Discharged to Karak torrent
10	Abu Nusair	4000	2570.8	2512.3	Activated sludge and Rotating Biological Contactor	Discharged to Berien, part of flow used for forest irrigation
11	**Tafila**	1600	1380	1214.7	Biological filter/and maturation pond	Irrigate the Forest trees – discharged to Ghour Fifa
12	Ramtha	7400	3488.3	2724.9	Activated Sludge	Irrigation
13	**Ma'an**	7000	3170.8	3067.3	Extended Aeration	Irrigation
14	Madaba	7600	5172	4792.5	Activated Sludge	Irrigation
15	Kufranja	1900	2763	2565.2	Biological filter and polishing pond	Discahrged to Wadi, it is being diluted and reused.
16	Wadi Al Seer	4000	3623.8	3225	Aeration Lagoon	Discharged to the Wadi, reches Al Kafrien dam
17	Fuheis	2400	2221	2166.9	Activated sludge	Discharged to Wadi Sho'eb, Farmers at Ghour reuse it

No.	Plant[a]	Avg. Design Flow m^3/day	Avg. Inflow (Actual,2010) m^3/day	Avg. Outflow (2010) m^3/day	Type of treatment	End use
18	Wadi Arab	20800	10264	9539.1	Extended Aeration	Flow
19	**Wadi Mousa**	3400	3028.9	2835.4	Extended Aeration	Irrigation
20	Wadi Hassan	1600	1131.8	969.6	Oxidation Ditch	Irrigation
21	Tall Al Mantah – Dier Alla	400	300	291.6	Biological Filter and Activated sludge	Irrigation
22	Al Akaider	4000	3907.8	2906.8	Waste stabilization ponds	Irrigation
23	Ajloon	1000	853.1	725.1	Waste stabilization ponds	Irrigation
24	South Amman – Thuhaibeh		Under construction			
25	Shallaleh	13500	Under construction			
26	Jarash West		Under construction			
27	Al Jeezeh and Talbeyyeh	4000	703.9	202.8	Activated Sludge	
28	**Shoubak**	300	100 (Approx.)	-	Anaerobic/facultative lagoon with sand filtration	evaporation
29	Mazar/Mo'uta		Under construction			
30	**North Shouneh**		Under construction		Anaerobic/facultative lagoon with sand filtration	

Reference: WAJ Annual Reports 2008 and 2009. Supplemental data were provided by WAJ (unpublished data).
[a] Plants with underlines have been funded (either entirely or partially) by USAID.

As indicated in the table with underlines, the following plants were funded by USAID:

- As Samra
- Aqaba
- Irbid
- Salt
- Mafraq
- Karak
- Tafila
- Ma'an
- Wadi Mousa
- Shoubak
- North Shouneh

2.2 Wastewater Effluent Quality

The characteristics of wastewater effluent depend primarily on the type of in-coming wastewater (wastewater collected through sewer systems, or septage transferred to the plant by trucks), and the treatment technology at the treatment plant. Industrial wastewater entering the sewer system, the quality of freshwater, and the life style of the community in the service area also affect the quality of in-coming wastewater via the sewer systems.

The Water Authority of Jordan (WAJ) issues a permit for the industries when they wish to discharge their wastewater to sewer collection system. The industry must comply with the quality limits and is also required to monitor the wastewater quality to make sure the quality

is in accordance with the permit limits. It is estimated that 10% of the organic loading comes from industrial discharges (MWI, 2011).

The average total dissolved solids (TDS) of municipal water supply is 580 mg/L, and the average domestic water consumption is around 70 L/capita/d country-wide (MWI 2011). The low per capita water consumption results in high concentration of organic compounds and salinity levels in wastewater. The high salinity level in reclaimed water can be exacerbated when waste stabilization ponds are used to treat wastewater, because part of the water is lost through evaporation (MWI, 2011).

Annual average effluent quality reported by each wastewater treatment plant is shown in Appendix A. Effluent quality at short-listed treatment plants is discussed further in Section 6.

2.3 Water Reuse in Jordan

In 1995 the Jordanian government recognized the need to have a proper national policy towards the use of reclaimed water to reduce potential risks to public health and the environment, and the first set of standards (JS893:1995) was issued to identify the allowable uses of reclaimed water. In 2006 a revised set of standards was enacted to provide the basis for proper use of reclaimed water (MWI, 2011).

Direct use of reclaimed water is currently regulated by the Standards JS893:2006. The Standards specify the applications for which reclaimed water could be used, and they set the quality limits according to the type of reuse applications. A summary of water quality limits in the JS893:2006 is shown in Appendix B.

Water reuse is currently planned along with the construction of wastewater treatment plants. The Water Authority of Jordan (WAJ) is responsible for the management of wastewater systems in the country, and it is also responsible for the management of water reuse projects. Generally, WAJ generates a Terms of Reference (TOR) or Request for Proposal (RFP) for the construction of wastewater treatment plants to conduct feasibility study; conceptual, preliminary, and detailed design, and tender documents. Through this process, an environmental impact assessment (EIA) is conducted, and the EIA must include the impact assessment for the effluent use and discharge. The EIA is evaluated by the Ministry of Environment (MoE); other entities such as the Ministry of Health, Ministry of Agriculture and others will serve the committee members for the evaluation. Operation and maintenance of the wastewater treatment plant is currently shifted from the government to the privatized water companies. However, the contract and tariffs related to the use of reclaimed water are the responsibility of WAJ, which can either sell reclaimed water to farmers, or rent the land owned by WAJ with the right to use reclaimed water. The contract with the farmer also includes the type of crops to be irrigated with reclaimed water, which is in compliance with the water reuse standards. Because the concept of water reuse is included in the development of all wastewater treatment plants and water reuse is stated in the Water Strategy plans, there is a mechanism to encourage water reuse when the treatment plant can produce sufficient water to support irrigation.

The number of contracts for the use of reclaimed water in agricultural irrigation is summarized in Table 2. The table also includes irrigated areas and reclaimed water quantities reused in 2009.

Table 2: Contracts for Reusing Reclaimed Water around the Wastewater Treatment Plants in Jordan (2010)

WWTP	Number of contracts	Irrigated areas (du)	Quantity used (m^3/yr)
Kherbet Al Samra	34	2990	3,274,050
Aqaba	5	1580	3,372,600
Ramtha	23	1302	1,425,690
Madaba	23	1236	1,353,456
Al Baqa'a	15	437	638,119
Kufranja	10	812	779,219
Karak	8	609	447,778
Mafraq	17	613	671,412
Salt	5	100	108,996
Ma'an	7	335	366,825
Ekeder	17	1069	1,170,175
Wadi Seer	1	62	67,693
Wadi Hassan	1	700	365,000
Wadi Mousa	1	1069	1,170,555
Al Fuhais	1	30	32,850
Al Jiza	irrigated inside the WWTP		109,500
Total	168	12,942	15,353,918

From: WAJ (2011a)

As-Samra, located approximately 30km north-west of Amman, is the largest wastewater treatment plant in Jordan, with a treatment capacity of 267,000 m^3/d. A lagoon treatment system was built in 1985, and it was replaced by an activated sludge plant through partial support of USAID funds. The new plant came online in 2008 to provide better effluent quality. As of 2008, the treatment plant received approximately 220,000 m^3/d (MWI, 2010), and treated effluent is discharged to the Zarqa River, which flows into the King Talal dam where it is mixed with surface water. The mixed water is being used for irrigation in the Jordan Valley for various food crops. The effluent from the As Samra plant constitutes over 70% of the total wastewater effluent in Jordan, and even though this is an indirect use of reclaimed water, the use of reclaimed water from As Samra WWTP through King Talal dam to the Jordan Valley is by far the largest water reuse scheme in the country. Note that the water reuse scheme through King Talal dam-Jordan Valley is not a part of the contracted reclaimed water use in Table 2. The contracted reuse from the As Samra WWTP is the direct use within the vicinity of the treatment plant.

The largest reclaimed water irrigation (both in quantity and the irrigated area) after As Samra is in Aqaba, followed by Ramtha and Madaba. Reclaimed water from the Aqaba WWTP is also used for the industrial purposes. The total quantity of reclaimed water used directly to irrigation under the WAJ contract in 2010 was approximately 15 million m^3/yr.

