WASTEWATER TREATMENT FACILITIES FOR SMALL COMMUNITIES IN JORDAN

TASK 3
DRAFT ENVIRONMENTAL ASSESSMENT
SHOBAK

December 2005

This publication was produced for review by the United States Agency for International Development and the Water Authority of Jordan. It was prepared by ECODIT in cooperation with MWHAJ under subcontract with IRG.

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Prime Contract EPP-I-00-03-00013-00
EPIQ II Task Order 800

DISCLAIMER

Executive Summary

The Water Authority of Jordan with the support of USAID plans to implement a low-maintenance wastewater treatment and reuse (WWT&R) project in Shobak using proven, appropriate technology. This WWT&R project is part of the wider USAID-funded activity, Wastewater Treatment Facilities for Small Communities in Jordan (the "Small Communities Project"). This report presents the Environmental Assessment for the project in Shobak. A separate Final Feasibility Study Report has also been submitted.

EA methodology

The project team conducted a scoping session on February 21st, 2005 at the National Center for Agricultural Research and Technology Transfer (NCARTT) in Shobak and submitted a scoping statement immediately thereafter. This draft EA report was researched and prepared on the basis of the MoE and USAID approved scoping statement by a multidisciplinary team of seven specialists with proven EA experience in Jordan under the supervision of the Chief of Party. The team visited the sites and surrounding area on several occasions, collected and interpreted data from several official sources and consulted numerous stakeholders to identify all significant environmental concerns and mitigation measures.

Major project stakeholders consulted regularly since the inception of the project include WAJ, the MWI, the Municipality of Shobak (MBJ), several local community leaders, the MoI (Mutassarif) and septage tanker operators. Several consultations have also taken place with various other stakeholders including the MoE, MoH, the Military, the MoA, DoA, DLS, other municipalities, environmental organizations and other local and regional NGO's and civil society organizations, research institutes and several members of the general public.

Description of the proposed project

The proposed WWTP service area and design capacity

The proposed WWTP will serve communities in the Shobak region that lack sewage collection networks and depend on septage tanker trucks for the collection and disposal of their wastewater. Initially, the proposed WWTP will serve a large geographical service area, including the Municipalities of Shobak Al Jadideh, Husseiniyeh Al- Jadideh and Asha'ari in the Ma'an Governorate as well as Qadissiyeh in the Tafileh Governorate. As time progresses the WWTP will only be able to serve the Municipality of Shobak and a small portion of some of the surrounding areas.

The plant is expected to begin operations in 2008 and is designed for a 20-year time horizon (i.e., until 2028) with an influent capacity of 350 m3/day of septage. As such, the WWTP can serve over 30,000 people in the earlier years of operation, tapering down to around 20,000 to 25,000 people as time progresses. The WWTP however, may be expanded up to 580 m3/day in order to serve a larger region for a longer period of time if needed in the future within the existing site and if using the same WWTP technology as that proposed here.

The proposed WWTP site

The proposed WWTP site is located 2 to 3 km northeast of the intersection between the main road coming from the Desert Highway to Shobak and the main road going to Qadissiyeh from Shobak: approximately 1 to 2 kilometers away on average from each of these main roads. The property (266 Dn) was selected in consultation with a wide range of stakeholders as one of the only properties in the area that satisfied several environmental, economic and technical criteria. The property and the area surrounding it is generally uninhabited, with the exception of some Bedouin families that may occasion the area during the spring and summer and some land owners sowing rain-fed fodder or renting their lands out for the same purpose. The property is privately owned and has been fully approved for acquisition without objection from the current owner. There are no permanent surface water flows in or near the project area and the groundwater level is relatively deep (100 to 200 m bgl). There are no groundwater wells in the vicinity and the nearest springs (about 3 km away) are dry.

The proposed WWTP technology

Following a rigorous comparison of several treatment alternatives, the detailed design of the WWTP in Shobak will be based on: screening and grit removal; sedimentation/sludge digestion tanks; intermittent sand filters; constructed wetlands (reed beds); evaporation ponds; and sludge drying beds. These consecutive treatment steps are required to ensure zero effluent discharge through evapo-transpiration (reed beds) and subsequent evaporation, while effectively removing and handling solids during the pre-treatment steps to avoid any solid-related problems (e.g., clogging of reed beds). The sludge removed and sent to the drying beds will be stable after a minimum of 30 days digestion. All treatment units will be concrete or HDPE lined.

Reuse

As there will be zero discharge from the proposed WWTP, no reuse of effluents in irrigation will occur. Productive use of the WWTP byproducts including reeds harvested from the reed beds and sludge produced and treated according to relevant standards will be encouraged.

Potential impacts, mitigation measures and environmental management

The overall net impact of the project on the environment in the area will be positive. Potential adverse impacts, mostly limited to the area immediately surrounding the WWTP, have nonetheless been comprehensively identified and assessed. Specific mitigation measures are proposed that ensure potential impacts are minimized.

Positive impacts

The project will result in several positive impacts on the environment and communities in the area. Most significant of these are that it will: reduce the costs borne by households to empty cesspits by providing a nearby, long-term WWTP solution that will receive and treat septage in an environmentally friendly manner. It will improve public health/sanitation and protect soil and water resources in the region by minimizing current cesspit overflows and controlling current tanker disposal practices.

The project will also help strengthen local institutions and forge community and public/private partnerships as well as improve public perception in relation to use of WWTP byproducts. The project planning process included measures to enhance these and other potential positive impacts. The design will provide further enhancement of positive impacts as will the environmental management plan for the long-term operations.

During construction

As with all infrastructure projects, the potentially significant adverse impacts during construction include air quality deterioration from earthworks and transportation, impacts from the disposal of excavated materials and construction waste as well as health and safety hazards. The mitigation measures proposed include strict coordination with the military, carefully designing and planning earth works and a construction transport management plan, implementing various measures to minimize dust impact, ensuring appropriate separation, handling and disposal of wastes and requiring various other health and safety measures to be implemented.

The construction site itself is also at risk from erosion, however an evaluation of the site and the design and implementation of necessary erosion/runoff control will minimize this risk if construction is to carry through to the winter. With such mitigation measures, discussed and specified in detail in this report, all residual adverse impacts will be minimized.