3 Water Reuse Projects Funded by USAID

Direct and planned use of reclaimed water in Jordan was first established in pilot projects by USAID during the Water Reuse Implementation Project (WRIP, 2002-2004). Following the success of the WRIP, water reuse pilot activities were expanded during the Water Reuse for Agriculture, Industry and Landscaping Project (RIAL, 2004-2007). The WRIP project was implemented at three demonstration sites: Aqaba, Wadi Mousa and the Jordan University for Science and Technology (JUST). Activities of the RIAL project included operation and maintenance of these three site projects, with an additional pilot at the Greater Amman Municipality (GAM) demonstration site in Abu Nseir. Among the pilot projects implemented by USAID, the project in Wadi Mousa has been highly publicized as one of the landmark reuse pilots, because it brought income to a local community and because the reuse program has been operated and managed by the local community. Reviews of the previous USAID reuse pilot projects are reported in the *Comprehensive Review of Water Reuse Pilot Projects* (Task 4 Tech Memo II, June 2011); a brief summary of the previous projects is presented in the following sections to provide the background for the lessons learned, which are presented in Section 4.

3.1 Wadi Mousa

A demonstration pilot program for the use of reclaimed water for irrigation was first established in Wadi Mousa during the Water Reuse Implementation Project in 2002 as a 6.9 ha demonstration site, and it was later expanded to approximately 37 ha to include the use of reclaimed water by a local community. During the RIAL project, the pilot program was further expanded, and reclaimed water was used for irrigation of alfalfa, olive, fruit trees and other tree crops.

The pilot has been operated by Sad Al-Ahmar Association, the water reusers' association established in 2002, with support of USAID to ensure sustainability of the project. Currently, the association is managed under the supervision of the Hashemite Fund for the Development of Jordan Badia (HFDB). The Association represents the local community, of which 40 farmers (34 men, 6 women) work directly with the pilot. Each farm unit was allocated 0.3 to 0.45 ha, and cropping patterns were identified with the technical support of the project team. The pilot program demonstrated that the use of reclaimed water could be practiced safely and that stable income could be brought to the local communities. By the winter of 2006-7, the total area used for reclaimed water irrigation was over 52 ha, and the net income per farm ranged from $3100 to $4600 per year, depending on the type of crops irrigated (in 2007 dollars; RIAL Completion Report: 2008).

3.2 Jordan University for Science and Technology (JUST)

Jordan University for Science and Technology (JUST) is located in Irbid. There are four pilot project sites within the JUST campus, and one at the Wadi-Hassan WWTP. Within the JUST campus, approximately 1200 m3/d of reclaimed water is diverted for irrigation purposes. Up to 200 m^3/d is being transferred from the JUST WWTP and stored in a storage pond near the treatment plant, which is used for irrigation at the pilot project site without mixing with other types of water. The rest of the treated effluent from JUST, and up to 1000 m^3/d of the Wadi Al-Hassan WWTP effluent is diverted to the irrigation water holding reservoir within the JUST campus. Effluent from the Wadi Al-Hassan WWTP is transferred to the JUST campus through a 9 km pipeline (6 inches in diameter). The pilot sites are maintained by the Agricultural Services Department of the University and all sites were in use at the time of the visit (October 2010).

3.3 Aqaba

In Aqaba, the effluent is being reused in three sectors:

- Agricultural irrigation (lagoon effluent)
- Landscaping (approximately 30% of the tertiary effluent)
- Industry: currently using about 5,000 m^3/d of effluent (or 70% of tertiary effluent)

The largest user of reclaimed water is the industrial area. According to the discussion with the staff member of Aqaba Special Economic Zone Authority (ASEZA) and Aqaba Water Company (AWC), the current use is approximately 5000 m^3/d as stated above. Reclaimed water is supporting approximately 30 percent of the total water use by the industrial area.

The Pilot Project site by RIAL is located within the WWTP boundary, with a total area of approximately 100 dunum (10 ha). Various plant types were irrigated with reclaimed water to investigate the suitability of reclaimed water irrigation.

The RIAL pilot site is in the process of closing, because the objective of the pilot study has been achieved. A new project is being developed under NCARE for reusing effluent water in planting bio-diesel plants (*Jatropha Curcas* *and* *Hohopa* *or* jojoba *Simmondsia chinensis*). The project will be implemented in an area of 10 ha.

3.4 Greater Amman Municipality

Greater Amman Municipality (GAM) governs the Amman governorate and provides services to the City of Amman. Reclaimed water is transferred from the reclaimed water fill station outside of the Abu Nasir WWTP to the site by tankers. During the first three years, reclaimed water was used mainly for irrigation. Afterwards, the use of reclaimed water was expanded to include street washing, compacting base-coarse, and other similar uses. USAID provided funding for the reclaimed water fill station and a building outside the WWTP to keep track of the traffic at the fill station. Unused effluent is discharged to the Wadi.

4 Lessons Learned from Previous Water Reuse Pilot Projects

As presented in Section 3, safe and efficient use of reclaimed water was demonstrated by previous USAID projects, and technical and institutional assistance was provided to make the water reuse projects sustainable. The water reuser's association at the Wadi Mousa pilot was the first association in Jordan to operate, maintain and manage a reclaimed water irrigation system. Lessons learned from these previous projects should be disseminated to the water reuse practice in other locations, and will be reflected in the criteria used to select new pilot project sites.

Key lessons learned from reviewing the previous pilot projects are summarized below. Note that lessons described in this section focus primarily on the Wadi Mousa pilot, as the main goal of the new pilot projects to be developed by the Water Reuse and Environmental Conservation Project is to support community livelihood enhancement through the water reuse activities, similar to the main achievement of the Wadi Mousa pilot.

4.1 Project Location, Roles, and Ownership

The planted area at Wadi Mousa pilot is near the WWTP. The development of the farming site and the pressurized irrigation system in the Wadi Mousa pilot project was phased over the course of the WRIP and RIAL projects. The pilot project activities started in 2002 under the WRIP as a 6.9 ha demonstration site to implement reclaimed water irrigation. It was then expanded to 36.9 ha during the WRIP and further expanded during the RIAL project to 66.9 ha. At the peak of the RIAL project, about 90% of the total project area (58.7 ha) was irrigated with reclaimed water, and almost all treated effluent was utilized during a high

irrigation demand season. Clearly, **it is preferred that the pilot site be located near the WWTP.** Also, the development of new reuse sites could be phased to start from a small scale project, and expand the area as the local community is trained to operate and maintain the pilot technically and financially.

According to the site investigation conducted by the project team at Wadi Mousa in December 2010, the area under cultivation was around 44 ha; 16 ha were planted with alfalfa and 28 ha were planted with fruit trees and barley. It was observed that a few farm units were not utilized at all, and some farm units were used but not maintained well, indicating a gradual decline in the state of the pilot. The decline in farm area and the condition of farm units may be due to the lack of constant technical supervision by a resident engineer. A lesson from the declining condition of the pilot is that time and personnel are required to make the pilot project sustainable. Even though Wadi Mousa pilot clearly identified the responsible parties towards the end of the RIAL project, the roles of stakeholders might not have been understood or exercised as planned at the time of the project team's site investigation. So overall the lesson is that **roles need to be clearly defined and that sustained maintenance takes time and personnel.**

The need for clear identification of land ownership is another important lesson learned from the previous pilot projects. All previous USAID reuse pilot projects were implemented within a university, wastewater treatment plant, road median, or land owned by a municipal government. Through the review of the previous projects, the project team identified that **well-defined ownership of the land** appropriate for the pilot project as one of the most critical elements that determine the sustainability of the pilot project.

4.2 Irrigation System Maintenance

Through the two reuse projects (WRIP and RIAL), the Wadi Mousa pilot was expanded from a demonstration site into a sustainable operation that delivers water and other services to each farm unit. Irrigation schedules were developed and included in the operation and maintenance (O&M) manual. Drip irrigation was proven to be suitable for cultivation of forage crops with reclaimed water, and achieved high efficiency. It was also demonstrated that the irrigation system should include effective filtration systems to minimize the emitter clogging. Irrigation schedules among farm units should be planned to achieve the best levels of uniformity of water distribution. **Regular maintenance and rehabilitation for irrigation components should be made available**.

The irrigation system is operated with simple operational plans so each farmer knows exactly when water is available and what days of the week the farmer entitled to irrigate, and there is no uncertainty for farmers in terms of water availability. An important lesson learned from the site investigation is **the importance of the protocol to allow simple and reliable operation.**

4.3 Cropping Pattern

By **planting perennial crops** (e.g., alfalfa, trees) and annual (e.g., barley) crops, the Wadi Mousa pilot could utilize reclaimed water year-round and minimize the volume of water to be discharged to a Wadi while maintaining revenues from reclaimed water irrigation. From the investigation of the current cropping pattern at Wadi Mousa, some deterioration of farm units was observed. The fields planted with trees and vines tended to be infested with weeds and it could affect the productivity of the trees. Heavy infestation of weeds was observed in the fields with Grape and Guava trees, and the area was generally described as in moderate to poor conditions.

4.4 Availability of Reclaimed Water

In the RIAL completion report, it was reported that the Wadi Mousa had very limited potential for expansion, and when more reclaimed water became available, the farmers would be able to expand the alfalfa plots. Based on the site investigation at Wadi Mousa by the project team, currently almost all reclaimed water is used for irrigation during high irrigation demand season, and excess water is discharged to Wadi when irrigation demand is low.

In Aqaba, approximately 5,000 m^3/d of tertiary-treated reclaimed water is used by industry and the rest is used for landscaping. Reclaimed water is supporting approximately 30 percent of the total water use in the industrial area, and the industry is willing to take more water if it is available. Thus the use of reclaimed water for landscaping can be limited by the contract with the industry, while it is easier to manage excess water during low demand season, as industry can always take water on a more consistent basis throughout the year. **When there are multiple users of reclaimed water, it is important to consider the water balance between users both daily and seasonally.**

4.5 Monitoring

RIAL established a monitoring and evaluation system that includes periodical sampling and testing of the parameters deemed necessary to monitor the safe and sustainable use of reclaimed water. The monitoring plan included reclaimed water quality, as well as soil, plant, and ground water quality, based on the Jordanian standards. The RIAL completion report stated that standards in Jordan were applicable and reliable for reuse activities. However, the standards do not include clear requirements of monitoring and reporting. **A new project design should include a monitoring system based on the national guidelines and standards and best practices in other parts of the world. Monitoring of the socio-economic aspect of the project is critical as well.** The project should identify all monitoring responsibilities, as well as task distributions among all the project implementing partners.

4.6 Institutional Arrangements

RIAL helped in institutional strengthening and public participation activities, including support for the Water Reuse and Environment Unit (WREU) within WAJ to make sure the function of the WREU is fully exercised. The role of the WREU for the pilot projects included monitoring of the reclaimed water quality, and adaptation of safe reuse schemes in accordance to the Jordanian Standards. The Wadi Mousa project also pioneered the Water User Association (WUA) at Wadi Mousa for operating and managing reclaimed water reuse activities. The RIAL project also developed sustainability plans which addressed financial, marketing, environmental and technical aspects for future expansions. These were achieved through working with stakeholders and local agencies to address and formulate the national policy on the role of reuse in Jordan. It is important to note that the responsibilities by key stakeholders were clarified at the end of the RIAL project and the roles generally maintained. However, the mechanism to maintain the irrigation system was not fully functioning as originally planned, as evidenced by the observed deterioration of the pilot. Further **investigation on the institutional structure for the operation of the pilot project** is warranted for the new pilot projects to allow the new pilots to become self-sustainable after a few years of intervention.

4.7 Social Aspects

At Wadi Mousa, farms were allocated to the WUA members who had not been working in a full time job, thus improving their economic status. RIAL conducted public awareness and training events to improve acceptance of water reuse. Even though the use of reclaimed

water appears to be accepted by the farmers and they have been selling the harvested crops, the RIAL project team also observed continuing resistance to buy crops irrigated with reclaimed water. **Additional investigation will be necessary to more accurately understand the socioeconomic impact of water reuse for the local communities**.

4.8 Sustainability

At the initial stages of the project, RIAL staff worked directly with farmer and supported farmers in identifying markets for their crops. As farmers gained experience, and showed capability of continuing to manage their farms in a sustainable manner, RIAL staff gradually withdrew from working side by side with the operators and farmers. The intent was to allow the farmers and the WUA to become sustainable without continuing intervention. During the site investigations, however, the farmers claimed that they did not have sufficient financial resources to pay for maintenance of the main components of the irrigation system. **Clear allocation and understanding of responsibilities for the operation and maintenance of the pilot site will allow sustainable and independent pilot projects.**

4.9 Technical Supervision

At the Wadi Mousa pilot, the Water Users' Association is responsible for the maintenance of irrigation system, preparation and implementation of the irrigation schedule, monitoring the types of grown crops, and offering needed machinery for cropping and harvesting for farmers. There appeared to be a lack of technical supervision to some parts of the pilot, such as weed control and maintenance of the farm irrigation units.

5 Development of Site Selection Criteria

Based on the review of water reuse projects funded by USAID (Sections 3 and 4) and on preliminary discussion with key stakeholders, draft selection criteria were proposed by the project team and were discussed and finalized with the Water Reuse Pilot Workgroup. The relative importance of the criteria was also determined through discussion with the Workgroup. The selection criteria are categorized as described in this section.

5.1 Availability of reclaimed water

- Quantity of reclaimed water

  Reliable supply of reclaimed water is crucial to developing a reuse project. The quantity of reclaimed water that will be available for new reuse pilot project is also important in assessing storage requirements. Where more than one reclaimed water user exists, the water balance among the reclaimed water users should be assessed to make sure each user will be able to receive the entitled (contracted) amount of water.
- Quality of reclaimed water

  Quality of reclaimed water must meet the water reuse standards (JS893:2006) when it is used for beneficial purposes. Even though minor add-on treatment such as sand filters and additional disinfection process may be considered to make sure the reclaimed water for the pilot project consistently meets the required quality level, it is assumed that major modification to the wastewater treatment plant cannot be made for the purpose of the pilot project.

5.2 Availability and suitability of lands

- Land Ownership

  The land for a reuse project must be near the WWTP. The lands near WWTPs in Jordan include private lands, non-dedicated government lands, and

governmental land dedicated to certain government Authorities. Non-dedicated government lands are considered preferable for new reuse project.

- Land suitability for intended crops
  The suitability of land for growing crops to generate income for local communities is an important factor in selecting the new reuse pilot project.
- Potential of artificial groundwater recharge
  Reclaimed water can be stored and recovered in aquifer in place of storage ponds if there is aquifer that is not connected to drinking water source. If such an aquifer is known or anticipated to exist, the project may consider the site as a potential pilot site to implement aquifer storage and recovery for agricultural irrigation.

5.3 Environmental impact

- Potential groundwater contamination
  Contrary to the potential to implement groundwater recharge, there is also a risk that the use of reclaimed water could contaminate an unconfined aquifer connected to the drinking water sources. If a potential pilot site is known or suspected to be within an area with sensitive shallow and unconfined aquifer, the site may not be appropriate for the pilot project.
- Exposure risk to neighboring community (sensitivity of the local environment)
  Direct contact to reclaimed water without appropriate safety measures can pose adverse health impacts. The pilot project will be designed and the reclaimed water users will be trained to follow appropriate protection measures. However, the site may be considered less preferred if the area is in close proximity to the residential areas.

5.4 Socioeconomic impact

- Geographic location
  The new pilot sites should be located in diverse geographic and climatic zones. It is also preferred the pilot be established where water availability for agriculture is limited.
- Socio-economic status
  A geographic location with a high poverty rate may be considered preferable, as the main goal of the pilot is to enhance community livelihood through income generation with reclaimed water.
- Local community's willingness
  Cooperation and participation of local community with the project team in implementation, operation and management of reuse pilot project are important to the success the project.
- Potential of marketing
  Farmers should have access to the appropriate markets for selling their products according to applicable regulations. A proper market survey must be conducted to assess the possibility to market the production.
- Efforts needed to form a reusers' association
  The project team will investigate the possibility of establishing a water reuse association to implement the new reuse pilot project and to be responsible for sustainable operation and management of the project. It should be noted, however, that the engagement of an existing association may also be considered.
- Urgency to promote water reuse at the site
  Urgency to promote water reuse could be recognized for two main reasons: potential adverse impact of effluent discharge, and the demand of additional water for beneficial purposes, primarily for agriculture.