During operation

Potential adverse impacts during operation include odor emissions, pollution from inappropriate treatment and reuse / disposal of sludge, an increase in nuisance species including the black rate and house mouse as well as venomous scorpions, occupational health and safety hazards (e.g., workers falling in open basins, exposure to dosing chemicals and reuse effluent), and potential occurrence of parasitic diseases. Impacts from effluent discharge and or reuse of TWW are not applicable, as the selected WWTP does not produce any effluents. Nonetheless, seepage and or leaks from the lined units could occur and are adequately mitigated. It is important to note, the site is located in an area that is already degraded from intensive grazing and groundwater abstraction has irreversibly lowered the water table.

Mitigation measures proposed include a major focus on odor minimization in the WWTP design, conservative design with high operational flexibility including several hydraulic safeguards as appropriate, disease vector and pest control management as well as requiring various other standard health and safety procedures. Planned groundwater monitoring and early warning systems will help protect the water resources in the immediate area. These systems and other mitigation measures will also assure rapid remediation of any unanticipated adverse effects.

Risks to the WWTP structures and its appropriate operation

The project site is situated within Region B on Jordan's map of seismic zones. The probability of experiencing a severe earthquake in Shobak is considered low, however the WWTP will be designed and built with strict adherence to the relevant Jordanian building codes (Zone B). Several other risks that may hinder normal operations include receiving non-residential septage, volumetric flow imbalances, flooding and power failures. The project design and operating procedures will include emergency response procedures and specific contingency plans for each of these risks to ensure adequate protection of the environment.

Environmental management and monitoring

This report presents a meticulous environmental management and monitoring plan (EMMP) to ensure environmentally sound project implementation, monitoring and follow-up with responsibilities and timings assigned for each particular mitigation measure. This EMMP must be continuously revisited by the project team, contractor, Shobak Municipality and other concerned stakeholders to ensure it is being implemented, remains up to date and is adjusted where and when necessary to keep potential adverse impacts at a minimum and increase the benefits generated by the project.

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Acronyms and Abbreviations

AIPS	Advanced Integrated Pond Systems
AL	Aerated Lagoons
AS	Activated Sludge
asl	Above Sea Level
BAF	Biological Aerated Filters
BOD	Biological Oxygen Demand
CBD	Convention on Biological Diversity
CITES	Convention on International Illegal Trade with Endangered Species
CMS	Conservation of Migratory Species
COD	Chemical Oxygen Demand
CW	Constructed Wetlands
DLS	Department of Lands and Surveys
Dn	Dunums (1 Dn = 0.1 Hectares = 1,000 m^2)
DOA	Department of Antiquities
EA	Environmental Assessment
EMMP	Environmental Management and Monitoring Plan
EPIQ II	Environmental Policy and Institutional Strengthening Indefinite Quantity Contract II
FPR	Al-Fujaij Pastoral Reserve
FS	Feasibility Study
GHG	Greenhouse Gases
H&S	Health & Safety
HDPE	High Density Polyethylene
IBA	Important Bird Areas
IEE	Initial Environmental Examination
IUCN	International Union for the Conservation of Nature
JADIS	Jordanian Archaeological Data Information System
JD	Jordanian Dinar (1 JD = 1.41 USD)
bgl	Below ground level
MBR	Membrane Bioreactor Systems
MWI	Ministry of Water and Irrigation
NCARTT	National Center for Agricultural Research and Technology Transfer
NGO	Non Governmental Organization
O&M	Operation and Maintenance
OD	Oxidation Ditch Systems
RSF	Recirculating Sand Filters
TDS	Total Dissolved Solids
TF	Trickling Filters
TFCC	Total Fecal Coliform Count
TSS	Total Suspended Solids
TWW	Treated Wastewater
UASB	Up-flow Anaerobic Sludge Blanket
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WL	Water Level
WSP	Waste Stabilization Ponds
WWT&R	Wastewater Treatment and Reuse
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

In support of the people and Government of Jordan, USAID plans to finance the implementation of a low-cost low-maintenance wastewater treatment and reuse (WWT&R) project in Shobak. This is a four-year project implemented for the Water Authority of Jordan by IRG and ECODIT under the USAID Environmental Policy and Institutional Strengthening Indefinite Quantity Contract II (EPIQ II). In accordance with USAID (22 CFR 216) environmental review requirements, an initial environmental examination (IEE) prepared by USAID Jordan in August 2004 requires a full environmental assessment (EA) to be carried out for the proposed project. This report presents the EA, which is a detailed study of the reasonably foreseeable significant effects, both beneficial and adverse, of the proposed WWT&R project on the environment.

1.1. Background to the Small Communities Project

The WWT&R project in Shobak is part of the wider activity, Wastewater Treatment Facilities for Small Communities in Jordan (the "Small Communities Project"). The Small Communities project will design, supervise and construct proven low-cost/low-maintenance, wastewater treatment plants (WWTP) and reuse facilities to serve Shobak and North Shouneh (both communities lack sewage collection networks).

The Jordanian Wastewater Management Policy states that central treatment plants shall be built to serve semi-urban and rural communities and collection of wastewater shall be made initially through trucking until such a time when collection systems (such as an underground piping network) are justified. Trucking wastewater to the central treatment plants eliminates the need for expensive collection infrastructure and provides flexibility in selecting sites. It also facilitates a "community cluster approach," serving several neighboring rural communities.

The Small Communities Project will also develop local capacity to operate and maintain the facilities in a sustainable manner after the project ends, turn over the operation and maintenance of these facilities to local bodies (Municipality, Village Councils, Private Sector, etc.), and eventually reuse the treated wastewater (TWW). This will serve as a model for other areas in Jordan. The Project began in the summer of 2004, will span four years and covers a scope of work comprised of the following detailed tasks:

- **Task 1:** Conduct preliminary planning activities (& select communities to work in);
- **Task 2:** Prepare a feasibility study
- **Task 3:** **Conduct a Scoping Session for the public and stakeholders and prepare EIA;**
- **Task 4:** Establish "institutional partnerships" and cost recovery mechanisms;
- **Task 5:** Prepare detailed engineering design/drawings and bid documents;
- **Task 6:** Select contractors and supervise construction;
- **Task 7:** Monitor plant operations and the quality of treated effluents;
- **Task 8:** Implement the wastewater reuse components;
- **Task 9:** Provide capacity building and training related to the projects;
- **Task 10**: Assist the Government of Jordan in the formulation of policies, guidelines, and standards related to WWT&R; and
- **Task 11:** Prepare final report including lessons learned.

This chapter describes the location of the wastewater treatment plant, summarizes the project activities during the pre-construction, construction, operation and maintenance phases as well as the planned activities in relation to water reuse.