- Availability of local labor
  As the main objective of the reuse pilot is to enhance livelihood of local community, it is preferred to select a site with potential labor to work on agricultural practice near the potential site.

5.5 Stakeholder impact

- Preferences by the funding agency (USAID)
  The preference of the funding agency (USAID) is that the wastewater treatment plant be one funded by USAID.
- Accessibility to the land by stakeholders
  There must be easy access to the new pilot sites by stakeholders and farmers without facing obstacles such as security clearance.
- Readiness of the WWTP
  Priority will be given to the WWTP's that are ready to meet the required conditions to start the pilot project. The status of the wastewater treatment plant (i.e., treatment level and effluent quality already meeting the Standards to implement water reuse) is considered for this criterion.
- Considered by other project
  The sites where project(s) by other donor agencies or government agencies have already been considering using the reclaimed water will be considered less preferable for the pilot project site.

As discussed in Section 7, potential risk of exposure was not included in the scoring process as it was recognized as a management issue rather than a site selection criterion, but it was left in the above list because the management of exposure risk was considered critical during the planning phase of the pilot projects.

The Project team and the Workgroup discussed the relative importance of the criteria listed above. The priority was ranked from 1 to 5, with lower numbers signifying higher importance. The priorities were then converted into the weights during the scoring the potential sites against the site selection criteria. The priorities and weights of the criteria are also discussed in Section 7.

6 Identification of Potential Reuse Pilot Sites

The new reuse pilot project will be developed around USAID-funded wastewater treatment plants. As discussed in Section 2, four treatment plants were identified by USAID as the primary candidate sites: Ma'an, Mafraq, Shobak, and North Shouneh. The project team also reviewed other treatment plants and identified four more treatment plants funded by USAID: As Samra, Karak, Tafileh, and Irbid. During the discussion with the Workgroup, Madaba was also suggested as a potential site, even though the Madaba WWTP was not funded by USAID.

Of these plants, As Samra WWTP was excluded as a potential pilot site because: (1) most of its effluent is discharged to the King Talal Dam and subsequently used in the Jordan Valley as valuable water source for agriculture, and (2) other donor agencies and governmental organizations have been engaging in projects using the effluent from the Samra WWTP, both near the Samra WWTP or in Jordan Valley.

Using the criteria provided above, a total of eight wastewater treatment plants were shortlisted as candidate pilot sites:

- Four treatment plants were identified as the primary candidate sites: Ma'an, Mafraq, Shobak, and North Shouneh. These were funded by USAID and listed in the USAID project contract.
- Four treatment plants were funded by USAID but not listed in the contract. These treatment plants include Irbid, Karak, and At Tafielah
- Madaba WWTP, as suggested by the stakeholder

In this section, a brief description of the shortlisted sites is presented.

6.1 Ma'an

The City of Ma'an is the capital of the Ma'an Governorate which has a total population of approximately 114,000 (2009 estimate, Department of Statistics). It is located in the western part of the desert region 220 km south Amman. Ma'an Development Area (MDA) includes an Industrial Park about 6 km east of Ma'an WWTP.

Ma'an WWTP

WWTP has an activated sludge treatment system, and part of the reclaimed water is currently used for agricultural irrigation. The design capacity is 7,000 m^3/d based on BOD of 700 mg/L and TSS of 700 mg/L. The influent volume in the year 2008 was 2,325 m^3/d. It has been under operation since 1989, and it was upgraded in 2009 from natural to mechanical treatment system.

The treatment system includes the following units:

- Fine and coarse screens
- Equalization tank
- Grit and oil removal
- Anaerobic tank
- Anoxic tank
- Aerobic tank
- Clarifiers
- Sludge pump station
- Thickeners
- Polishing ponds
- Drying beds
- Chlorination

Details about inflow, effluent, and biochemical analysis for the reclaimed water are summarized in Table 3.

Reuse of reclaimed water

Reclaimed water from the Ma'an WWTP is used by local farms, and excess water is being discharged to the Wadi. Al-Tamayouz Sociaty, a small local society established by private sector in the region, initiated a water reuse project near the WWTP in 2010 (as of March 2011 they were not active at the irrigation site). The total planted area around the WWTP is approximately 35 ha, with four farmers planted Alfalfa and barley using surface irrigation system. The farmers are receiving water quality according to Jordanian standard (JS893/2006).

6.2 Shobak

Shobak is located in the western Ma'an Governorate, 30 km north of Petra. The Shobak area does not have a sewer system to collect wastewater and it is collected by septic tanks.

Shobak WWTP was constructed to receive wastewater being transferred from septic tanks, with wastewater collected from three areas:

- Shoubak: 20,000 population
- AL-Husayneyeh: 10,000 population
- Al-Qadeseyeh: 15,000 population

Shobak WWTP

The Shobak WWTP design capacity is 350 m^3/d. The WWTP was commissioned in 31/12/2009, and it currently receives an average of 7 tankers per day. The treatment system includes the following:

- Septage receiving station
- Settling/digestion tanks
- Anaerobic/settling lagoon distribution box
- Anaerobic/settling lagoons (two)
- Dosing basin (collect effluent from anaerobic lagoon before sand filter)
- Sand filters (ten)
- Reed bed distribution box (one)
- Reed beds (two)
- Evaporation distribution box and non-potable water wet well (collector from reed beds)
- Sludge drying beds

Current incoming flow is around 100 m^3/d with only one of the two lagoons under operation. Because of the low inflow to the WWTP, the effluent is rarely discharged to the evaporation basin. The treatment process is not designed for de-nitrification due to the small flow quantities and expected water reuse opportunities. The treatment design includes a chlorination chamber, but it is not used, as there is no effluent being discharged from the reed bed.

6.3 Mafraq

The City of Mafraq is located 60 km northeast Amman. The region has a desert climate with hot and dry summers and relatively cold winters. Mafraq WWTP was identified as a potential reuse pilot site during the RIAL project after the Wadi Mousa pilot (Task 1 Completion Report, 2008), but it was not implemented due to the delay with the construction of the Mafraq WWTP upgrade. The design for the reuse scheme has been developed as part of the WWTP upgrade (Design Report for the Reuse System, 2007).

Mafraq WWTP

Mafraq WWTP is located approximately 6km north of the city of Mafraq, close to Aal-albayt University and the industrial city. The WWTP has been under operation since 1988, and it utilizes stabilization ponds as the treatment process. The WWTP has been overloaded and in need of an upgrade. The design of the upgrade was developed with assistance from USAID. The design capacity of Mafraq WWTP is 1,800m^3/d with 845 mg/L of BOD_5 and 920 mg/L of TSS. Current effluent quality is shown in Table 3. It is worth noting that the effluent quality (in annual average) is not meeting the total nitrogen limit for the fodder crop irrigation.

The current treatment process includes:

- Pre-treatment (coarse screen)
- Two treatment trains with 12 ponds (0.5 ha each), consisting of:
  - anaerobic lagoons
  - facultative lagoons
  - polishing lagoons

The treatment plant is in the process of being upgraded. Once this is completed, the upgraded treatment plant will have an activated sludge process, with the existing ponds to be used as polishing ponds. The effluent quality from the upgraded treatment plant is expected to be suitable for reuse in all categories specified in JS893:2006.

Reuse of reclaimed water
The farmers are reusing reclaimed water for agricultural uses inside and outside the WWTP boundary. The governmental land inside the WWTP is rented to farmers, and they have planted forage crops (Barely, Sudani Grass, Corn, and Alfalfa) using the reclaimed water for irrigation. A total of 49.1 hectares inside and outside the WWTP boundaries is being planted for reuse purposes:

- Eight farmers have planted approximately 39.5 ha
- A private association has planted approximately 9.6 ha

6.4 North Shouneh

North Shouneh is located in the northern part of the country, near the border with Syria. The region is famous for its citrus farms. The Jordan Valley Authority (JVA) provides the farmers with fresh water to irrigate their farms from the King Abdallah Canal and the Wadi Al Arab Dam.