1.2. Purpose of the EA

Consistent with USAID environmental regulations 22 CFR Part 216 and Jordanian draft EA guidelines, the objectives of this EIA are to:

1) Assess and analyze the significant environmental issues related to the project;
2) Describe and compare project alternatives;
3) Identify and describe the positive and potential adverse impacts of the project on the environment; and
4) Propose measures to mitigate the potential adverse impacts and formulate a monitoring program with clear delineation of responsibilities. The EA is also a planning tool to minimize negative environmental impacts by enhancing the project design.

According to the IEE prepared by USAID Jordan in August 2004, all of the above project tasks with the exception of Task 6 and Task 8 qualify for "Categorical Exclusions" per 22 CFR 216.2(c)(2)(iii), (xiv), (xv) and/or (i). Task 6 is given a "Positive Determination" requiring the design, feasibility, and construction management contractor to prepare a combined scoping session and full EA per 22 CFR 216.2(d)(xi) as "classes of actions normally having a significant effect on the environment". Task 8 qualified for a "Negative Determination" as it is not expected to have a negative impact on the environment, as proposed mitigation measures will eliminate/minimize negative impacts. Nonetheless, reuse design and operational considerations are addressed in this EA.

1.3. Methodology

Guided by the IEE determination, the project team drafted a scoping brief based on the identified project alternatives and general understanding of the local situation. This brief provided the background for the Scoping Session that was conducted on February 21st, 2005 at the National Center for Agricultural Research and Technology Transfer (NCARTT) in Shobak. Following the scoping session in Shobak, the team prepared and submitted to USAID a scoping statement. The Scoping Statement anticipated potentially significant issues and proposed how and by whom the EA study will be conducted. This scoping statement was also used to establish a common understanding between USAID and the Water Authority of Jordan / Ministry of Environment on the EA issues related to the project in Shobak and forms the basis for this EA report. USAID submitted the scoping documents to MOE on March 15 and MOE replied with agreement in principle on May 2nd 2005. A final Scoping Statement was submitted to USAID in early June.

As a result of delays in finalizing and approval of the feasibility study, the submission of this DRAFT EA was also delayed. After the draft feasibility study was complete, WAJ noted that very little reusable water was produced while the capital costs of the proposed WWTP were comparatively high. WAJ and USAID requested the project team to prepare an amendment to the original study to compare the preferred alternative with a new alternative that would produce zero discharge of effluent. All of the alternatives studied are presented here.

The EA team visited the preferred candidate sites in Shobak and collected baseline data including population and economic activities, septage generation and collection (part of feasibility study), important recreational, cultural and historic areas, topography, hydrogeology, climate, biodiversity (fauna, flora, avifauna) and ecosystem as relevant to the defined study area and potential impacts identified in the Scoping Statement.

The project activities, their impacts and specific mitigation measures are summarized in tabular format along with the necessary monitoring requirements, indicating the roles and responsibilities for implementing the mitigation measures/monitoring etc. This environmental management and monitoring plan (EMMP) is intended to be practical and will need to be periodically reviewed and updated during the lifetime of the project. As such, it will serve as the cornerstone for ensuring the implementation of the EA recommendations and any adjustments where and when deemed necessary in the future.

1.4. Report Organization

This report is organized into seven chapters:

1. Introduction
2. Analysis of alternatives and description of the proposed project
3. Legal and institutional framework
4. Description of the existing environment (affected areas)
5. Assessment of impacts and proposed mitigation measures
6. Environmental management and monitoring plan
7. Conclusions

There are six appendices to the main report:

Appendix A	Preliminary WWTP Layout, Process Flow and Hydraulic Profile
Appendix B	Sludge Standards JS 1145/1996
Appendix C	Population and Monthly Wind Data
Appendix D	Jordan Archaeological Data Information System (JADIS)
Appendix E	List of Observed and Known Species
Appendix F	References
Appendix G	The EA Team
Appendix H	Stakeholder consultations and approvals

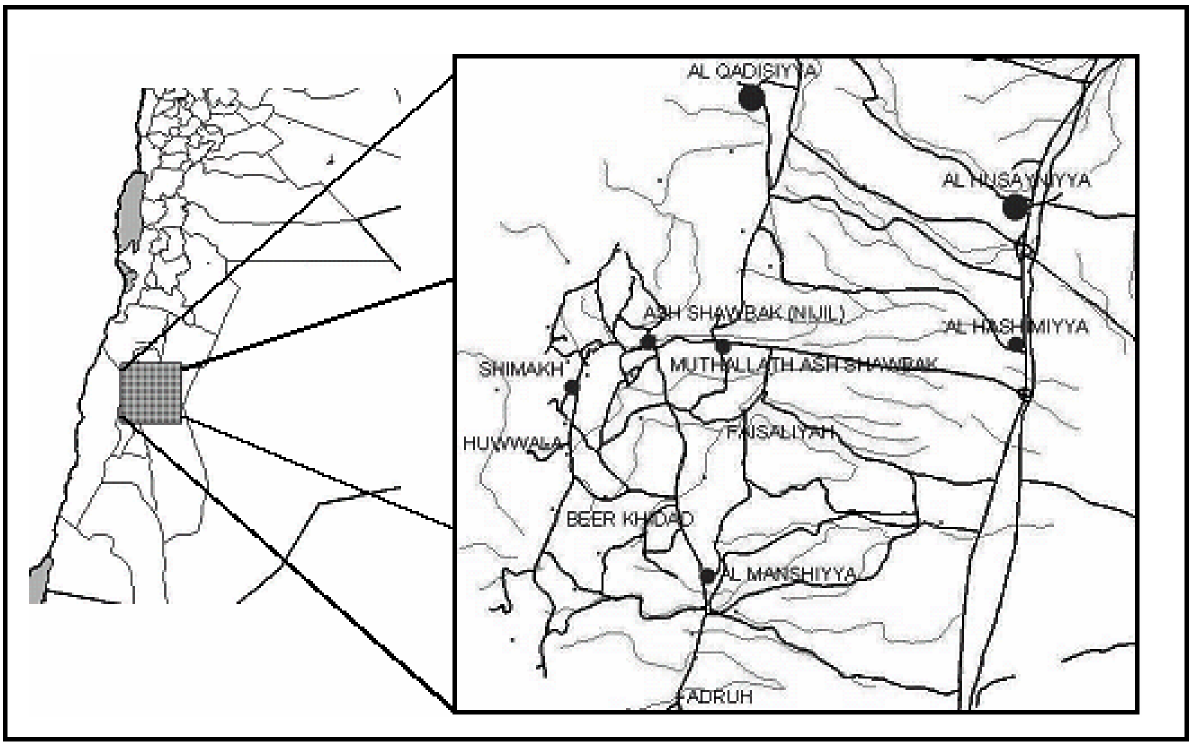
2. ANALYSIS OF ALTERNATIVES AND DESCRIPTION OF THE PROPOSED PROJECT

This chapter provides an overview of the project area and its current situation with respect to septage generation, collection and disposal. It discusses the need for the project, the project alternatives considered and provides the rationale for the preferred action: including the preferred location for the wastewater treatment plant, technology to be used, the service area and the proposed water reuse activities. It also summarizes the project activities during construction, operation and maintenance.

2.1. Overview of potential service area alternatives and need for the project

The sub-district (Liwa'a) of Shobak is located in the south of Jordan, in the northernmost part of the Ma'an Governorate. Liwa'a of Shobak has a population of approximately 12,000 people (with Shobak Najil and Muthalath as its two largest towns). Two Municipalities within Ma'an Governorate border Liwa'a Shobak: the Municipality of Asha'ari (with Manshiyyeh as its largest town) to the south and the Municipality of Al Husseiniyeh Al-Jadideh (with the towns of Husseiniyeh and Hashmiyeh) to the northeast. The Municipalities of Asha'ari and Al Husseiniyeh have populations of approximately 3,500 and 8,000 people respectively. To the north, the town of Al Qadissiyeh (approximately 7,000 people) falls within the Tafileh Governorate. Additional details on the demographics of the area is available in Section 4.2.a. Population density is relatively low with the exception of the central areas of a few towns. Figure 1 below shows the main towns and roads in these areas

Figure 1
Map of the Shobak Area



Within these areas, five septic tankers currently operate full-time to dispose of 200 to 300 m3 of septage per day. Occasionally, a few additional tankers work the area. Some households have to pump their cesspits more frequently than others, depending on the household size, location (geology), the age and size of their cesspit, and other factors. On average, households pay anywhere between 5 and 25 JD[1] for this service (each tanker trip), depending on the distance tankers must travel. Currently tanker drivers dispose of septage in designated dumping areas (not WWTPs) that are causing greater and greater environmental damage and health hazard as time progresses. Additional details on the quantities of septage produced and projections for the future are available in Section 4.2.b.

2.1.a. The no action alternative

The only acceptable alternative to current practices is to dispose of the septage at existing WWTPs. These existing WWTPs are 30 to 80 km away depending on the source village/town. This alternative would place a heavy economic burden on households (as tankers must charge them significantly higher prices) and reduce the number of trips that tankers can make in a day as a result of the longer round-trip distances. This, in turn, would limit the number of households they can serve in a day and would eventually cause a backlog or waiting list for their services.

During the summer months and at average current private tanker transport rates, the septage transport savings associated with the selected site may reach as high as 30,000 JD per month when compared with the no-action alternative of requiring tankers to discharge at the Ma'an WWTP. This can be expected to increase beyond 70,000 JD per month by 2028 without considering inflation in transport costs.

Some households are already failing to empty the tanks as frequently as they should because costs are so high. The reduced service levels caused by longer travel distances would exacerbate the problem. Households would pump their cesspits with even less frequency, there would be more overflows and, because of the increased costs, the communities would see even more evasive strategies such as digging new permeable cesspits, which would further damage the environment and negatively impact community health. Tankers would also be more likely to discharge in illegal areas along the way. The quantities requiring disposal are increasing over time and without this project, would increasingly cause significant pollution of soils, water resources as well as a further hazard to public health and further drain meager family incomes.

2.2. Design capacity, service area and phasing

Service areas and design capacities for septage-based WWTPs differ significantly from WWTPs designed to treat raw sewage (i.e., arriving to the plant via a sewage collection network). With septage hauled by tanker trucks, the service area can vary over space and time: whereas in the case of sewers, the service area is usually well defined over both space and time. This means that the service area for septage can be larger during the earlier years of operation to make use of excess capacity. Septage also tends to peak during the summer, while lower volumes characterize the winter flows - with all quantities arriving during the daytime. The service area may also be expanded during the winter, balancing seasonal flow differences. Daily peak flows can easily be accommodated within implicit equalization capacity.

There are several alternatives regarding the design capacity, corresponding to different service areas for the WWTP (i.e., the communities that will send their septage to the WWTP). The two extremes, with options in between, are:

1. "**Shobak Only**": with a WWTP design capacity of 350 m3/day (high flow), serving all communities in the Shobak Sub-district ("Liwa'a")
2. "**Shobak Region**": with a WWTP design capacity of 750 m3/day (high flow), serving all communities in the Shobak Sub-district, in addition to Qadissiyeh in the Tafileh Governorate as well as the Municipalities of Husseiniyeh Al- Jadideh and Asha'ari in the Ma'an Governorate.

In each case, the WWTP would be designed to receive septage from each potential service area for 20 years (20-year time horizon); after that, additional expansion or another WWTP would be required to

[1] Conversion rate: 1 JD = 1.41 USD

meet the additional septage being generated by increased population. Several combinations of municipalities or communities being served were also assessed with resulting design capacities falling within these two extremes. During the EA scoping session, there was a preference from the majority of stakeholders to opt for the "Shobak Region" service area alternative.

An appropriate site that satisfied both extremes mentioned above was found and selected as discussed in Sections 2.3. Upon further assessment, the project team was unable to confirm which choice of service area is the optimal one from an economic or institutional perspective. The possibility of building the WWTP in two phases therefore allows for this decision to be made in the future if needed. Therefore, the project team recommended a flexible approach, which satisfies the short-term needs of the region, medium term-needs of most of the region, but leaves long-term decisions on the final capacity and service area of the WWTP to be determined at a later date. As such, the recommended capacity is for an average annual daily flow of 350 m3/day, which in 2028 can serve all of the communities within the Shobak Municipality as well as a portion of the septage from some of the other surrounding municipalities.

2.2.a. Proposed design capacity and service area

The influent design capacity for the WWTP is 130,000 m3/year. This corresponds to an average daily influent of 350 m3/day throughout the year. With such a design influent distribution the WWTP can accept septage from a relatively wide region during the short-term including all communities under the jurisdiction of Shobak, Al Asha'ari, Husseiniyeh and Qadissiyeh municipalities. Septage from a few other towns within Tafileh Governorate (e.g. Busaira, Ain Al Baydha and Ghrandal) could also be accepted, especially during the earlier parts of this period, but would need to be limited.