Nourth Shouneh WWTP
The WWTP is currently under construction and expected to be commissioned in 2011. The WWTP is designed to receive wastewater collected by tankers. The TP design capacity is 1,200 m^3/d. The facility under construction includes (information provided by Wastewater Treatment Facilities for Small Community Project):

- Administration building
- Septage receiving station
- Settling/Anaerobic digestion/de-nitrification basin with all accessories
- Distribution boxes
- Earthen facultative lagoons (two)
- Concrete filter dosing basins (two)
- Earthen recirculating sand filters (twelve)
- Nitrate recycling pump station equipped with four vertical turbine pumps
- Constructed wetlands (two reed beds)
- Storage reservoir (one)
- Hydro-pneumatic tank
- Duplex sludge transfer pumping stations (two)
- Sludge drying beds (twelve) and composting pads (three)
- Groundwater monitoring well and piezometers
- Plant access roads
- Conveyance piping between process units
- Electrical power distribution system and site lighting
- Operator's station
- Duplex irrigation pumping system and irrigation water distribution network

Reuse of reclaimed water
The area within the WWTP is approximately 300 dunums, part of which could be irrigated with reclaimed water. Within the WWTP boundary, a reclaimed water irrigation system has been designed, with a preliminary plan to irrigate:

- 2.5 dunum for nursery
- 50 dunum for citrus
- 7 dunum for alfalfa

- 10 dunum for trees

Outside of the WWTP, there are existing farms in the close proximity. According to the USAID Wastewater Treatment Facilities for Small Community Project, some of the farmers have made a preliminary agreement to utilize the reclaimed water.

6.5 Karak

Karak City is the capital city of Karak Governorate, 140 km to the south of Amman on the King's Highway, and is known for the famous crusader castle of Karak. It is located on a hilltop about 1,000 meters above sea level and is surrounded on the three sides by valley.

Karak WWTP

The WWTP is located in the north-west of Karak city. It is located in Karak Valley near Ain Sara spring. The treatment system is based on Imholff tank and biological trickling filters. The WWTP has been under operation since 1988, with a design capacity of 785 m^3/d. The average inflow exceeds 2,000 m^3/d. The treatment process includes of the following units:

- Screens
- Grit removal
- Flow measurement
- Septage unloading
- Imholff tank
- Trickling filters (two stages)
- Sedimentation tank
- Chlorination
- Maturation pond/Polishing lagoon
- Sludge lagoons, sludge drying beds

The total effluent from WWTP was 1,674 m^3/d in 2010. Effluent quality as of 2010 is presented in Table 3.

Reuse of reclaimed water

All available reclaimed water is being reused in:

- Al-Rasees project implemented by the Ministry of Agriculture
- 8 other private farmers private
- One project for Zain Company

The re-users are charged 0.01 JD per cubic meter. Reclaimed water is transferred by gravity in a 300-mm diameter pipe with a total length of 8 km. The pipe is lined parallel to the street that leads to the Dead Sea. Part of the reclaimed water is reused by the Ministry of Agriculture (MoA) in agricultural irrigation for forest trees planted 5 km from the WWTP. Farmers are reusing reclaimed water in irrigating their orchards planted with olives, grapes and figs. The surplus of the reclaimed water is discharged to the Wadi.

6.6 At-Tafila

At-Tafilah is a small city located 183 kilometers southwest of Amman. It is well-known for having green gardens planted in olives, figs, and grapevines.

At-Tafieleh WWTP

At-Tafieleh WWTP is located west of At-Tafieleh City. The WWTP has been under operation since 1988 with a design capacity of 1,600 m^3/d, BOD_5 1,060 mg/l and 1,175 mg/l of TSS. The WWTP receives wastewater collected by the sewer system that serves AL-Tafileh City, Barnees Village and Wadi Zied by gravity. The average daily inflow is around 1,400 – 1,500 m^3/d, where sometimes it reaches 2,000 m^3/d. This overloading is caused when operating the four pump stations (PS) serving AL-Ees and Al-Mansoura villages, two PS for each

village. The produced reclaimed water is being dumped into Siel Al-Ghwer that flows to the Dead Sea. The generated solid waste at the WWTP is transferred by tankers to Jarf Al-Daraweesh landfill, costing the TP around 2,000 JD per year.

The treatment system of WWTP includes;

- Screening unit
- Imholff tank
- Chlorine contact basins
- Bio-filters
- Return sludge pump
- Secondary clarifiers
- Maturation ponds
- Waste sludge pumps
- Sludge drying beds

Influent and effluent quantities at the TP are summarized in Table 3. The table also summarizes the reclaimed water biochemical analysis results for the years 2008, 2009 and 2010.

Reuse of reclaimed water

The lands around the WWTP are not accessible for vehicles. Part of the reclaimed water is used by:

- Al-Mansoura Cooperative Association
  - Established in 2007
  - Stopped working in 2009 since they have accumulative loans to the ministry
  - Granted by 100,000 JD from the Ministry of Planning for land preparation, planting and the irrigation system
  - They planted an area of 11.4 ha
  - They were charged 0.01 JD/m^3, but they used to pay as a total of 90 JD/year
  - No water meter installed to measure the quantity of water they were using to irrigate their crops
- Farms planted in olives surround the WWTP. The owners are using ground water for irrigation.
- Recently, private farmers want to have reclaimed water to plant 4.2 ha to irrigate alfalfa crop

6.7 Irbid

Irbid is the largest city of the Irbid Governorate that is located on the northern ridge of the Gilead, equidistant from Pella, Beit Ras (Capitolias), and Umm Qais, almost 70 km north Amman. The city of Irbid is the third largest city in Jordan by population following Amman and Zarqa. There are three WWTPs in Irbid: Fou'ara, Dogara and Wadi Shallaleh (under construction).

Irbid (Fou'ara**) WWTP**

Irbid WWTP has been under operation since 1986. The treatment system in this WWTP includes combined system trickling filters and activated sludge. The design capacity of Irbid WWTP is 1,100m^3/day with 800mg/L BOD_5 and 800mg/L TSS.

The treatment system includes;

- Bar screens
- Grit and sand removal
- Primary clarifiers
- Trickling filters

- Aeration basins
- Secondary clarifiers
- Thickener
- Digester
- Holding tank
- Drying beds
- Chlorination basin

Reuse of reclaimed water
The reclaimed water produced at both Fou'ara and Dogara WWTPs is transferred by an 8-km pipeline into the Jordan River. The pipe is lined close to Wadi Al-Arab Dam, and it is illegal to dump the reclaimed water into the Dam to avoid polluting the groundwater wells located close to the dam. There are no available areas for reuse except those located close to the Wadi Al-Arab Dam. However, there are no agricultural practices in the areas due to limited machinery access since it is in a valley.

6.8 Madaba

Madaba WWTP has been in operation since 1989, with a design capacity of 4,000m^3/d. It was upgraded in 2003 to a design capacity of 7,600 m^3/d with 950 mg/L of BOD_5 and 1,000 mg/L of TSS. The WWTP implements the extended aeration treatment method.

Madaba treatment system consists of the following units:

- Grit chamber
- Grease removal
- Equalization pond
- Anaerobic tank
- Anoxic tank
- Aerobic tank
- Settling tank
- Polishing pond
- Tertiary maturation pond
- Rock filtration
- Chlorination chamber
- Thickener
- Drying bed

Reuse of reclaimed water
An important management issue for the Madaba WWTP is to avoid discharge to the Wadi. Nearly all of reclaimed water is used for agricultural irrigation within and around the treatment plant. When there is a significant rainfall (which is usually during the low irrigation demand season), some of excess water appears to be discharged to a Wadi. The maturation ponds can hold 150,000 m^3 of reclaimed water, and an appropriate flow management should be able to adjust the flow to the farmland to avoid or at least minimize the amount of water to reach the Wadi.