During the medium term, the WWTP will be able to accept septage from Shobak and Qadissiyeh municipalities, but will need to start limiting septage received from other municipalities, especially towards the latter stages of this second period. At 130,000 m3/year, the WWTP will be able to continue to accept septage from an ever-decreasing service area until around 2018, possibly through to 2022. At that time the WWTP would only be able to accept a volume of septage equivalent to that produced by Shobak and Qadissiyeh municipalities.

The evolution of the service area over time can follow a different order to that mentioned above and will need to be determined as and when needed by the operator of the WWTP, WAJ and through the institutional arrangements vital for the project's success. Nonetheless, throughout its lifetime the plant should continuously serve 25,000 to 35,000 people. The exact number of people will vary with the service area, and may in fact be slightly higher or lower than this range, as different communities generate septage at different rates.

2.2.b. Phasing, expansion and decommissioning

Selecting 130,000 m3/year for the design capacity is deemed most appropriate as it provides flexibility in making regional phasing/planning decisions as required. For example, by adding additional treatment trains at anytime during the first 5 to 15 years of operation, the WWTP can be expanded in order to maintain a larger regional service area. Conversely, it can be kept at 130,000 m3/year without expansion for 10 to 20 years if, by then, it is deemed best to keep this WWTP for a smaller service area and build separate WWTP's in other locations for the long-term. If deemed best to keep this WWTP for Shobak and Qadissiyeh municipalities only, then the WWTP would need to be expanded around year 15 in order to continue serving both communities for a longer period of time (e.g., by adding another treatment train in order to last for another 10 years).

A design capacity of less than 130,000 m3/year would require such planning decisions to be made under pressure during a more limited timeframe. On the other hand, aiming for a higher treatment capacity upfront risks building a WWTP that is oversized for what may be the most efficient or desired service area in the long-term as the situation on the ground can be unpredictable and policies may change in the future. Given inherent uncertainties in the evolution of septage generation over time, such decisions are best left until the WWTP has been in operation for several years and better information is available through the operating records of the plant. Expansions would be more appropriately designed and overloading less likely as capacity limitations (and decentralization policies) will have been more realistically established. Centralization/expansion has the advantage of reducing costs through economies of scale, in particular operating costs; while decentralization has the advantage of reducing the transportation cost burden on households and associated environmental risks of longer transport distances.

The ability to convey sewered wastewater to the site by gravity was taken into consideration during site selection and the WWTP will be designed to minimize any modifications needed to be able to accept sewered wastewater if needed in the future. Though these efforts have and will be included, conveying and treating sewered wastewater are not the main purpose of this project's design.

Decommissioning is not considered here as the WWTP is expected to either continue to serve a portion of the population within the design capacity, in which case a separate treatment plant will need to be provided or it will be upgraded, as are most WWTP's in the country, in order to be able to serve a larger population for a longer period of time.

2.3. Alternative WWTP sites

The project team in close cooperation with the Municipality and other stakeholders identified and assessed six potential WWTP locations. These are:

Site 1. Approximately 2 to 3 km southeast of the village of Faisaliyeh (previously, Mudhaibee);

Site 2. Near the Qadissiyeh – Shobak intersection, between the main road coming from the Desert Highway to Shobak and the main road going to Qadissiyeh from Shobak. Approximately 200 meters to half a kilometer away on average from each of these main roads;

Site 3. Approximately 2 to 3 km north of the village of Beir Khdad, 1 to 2 km east of Huwalleh;

Site 4. Approximately 1 to 2 km south east of Muthalath Shobak, 2 to 3 km east of Zbairiyyah;

Site 5. Approximately 1 to 2 km north east of Site 2, making this site approximately 1 to 2 kilometer away on average the main roads (Desert Highway-Shobak and Qadissiyeh-Shobak roads); and

Site 6. Approximately 1 to 2 km North West of Site 5, just to the west of the Qadissiyeh-Shobak main road, located in the Fujaij rangeland/pastoral reserve.

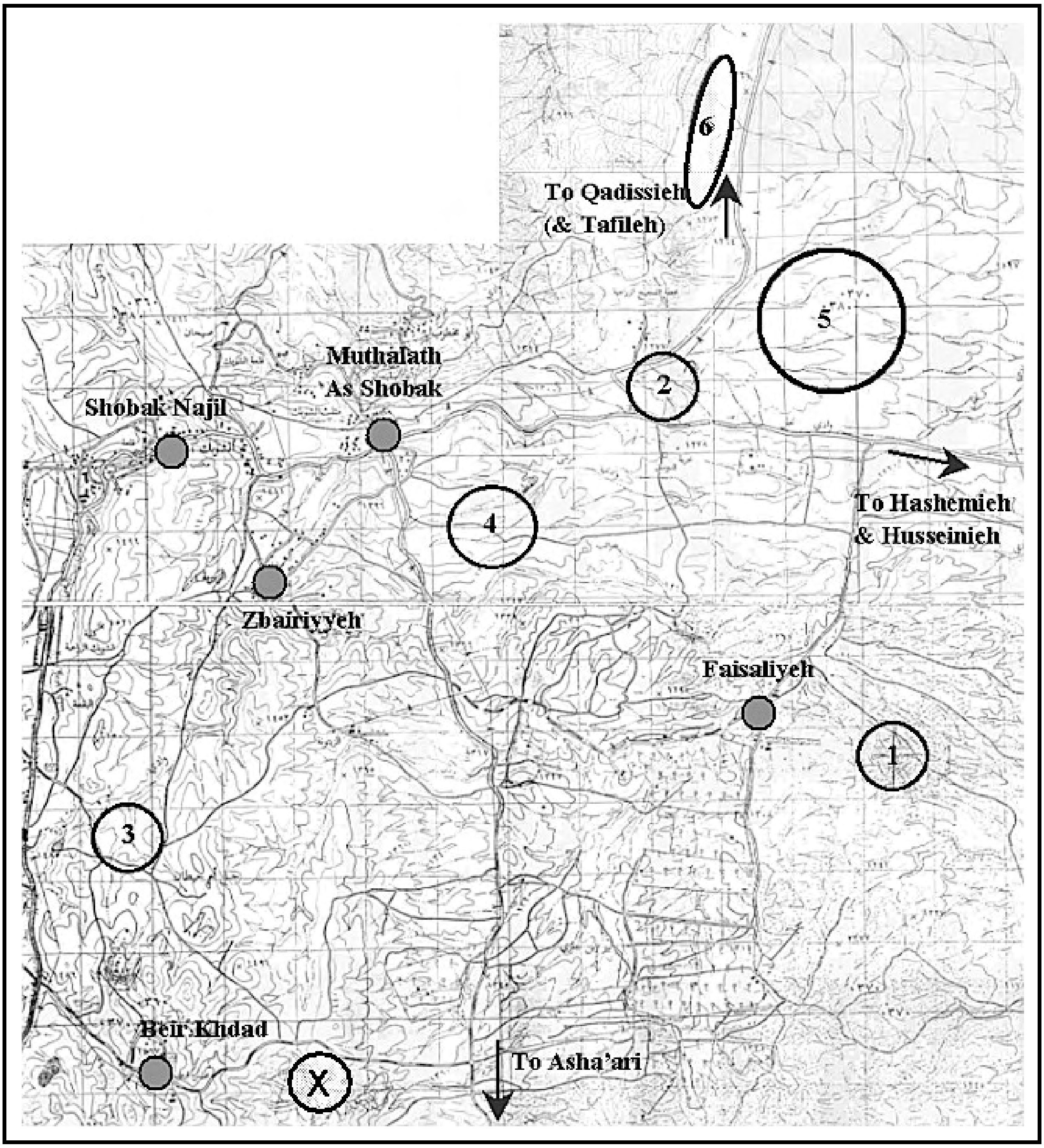
The advantages and disadvantages provided in Table 1 and the subsequent rationale and recommendations for the preferred alternative provided in the section that follows are based on the project team's assessment of these sites and build on stakeholder opinions solicited during discussions on the project alternatives at the Scoping Session and site visits with an inter-ministerial site selection committee. A map of these 6 sites is available in Figure 2.

Table 1
Key Advantages & Disadvantages of Site Location Alternatives

Site	Advantages	Disadvantages
Site 1.	• Government owned property • Plenty of space for future expansion • Plenty of suitable reuse areas nearby • Already approved by relevant government institutions • Minimal transport required through major residential areas	• Far from most communities (significantly the highest transport costs under all scenarios) • Least appropriate for potential future sewerage (except for Faisaliyeh) • Requires about 2 km of access road, water & electricity supply lines • Near Faisaliyeh (odors, mosquitoes, pests)

Site	Advantages	Disadvantages
Site 2.	• Government owned property • Downstream of major population centers (potential future sewerage): ~1,280 m.a.s.l. - potential sewerage for Qadissiyeh as well as main Shobak towns • Ideal location in terms of distance from main septage generating towns/villages (lowest transport costs) under the "Shobak Region" service area alternative • Downwind & far enough from residents, Adjacent to utilities (electricity, roads,) • Minimal transport required through major residential areas	• Very close to main roads (esp. on route to Petra) and could present a risk in terms of aesthetic impacts (odors and scenery) • Potentially limited space for future expansion under the "Shobak Region" service area alternative • Considered a prime-property (potentially more valuable development in the future on such a site) • Although appropriate for most towns in the "Shobak Region" service area alternative with respect to distances, this area is furthest from some villages (e.g. Beir Khdad & Huwalleh) – however, the slightly additional distance is outweighed by the quality of roads (less tortuous and less climbs)
Site 3.	• Government owned property • A good site in terms of distances (transport costs) under the "Shobak Only" service area alternative	• One of the main routes to the site passes by a school and is relatively twisty and steep in some sections • Very high elevation (~1,500 meters a.s.l.) and concerns about cold temperatures during the winter affecting treatment efficiency • High excavation costs due to geology (many rock outcrops) and requirement to construct deep lagoons as a result of the cold temperatures • Improbable location for future gravity-conveyed sewerage from any main towns
Site 4.	• Ideal location in terms of distances (transport costs) under the "Shobak Only" service area alternative • Well-protected from winds and difficult to see from roads or nearby villages	• Privately owned properties, relatively higher value lands as already developed agriculturally and in close proximity to Muthalath • Very close to Muthalath As Shobak, even though downwind 90% of the time, but could nonetheless present a constraint to residential expansion in that direction • Upwind and upstream of Beir Khdad and a few large apple farms, although 3 – 4 km away, concerns related were expressed • Potential future sewerage uncertain (~1,330 to 1,300 meters a.s.l.) • Would create unnecessary transport required through major residential intersection (esp. when including non-Shobak towns)
Site 5.	• Similar to the advantages listed under Site 2, with the added advantages of being further from main roads • One of the best sites for potential reuse on-site and in immediate vicinity • One of the lowest hydrological risk sites • Low risk ecologically & archeologically as in already heavily disturbed area • Hidden from view	• Privately owned properties • Requires 1 to 2 km of access road, water and electricity supply lines • Not the most desirable site in terms of distances (transport costs) under the "Shobak Only" service area alternative – however, the slightly additional distance is outweighed by the quality of roads - an ideal location for the "Shobak Region" alternative • Potential for disturbance and pollution risk to wadis flowing to the East
Site 6	• Government Owned Property • Reuse potential directly in Fujaij Reserve • Reuse potential in rain-fed agricultural areas if conveyed downstream to the west and east • Closer to Qadissiyeh	• Limited area to chose a final site within • Within a protected reserve and would be disturbing relatively undisturbed area • Close to and upwind of main touristic road • Could ecologically disturb Wadi Dana Reserve as fauna travel to roost and feed in this area • Disturbs the scenery, especially when viewed from the higher areas to the North and West • Potential pollution risk to wadis flowing to the east and west and potential springs at the foothills to the West • Higher archeological risk – large artifacts observed

Figure 2
Map of potential site locations (1 to 6) for the WWTP and the existing Dump Site ("X")



Note: Site 6 lies within the Fujaij Pastoral Reserve, with the reserve extending slightly further to the North, bound to the east and south by the main road to Qadissiyeh.

2.3.a. Comparative analysis of site alternatives in Shobak

Site No. 1

This site was previously recommended by the inter-ministerial site selection committee and was generally commendable from most points of view. Residents of the only nearby community however expressed deep concerns about this site being too close to their small village (Faisaliyeh). The economic assessment also determined that this site would result in unsustainably high transportation costs under any service area alternative due to its distance from population centers and associated high transportation costs.

This site would result in an increase in the estimated annual transportation costs by 30,000 to 50,000 JD (with current quantities) when compared with some of the alternative sites proposed. The additional costs will potentially more than double in the future as septage quantities and transportation costs increase.