Table 3: Treatment Plants Shortlisted for Consideration, Type of Treatment, Biochemical Effluent Parameters, Fund for Establishment, and Status of Reuse in 2010

					Biochemical Effluent Parameters*							
WWTP	**Type of treatment**	**Avg. Design Flow m^3/d 2010**	**inflow m^3/d 2010**	**Avg. Effluent m^3/d 2010**	**pH**	**BOD_5 mg/l**	**COD mg/l**	**TSS mg/l**	**TDS mg/l**	**T-N mg/l**	**Fund for establishment**	**Status of Reuse**
Irbid	Biological filters & activated Sludge	11023	8132.1	7171.8	7.5	59.4	245.9	75.9	1007	92	Loan - USAID	Discharged to the Wadi
Mafraq	W.S.P	1800	2008.8	1643	7.95	139	432	137	1089	125.7	will be upgraded soon - fund from USAID	Farmers are reusing the effluent to irrigate fodder crops (49.1 ha)
Karak	Biological filters	785	1753.4	1674.3	7.76	72	321	112	904.3	71.5	Loan - USAID MWI - upgrade under studying - upgrade fund from Germany	MoA irrigat the forest trees Farmers irrigate olives and fodder crops Surplus is discharged to the Wadi
Tafila	Biological filters	1600	1380	1214.7	7.9	40.9	150.8	45.7	1007	77.8	Loan - USAID	Farmers used effluent to irrigate olives and fodder crops Surplus is discharged to the Wadi

					Biochemical Effluent Parameters*							
WWTP	**Type of treatment**	**Avg. Design Flow m^3/d 2010**	**inflow m^3/d 2010**	**Avg. Effluent m^3/d 2010**	**pH**	**BOD_5 mg/l**	**COD mg/l**	**TSS mg/l**	**TDS mg/l**	**T-N mg/l**	**Fund for establishment**	**Status of Reuse**
Ma'an	Extended Aeration	7000	3170.8	3067.3	7.7	9.4	49.7	15.1	1019	16.7	natural treatment (1989) loan from EIB - upgrade for mechanical treatment (2009) USAID - 50% of the cost	Farmers used effluent to irrigate olives and fodder crops (35 ha) Surplus is being discharged to the Wadi
Shobak	Activated Sludge	300										The effluent is low, discharged to evaporation basin
North Shouneh	Activated Sludge	1200										Under construction. Reclaimed water irrigation system is being design to irrigate citrus, Alfalfa, trees and nursery.
Irbid	Biological filters & activated Sludge	11023	8132.1	7171.8	7.5	59.4	245.9	75.9	1007	92	Loan - USAID	Discharged to the Wadi
Karak	Biological filters	785	1753.4	1674.3	7.76	72	321	112	904.3	71.5	Loan - USAID MWI - upgrade under studying - upgrade fund from Germany	MoA irrigat the forest trees Farmers irrigate olives and fodder crops Surplus is discharged to the Wadi

					Biochemical Effluent Parameters*							
WWTP	**Type of treatment**	**Avg. Design Flow m^3/d 2010**	**inflow m^3/d 2010**	**Avg. Effluent m^3/d 2010**	**pH**	**BOD_5 mg/l**	**COD mg/l**	**TSS mg/l**	**TDS mg/l**	**T-N mg/l**	**Fund for establishment**	**Status of Reuse**
Tafila	Biological filters	1600	1380	1214.7	7.9	40.9	150.8	45.7	1007	77.8	Loan - USAID	Farmers used effluent to irrigate olives and fodder crops Surplus is discharged to the Wadi
Madaba	Activated sludge	7600	5172	4792.5	7.72	21	44	13	1169	13	Part of fund is loan from EIB	The reclaimed water is used for irrigation. Surplus is stored in ponds

REF: WAJ Annual Reports 2008 and 2009, personal contacts and site visits.
* The biochemical parameters in red color (or grey if this is printed black and white) are taken from WAJ Annual Report 2009, and the numbers in black color from Annual Report 2008.

7 Multi-Criteria Analysis

The shortlisted sites described in Section 6 were evaluated for the site selection criteria described in Section 5. As discussed in this section, the criteria were prioritized so that higher priority criteria will give higher influence to the decision. To minimize subjectivity to the scoring, scoring guidelines were developed, and the scoring exercise was done at a Workgroup Meeting (June 27, 2011).

7.1 Assessment of Potential Sites Based on Site Selection Criteria

Because identified criteria had varying importance to the selection of potential pilot sites, the criteria were weighed based on the priority of each criterion. For the scoring of each treatment against the selection criteria, scoring guidelines were developed to minimize subjective scoring and avoid misunderstanding of the definition of the criteria. A matrix was populated during the Workgroup meeting and the scores discussed among the stakeholders.

7.1.1 Priority of Selection Criteria and Weighting

The weight of each selection criterion has been developed by the project team and agreed with the stakeholders' workgroup members, as shown in Table 4. By weighing high priority criteria with high weights, these high priority criteria will have a stronger influence in the final score. The criteria identified to be less important for the decision was given lower weight so the scoring on the low priority will have less influence to the final decision.

Table 4: Weighting Values, Priority

Priority	Weight/Percent influence
1	40%
2	30%
3	15%
4	10%
5	5%

7.1.2 Scoring Guidelines

To facilitate the scoring of selection criteria for each WWTP's; the project team developed a guidelines to score the criteria for each potential sites. The scoring guidelines are summarized in the following table (Table 5). The scoring was to be given with 1 to 10, but the scoring guidelines divided the guidance into four categories to simplify the scoring as following:

- The high scores group includes score 8,9,and 10;
- The middle upper group includes scores 6 and 7 ;
- The middle lower group includes scores 4 and 5;
- The low score group includes scores 1,2 and 3.

Table 5: Scoring Guidelines for Site Selection Criteria

No.	Selection Criteria	GUIDELINES			
		Scores 1,2,3	**Scores 4,5**	**Scores 6,7**	**Scores 8,9,10**
1	Geographic Location Agro-climatic Zone	Northern Highlands		Southern Mountains	Western Desert
		Southern Highlands			Northern Jordan Valley
		Western Highlands			Eastern Desert
2	Current Water Quality	Overloaded all the year, effluent has bad quality and don't meet JS	Seasonally overloaded, with no plans to be upgraded soon	Seasonally overloaded, and will be upgraded soon. effluent quality don't meet JS sometimes	The inflow is always below the TP design capacity, effluent always meets the JS
					Chlorination disinfection unit
3	Water Quantity	No or limited available quantity	Low available quantity	Moderate available quantity	Available quantity
4	Land Ownership/Land tenure	No governmental or private lands	Limited governmental and/or private lands	Limited governmental lands, available private lands	Governmental or private land are available
5	Land Suitability	No available lands for agriculture use	Limited available lands for agriculture reuse	Available land for agriculture reuse but far from the WWTP	Adequate available land close to the WWTP
			Intense management	Moderate management	Minimal management
			Not suitable for mechanized operation	Limited accessibility for mechanized operation	Suitable mechanized operation
6	Groundwater contamination	High contamination	Moderate contamination	Low contamination	No contamination

No.	Selection Criteria	GUIDELINES			
		Scores 1,2,3	**Scores 4,5**	**Scores 6,7**	**Scores 8,9,10**
7	Groundwater Recharge	No potential for groundwater recharge	Limited potential	Moderate potential	High potential
8	Community Willingness		The idea of reuse project not accepted by local community		The local community is interested in implementing the project
					The local community have agricultural background
9	Socio-economic status	High income	Moderate income	Low income	No income
		No unemployment	Low level of unemployment	Moderate level of unemployment	High level of Unemployment
10	Potential of marketing locally	No demand locally	Low demand locally, less than 50% of the produced forage could be consumed locally	Moderate demand locally, most of the produced forage could be consumed locally	High demand locally, all of the produced forage could be consumed locally
11	Effort needed to form association	High effort	Low effort	Moderate effort	Minor/minimal effort
12	Preference by USAID for funded a pilot project	Not funded by USAID		Suggested by stakeholders, not funded by USAID	Funded by USAID
13	Accessibility to the land by stakeholders	Restricted access to the land			No restricted access to the land
14	Urgency to promote water reuse at the site	No urgency	Foreseeable benefit	Potential adverse effect on ground water	Known hazards due to discharge of reclaimed water into wadi
15	Availability of Local Labor	Unavailable local labor	Difficult to find local labor	Possibility to find local labor	Available local labor