Site No. 2 and No. 3

The Project Team, in consensus with various stakeholders, recommended excluding Site No. 2 as it is unacceptably close to main tourist roads. Site No. 3 was also excluded as it presents treatment efficiency risks (cold weather), will prove costly for land preparation (c.f. excavations required to mitigate cold weather risks), and does not have safe road access (small, tortuous road that passes by a school).

Site No. 4

Stakeholders recommended excluding Site No. 4 as it is too close to residential areas, existing farms, etc.). This site was also rejected by the inter-ministerial site-selection committee for the same reasons. This site also presents some risks to downstream water resources and users.

Site No. 5

In the opinion of most stakeholders, the project team and almost all members of the inter-ministerial site-selection committee, Site No 5. is the preferred alternative due to its down-wind distance from roads and residential areas, but remains close enough to keep transport costs relatively low. It can also accommodate a more regional service area due to its centralized location. Stakeholders living furthest from this site were concerned that it would marginalize them and confront them with unnecessary transport costs. The Mayor and the project team however, feel that the additional distance (versus Site No. 4) is only slight, and is outweighed by the better quality of access road (making tanker trip time and tanker mechanical stress from these towns to Site No. 5 effectively lower, and hence transport costs as well).

It presents all the advantages of Site No. 2 but does not present the same concerns (too close to main roads) and is one of the lower risk sites in terms of water resources. Site 5 is also in an already heavily disturbed area, making soil, ecological, archaeological risks and aesthetic impacts insignificant. It also offers vast reuse opportunities as well as potential future sewerage for both Qadissiyeh as well as Shobak towns.

Site No. 6

Even though this site is on government owned property, this site was rejected after further assessment by the project team and in consultation with WAJ on the basis of hydro-geological, ecological and odor-related concerns. This site poses a higher risk to water resources than Site No.5 due to the presence of aquifer outcrops, thinner top-soils and the fact that it spans two surface water catchments -the western catchment being considered more sensitive and important than the eastern one (Site No. 5 is located in the eastern one). There are several wadis and seasonal springs (many of which are often dry) immediately downstream to the west. A WWTP would disturb the unique natural scenery, especially when viewed from the higher areas to the North and West.

Being on the edge of the escarpment also means a higher archaeological risk: some exposed archeological remains have been observed in the area. This site is also too close (within 500m upwind) of the Shobak-Qadissiyeh main touristic road. The reserve is also considered an Important Bird Area and the presence of lagoons could affect restricted indigenous birds. Establishing a facility in Fujaij area would result in minimizing the shrubbery area of the reserve, which is an important feeding source for the globally threatened Syrian Serin. Being a reserve, it represents an ecosystem and sub-systems, possessing key plant and faunal species at significantly relatively higher densities and should remain protected from such potentially damaging developments.

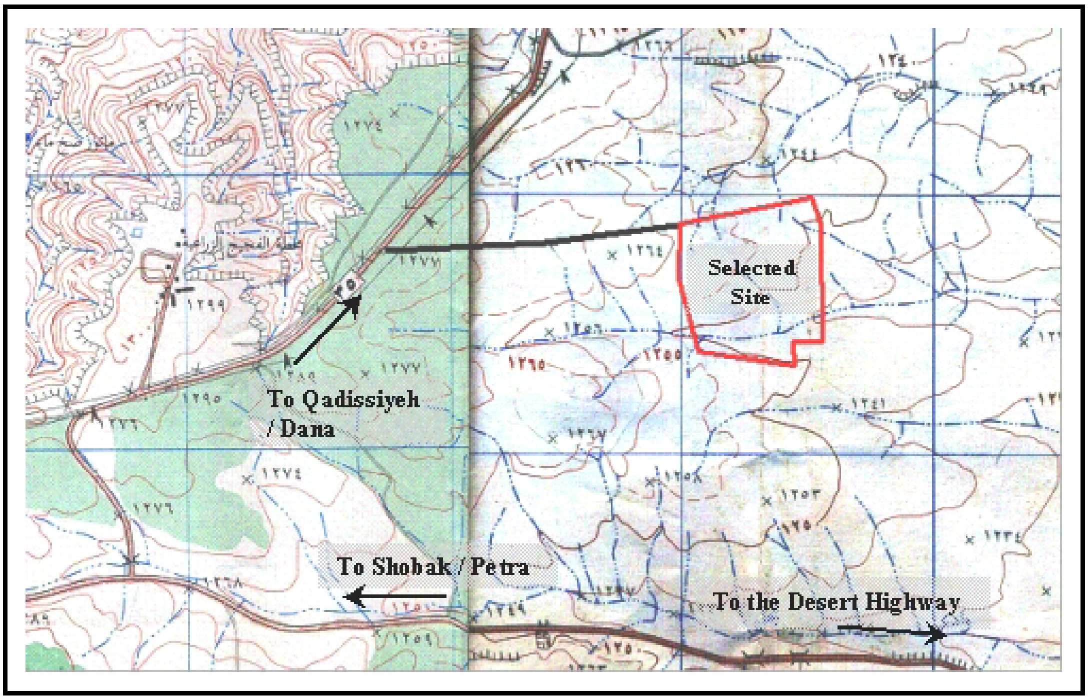
2.3.b. The preferred and selected site

The preferred site area is in Site No. 5 as it presents the following advantages over other potential sites that were assessed:

- It presents an ideal location in terms of distance from main septage generating towns/villages (lowest transport costs) in the region;
- Minimal transport will be required through major residential areas;
- Utilities are nearby (electricity, water, roads,);
- Property values are relatively low;
- It is downstream of major population centers, including Qadissiyeh as well as the main Shobak towns;
- It is far enough from main roads and far enough from any residential areas to mitigate any risk of odors and mosquitoes;
- It presents a relatively low risk to water resources; and
- There is excellent potential for reuse and greening of the area in the vicinity.

The selected property (parcel) is 266 Dn. The approximate location of this property, the proposed access road and the main roads in the area are shown in Figure 3 below.

Figure 3
The selected WWTP site and surrounding roads



As detailed previously, the Project Team, the Municipality of Shobak, and WAJ selected this particular property for several reasons. The property is large enough to host the proposed WWTP and potential future expansion as well as full on-site reuse of the treated effluent, even after plant expansion. The property layout, dimensions, and topography provide flexibility in WWTP layout and generally respects the hydraulic profile of the plant per the conceptual design, thus minimizing construction and O&M costs. The parcel is accessible by planned roads and its mid-point (coordinates 210,871 E, 9939,334 N) is around 1.3 km east of the Shobak-Qadissiyeh main road and 1.5 km north of the Shobak-Petra main road. This is one of the few properties in the area that satisfies all of the above conditions.