No.	**Selection Criteria**	**GUIDELINES**			
		Scores 1,2,3	**Scores 4,5**	**Scores 6,7**	**Scores 8,9,10**
16	Readiness of the WWTP	Not ready and no plans to upgrade the WWTP	There are plans to upgrade the WWTP	the WWTP will be upgraded soon or under construction	WWTP is ready to implement the reuse project
17	Considered by other project	The reuse of reclaimed water is planned by government or donors		participate in other planned projects	the produced reclaimed water is not considered by other projects

7.2 Results

The outcome of the scoring exercise at the Workgroup meeting is shown in Table 6. Based on the scoring (higher score is considered more preferable), the preferred pilot sites were ranked in the following order:

1. Ma'an
2. Mafraq
3. Madaba
4. Shobak
5. North Shouneh
6. Karak
7. Tafeleh
8. Irbid

The number of pilot project that will be designed and implemented is subject to the financing of the pilot project implementation. Therefore the workgroup did not draw a clear line to determine which pilot sites were "selected." Instead, the sites are prioritized as presented above, and planning for the Ma'an site, the site with the highest score, will commence upon an endorsement to proceed by USAID. Timing for the planning of the rest of new pilots will be determined based on the progress with the Ma'an site planning. At the time of this reporting, the assumption is that up to three pilot projects will be planned and designed.

Table 6: Site Selection Matrix, priority, weight for each selection criteria, scores of potential WWTP's, rank of potential sites

No.	Selection Criteria	Priority	Weight/Percent Influence	Wastewater Treatment Plants (Scores)*							
				Ma'an	Mafraq	Shobak	North Shouneh	Irbid	Tafeleh	Karak	Madaba
1	Geographic Location Agro-climatic Zone/ political	3	0.15	10	9	7	8	1	2	2	3
2	Current Water Quality	1	0.4	10	6	8	8	6	3	1	9
3	Water Quantity	2	0.3	7	9	1	2	1	8	8	5
4	Land Ownership/Land tenure	3	0.15	8	10	9	5	1	4	5	8
5	Land Suitability	3	0.15	6	8	8	10	1	4	4	8
6	Groundwater contamination	2	0.3	10	4	1	3	10	4	4	1
7	Groundwater Recharge	5	0.05	9	1	1	1	1	1	1	1

No.	Selection Criteria	Priority	Weight/Percent Influence	Wastewater Treatment Plants (Scores)*							
				Ma'an	Mafraq	Shobak	North Shouneh	Irbid	Tafeleh	Karak	Madaba
8	Community Willingness	2	0.3	10	10	7	7	7	7	7	10
9	Socio-economic status	3	0.15	10	10	10	7	5	10	10	7
10	Potential of marketing locally	2	0.3	8	10	6	7	7	4	8	6
11	Effort needed to form Association	5	0.05	10	10	10	1	1	10	10	10
12	Preference by USAID for funded a pilot project	5	0.05	10	10	10	10	6	6	6	4
13	Accesibilty to the land by stakeholders	3	0.15	10	10	10	1	10	10	10	10
14	Urgency to promote water reuse at the site	3	0.15	10	10	10	10	1	4	4	10
15	Availability of Local Labor	3	0.15	7	7	5	10	1	7	7	7

No.	Selection Criteria	Priority	Weight/Percent Influence	Wastewater Treatment Plants (Scores)*							
				Ma'an	Mafraq	Shobak	North Shouneh	Irbid	Tafeleh	Karak	Madaba
16	Readiness of the WWTP	1	0.4	10	7	10	7	8	5	7	10
17	Considered by other project	2	0.3	10	10	10	10	1	10	10	10
Class (Overall Weight)				**32.1**	**28.75**	**24.6**	**22.95**	**16.8**	**20.1**	**21.45**	**25.9**
Rank				**1**	**2**	**4**	**5**	**8**	**7**	**6**	**3**

*Score of 10

8 Water Reuse Pilot Project Planning

Following the identification of the pilot sites, the project team will develop detailed plans for the new pilot projects by:

- Identifying exact location of the pilot site within vicinity of the selected WWTPs
- Identifying specific goals and activities at the selected pilot sites, including, among others, plans to conduct training and research activities hosted by the stakeholders
- Seeking funding through the USAID Grant Program for implementation of the designed activities
- Developing organizational structure to implement, operate and maintain the pilots
- Reaching out to the local community to arrange the implementation of the pilot projects
- Developing detailed design and tender documents for the new pilot projects
- Supervising the implementation of the new pilot projects
- Clarifying the responsibilities for sustainable operation of the pilot projects
- Supporting stakeholders to engage in pilot activities with the local community

It is important to note that implementation of the pilot project will depend on the availability of the grant for the construction of the reclaimed water distribution system.

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Appendix A. Available Data

Table A-1. Wastewater Treatment Plants, Flows, and Quality

																		Effluent							
No.	Plant	in operation since	End use	Status	Fund for establishment	Notes	Type of Treatment (2010)	Avg. Design Flow m3/d 2010	inflow m3/d 2003	inflow m3/d 2004	inflow m3/d 2005	inflow m3/d 2006	inflow m3/d 2007	inflow m3/d 2008	inflow m3/d 2009	inflow m3/d 2010	Avg. Effluent m3/d 2010	pH unit	BOD5 mg/l	BODf mg/l	COD mg/l	TSS mg/l	TDS mg/l	T-N mg/l	DO mg/l
1	Kherbet As-samra W.S.P	1984		operating			Activated Sludge	267000	186823.1	209570	221509.3	224175	167190.3	70329	42874.1	230606	40728.4	7.89	97.1	77.3	314	92.3	868.8	312.8	
2	Kherbet As-samra Mechanical		flow	operating	USAID - 50% of the cost								61356.7	152587	179407		177248.6	7	8		139	10	1032.3	20.6	
3	Aqaba - tertiary	2005	irrigation + Potash industry (2.5 MCM/yr)	operating	USAID - 85% of the cost		Extended Aeration	12000			6951.5	7296	7630.2	8021	10101.8	9845.5	10410.3	7	5		19	4	637	26	
4	Aqaba - Natural	1987	irrigation	operating			Waste Stabilization Ponds	9000	10332.1	10332.1	7041	6229	5515.9	6626	6663.8	6730.6	6716.6	8	103	38	318	229	711	47	
5	Irbid	1987	flow through a pipeline to Wadi AL-Arab Dam where it is being reused in irrigation	operating	Loan - USAID		Biological Filter and Activated Sludge	11023	`8103.3	7776.3	6695.8	6353.8	6363.7	6463.5	8259.9	8132.1	7171.8	7.5	59.4		245.9	75.9	1006.6	92	5.8
6	Salt	1981	flow to Wadi Jerash	operating	some p		Extended Aeration	7700	4248.3	4431.3	4569.4	4321.9	4481.7	4483.6	4889.3	5290.7	4938.3	7.56	21.1		71.3	29.3	654.8	45.4	
7	Jarash East	1983	flow to Wadi Jerash where it is being diluted then reused	operating	part of the fund - Loan from France		Oxidation Ditch	3250	4358.6	3441.1	3593.3	3312	3391.9	3121	3224.6	3680.8	3477.8	7.2	64		289	83	1326.2	142.5	
8	Mafraq	1988	irrigation	operating		will be upgraded soon - fund from USAID	Waste Stabilization Ponds	1800	2188.5	2003	1958	1866.4	1990.8	2179	2234.9	2008.8	1643	7.95	139	139	432	137	1089	125.7	
9	Ain Basha - Baqa'a	1987	flow to the Wadi - then reaches Al-Malik Talal Dam where farmers reuse it	operating		upgraded in 2000 - Part of the fund (Loan from France)	Biological Filter	14900	12052.4	10587.6	10615	10978	11713.9	10720	11086.3	10208.6	9654.7	8	28		130	40	979	39.3	
10	Karak	1988	flow to Karak torrent	operating	Loan - USAID	MWI - upgrade under studying - upgrade fund from Germany	Biological Filter/and Maturation pond	785	1573.5	1755	1679.3	1618	1550.5	1205	1611.5	1753.4	1674.3	7.76	72		321	112	904.3	71.5	
11	Abu Nusair	1986	flow to Berien where part of is being used for forest irrigation	operating			Activated Sludge and R.B.C	4000	2214.9	2593	2240.3	2309	2357.6	2341	2563.6	2570.8	2512.3	6.4	16.4		49.2	12.7	942.5	23.8	
12	Tafila	1988	forest trees irrigation - flow to Ghour Fifa	operating	Loan - USAID		Biological Filter/and Maturation pond	1600	844.2	969.7	1116	1012.6	1181.1	1167.5	1249.3	1380	1214.7	7.9	40.9		150.8	45.7	1007.1	77.8	
13	Ramtha	1987	irrigation	operating		upgraded - fund (loan from France)	Activated Sludge	7400	3071.1	3053	3674.7	3492	3392.6	3561	3546.6	3488.3	2724.9	7	13		80	16	1374.7	3.4	
14	Ma'an	1989	irrigation	operating	natural treatment (1989) loan from EIB - upgrade for mechanical treatment (2009) USAID - 50% of the cost	MWI - another upgrade under studying	Extended Aeration	7000	2119.3	2370	2352	2644	2416.5	2325	2512.7	3170.8	3067.3	7.7	9.4		49.7	15.1	1019.1	16.7	
15	Madaba	1989	irrigation	operating	part of the fund - Loan from EIB	upgraded in 2003 - part of the fund loan from Korea	Activated Sludge	7600	4422.1	4542	4660.5	4584	4711.3	4883	4726.3	5172	4792.5	7.72	21		44	13	1169.3	13	
16	Kufranja	1989	flow to the Wadi where it is being diluted then reused	operating		will be upgraded	Biological Filter/and Polishing pond	1900	2787.1	2402.7	2794.6	3387	3930.5	2828.2	3518.3	2763	2565.2	7.3	102.8		370.8	104.5	1052.7	114.8	
17	Wadi Al Seer	1997	flow to the Wadi - then reaches Sad Al-Kafrein	operating	part of the fund - Loan from Korea		Aeration Lagoon	4000	2445.2	2265	2762	2718	3113	3426	3454	3623.8	3225	7.6	19.5	12.1	170.6	52.8	796.4	90.1	
18	Fuheis	1997	flow to Wadi Sho'eb where farmers at Ghour reuse it	operating			Activated Sludge	2400	1942	1560	1606.3	1684	1791.6	1860	2056	2221	2166.9	7.56	19		59	23	901.6	26.3	
19	Wadi Arab	1999	flow	operating	loan from KFW Germany		Extended aeration	20800	6666.5	7085	8315.9	9959.9	10701.4	9922	12190.9	10264	9539.1	8	10		83	7	1015.7	33.9	
20	Wadi Mousa	2000	irrigation	operating	USAID		Extended Aeration	3400	900.3	1391.4	1820.4	1669.9	1984.3	2265.8	2508.8	3028.9	2835.4	7.1	4		38.3	19.9	850.1	12.9	8.6
21	Wadi Hassan	2001	irrigation	operating	loan from KFW Germany		Oxidation ditch	1600	725.2	1061	1140.7	1098.5	964.3	997.6	1049.7	1131.8	969.6	6.9	13		67.2	11.7	1092.8	6.6	5.5
22	Tall-AlMantah - Der Alla	2005	irrigation	operating - septage	grant from Canada		Biological Filter and Activated Sludge	400			271.5	274.1	290.3	298	301	300	291.6	7	18.8		74.2	40.5	1226.4	120.4	
23	Al-Akaider	2005	irrigation	operating - septage			Waste Stabilization pond	4000			3156	2872	3698.8	3376	3437	3907.8	2906.8	8.07	106	82.7	475	159	1431	85.6	
24	Alljoon	2005	irrigation	operating - septage	will be upgraded	upgrade under studying	Waste Stabilization pond	1000			634.8	502	518	566.3	743.1	853.1	725.1	8	81.9	33.8	504	284.7	1767.1	135.2	
25	South Amman - Thehaibeh			under construction																					
26	Shallaleh			under construction	KFW Germany			13500																	
27	Jarash West			under construction																					
28	Al Jeezah & Talbeyyeh	2008		operating	New		activated Sludge	4000								703.9	202.8								
29	Shoubak			operating				300																	
30	Mazar/Mo'uta			under construction																					
31	South Shouneh			under construction																					
	Total m3/d								**249714.4**	**279189.2**	**301158.3**	**304357.1**	**312236.9**	**305552.5**	**314211**	**322836**	**303403**								
	Total MCM/yr								**91.146**	**101.904**	**109.923**	**111.090**	**113.966**	**111.527**	**114.687**	**117.835**	**110.742**								

Reference: Annual Reports of Water Authority for the year 2008, 2009, 2010

Appendix B. Quality Limits

Table B-1. JS893:2006 Quality Limits for Water Reuse and Wadi Discharge

Parameter	Unit	A. Cooked vegetables, Parks, Playgrounds and sides of roads within city limits	B. Fruit trees, Sides of roads outside city limits, and landscape	C. Field crops, industrial crops and forest trees	D. Cut flowers	Groundwater recharge	Wadi dischrage
Group A							
BOD	mg/L	30	200	300	15	15	60
COD	mg/L	100	500	500	50	50	150
DO	mg/L	>2			>2	>2	>1
TSS	mg/L	50	150	150	15	50	60
pH	pH unit	6-9	6-9	6-9	6-9	6-9	6-9
Turbidity	NTU	10			5	2	
Nitrate	mg/L	30	45	45	45	30	80
Ammonia	mg/L					5.0	
TN	mg-N/L	45	70	70	70	45	70
E coli	/100mL	100	1000		<1.1	<2.2	1000
Helminths	/L	≤1	≤1	≤1	<1	≤1	<0.1
FOG	mg/L	8	8	8	2	8	8
Group B							
Phenol	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
TDS	mg/L	1500	1500	1500	1500	1500	1500
MBAS	mg/L	100	100	100	15	25	25
T Phosphate	mg/L	30	30	30	30	15	15
Chloride	mg/L	400	400	400	400	350	350
Sulfate	mg/L	500	500	500	500	300	300
Bicarbonate	mg/L	400	400	400	400	400	400
Sodium	mg/L	230	230	230	230	200	200
Magnesium	mg/L	100	100	100	100	60	60

Parameter	Unit	A. Cooked vegetables, Parks, Playgrounds and sides of roads within city limits	B. Fruit trees, Sides of roads outside city limits, and landscape	C. Field crops, industrial crops and forest trees	D. Cut flowers	Groundwater recharge	Wadi dischrage
Calcium	mg/L	230	230	230	230	200	200
Aluminum	mg/L	5	5	5	5	2	2
Arsenic	mg/L	0.1	0.1	0.1	0.1	0.05	0.05
Beryllium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1
Copper	mg/L	0.2	0.2	0.2	0.2	1.5	0.2
Fluoride	mg/L	2.0	2.0	2.0	2.0	2.0	1.5
Iron	mg/L	5.0	5.0	5.0	5.0	5.0	5.0
Lithium	mg/L	2.5	2.5	2.5[a]	0.075	2.5	2.5
Manganese	mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Molybdenum	mg/L	0.01	0.01	0.01	0.01	0.01	0.01
Nickel	mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Lead	mg/L	0.2	0.2	0.2	0.2	0.2	0.2
Selenium	mg/L	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	5.0	5.0	5.0	5.0	5.0	5.0
Boron	mg/L	1.0	1.0	1.0	1.0	1.0	1.0
Chromium	mg/L	0.1	0.1	0.1	0.1	0.05	0.02
Mercury	mg/L	0.002	0.002	0.002	0.002	0.001	0.002
Vanadium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1
Cobalt	mg/L	0.05	0.05	0.05	0.05	0.05	0.05
Cyanide	mg/L	0.1	0.1	0.1	0.1	0.1	0.1
SAR	-	6	9	9	9	9	6

[a] for citruc crops, the limit is 0.075 mg/L
Note: TDS = total dissolved solids, MBAS = methyl blue active substances (detergents), SAR = sodium adsorption ratio