2.4. WWTP technology

2.4.a. Screening of WWTP technology alternatives

The project team has examined several possible WWT technologies: stabilization ponds, recirculating sand filters, activated sludge, Up-flow Aerobic Sludge Blanket (UASB), Advanced Integrated Pond Systems (AIPS), etc. Waste Stabilization Ponds (WSP), Aerated Lagoons (AL), Constructed Wetlands (CW), and Recirculating Sand Filters (RSF) are often referred to as low-rate systems, which use biological treatment processes and require little or no mechanical equipment. Often a combination of several low-rate systems is required to meet stringent effluent standards. When properly designed and operated, low-rate systems can produce a final effluent comparable to high-rate systems, which use mechanical equipment. High-rate treatment systems are typically used to treat wastewater generated from larger communities, because of the large land requirements of a low-rate system. Listed below are some of the most commonly used high-rate systems serving larger communities:

- Trickling Filters (TF)
- Activated Sludge Plants (AS) (high rate and extended aeration type)
- Oxidation Ditch Systems (OD)
- Biological Aerated Filters (BAF) and most recently
- Membrane Bioreactor Systems (MBR or "Activated sludge without clarifier")

Table 2 compares the advantages and disadvantages of some of the low- and high-rate systems listed above. The low rate processes are usually more cost-effective in developing countries and rural communities, where land is available at a reasonable cost and finances are limited.

Table 2
Advantages and Disadvantages of Various Treatment Systems

Criteria	WSP	CW	RSF	AIPS	AL	TF	AS
Technical							
BOD removal	G	F	F	G	G	G	G
FC removal	G	F	F	F	F	P	P
TSS removal	F	F	G	F	F	F	G
N removal	G	F	G	G	G	G	G
HE removal	G	P	P	F	F	P	P
V removal	G	P	P	F	G	P	P
Applicability to Septage	G	P	F	P	G	F	F
Economic							
Simple (O&M)	G	F	G	G	G	F	P
Foot print	P	P	F	P	F	G	G
Energy needs	G	G	G	G	F	P	P
Constructability	G	F	G	G	G	F	P

G = Good, F = Fair, P = Poor

After a careful evaluation, the project team has eliminated several of these alternative treatment technologies because the proposed WWTP:

- Must be proven low-cost/low-maintenance technology; and
- Must treat septage collected by tankers from cesspits, which:
  - Varies in quality from tanker to tanker;
  - Varies in quantity being received at the plant from day to day / week to week; and
  - Carries higher pollutant loads (namely BOD, COD and suspended solids) than raw sewage (i.e., sewage collected and transported via a sewer network).

For example, AIPS would not operate optimally under the conditions mentioned above. It would require significantly higher maintenance, given the concentration of suspended solids in septage. Similarly, UASB is sensitive to variations in quality and quantity, as well as requiring advanced technical capability on the part of plant operators. Mechanical aeration and the like simply cost too much to construct and more importantly, to operate, for the size of WWTP that would be appropriate for such communities. Technical capacity and experience required for efficient operation is again relatively high. Mechanical equipment has a shorter useful life, requires significantly more energy, is prone to breakdown, and is more expensive to repair. Some of the systems considered also require chemicals, all adding to the costs and making the technical and financial sustainability of any of these options questionable as a result.

Essentially, the only proven way to meet the low-cost/low-maintenance objective, and to be able to treat septage generated from such communities, is to use technology that includes influent screening/grit and WSP-type units. The effluent can then pass through recirculating sand filters and reed beds (man-made constructed wetlands) to further reduce solids, organics, pathogens, and nitrates to required levels. This treatment process requires no chemicals and no complex mechanical equipment.

Imhoff tanks were also considered as an upstream treatment unit in the treatment facility to allow for easier removal of solids, thereby decreasing the solids loading in downstream processes. In spite of the benefits of such a pre-treatment step, it has higher sludge handling requirements, necessitates sludge thickening system, might experience sludge transfer difficulties, needs higher maintenance, and would require additional complimentary treatment units in order to ensure overall process stability and treatment efficiency. On the other hand, a special sedimentation/digestion tank (S/D) designed for the conceptual design of a different treatment plant in the small communities project (Mafraq) can combine the functions of settling and sludge digestion without the drawbacks of Imhoff tanks.

2.4.b. Analysis of WWTP Alternatives

Following the above screening, four conceptual alternative treatment trains/processes were conceptually designed and assessed. All of the alternatives were designed with the ability to meet Class B effluent standards (JS 893/2002) with the following variation insofar as nitrates are concerned.

Alternatives 1 & 2 use the same design concept with the exception that Alternative 2 will meet the current standard of 10 mg/l of nitrate-nitrogen (N) – which is equivalent to 45 mg/l nitrate in the form of nitrate (NO_3^-) -- whereas Alternative 1 will meet a less stringent standard of 45 mg/l of nitrate-nitrogen. The same applies to Alternatives 3 & 4, with Alternative 4 being designed to meet the current, more stringent nitrate standard. Through this project, we have initiated discussions with the Government of Jordan to review the nitrates in these standards and as a result, the relevant authorities are currently reviewing JS 893/2002. The project team suggested that a less stringent nitrate standard would be quite appropriate, especially in a place like Shobak where the ground water table is relatively deep, the quantities of septage requiring treatment are relatively small, and full reuse in agriculture can be guaranteed at the project site.

At a later stage, a fifth alternative was developed to reduce capital and operation costs even further. This fifth alternative (The "Reed Beds alternative") is a zero-discharge alternative and do not need to meet any discharge standards.

Three parallel treatment trains are recommended under the first four alternatives and two trains under the Reed Beds alternative, for higher operational flexibility and easier maintenance. A larger number of treatment trains can be operated in parallel or in series. More units in parallel are also a better choice as they provide more operating flexibility for plants with different seasonal requirements like Shobak (e.g., different winter and summer temperatures, different incoming septage flows).

The average ambient air temperature is less than 5 ^{0}C for approximately 130 days out of 151 days from November through March. Minimal nitrification would occur and reduction of organic matter would be drastically inhibited during this period because of the cold temperatures. Therefore, it will be important to provide for storing septage during the winter and then treating the septage stored during the winter months together with new incoming septage during the summer under the first four alternatives. With the zero-discharge alternative, storage of winter influents is not needed as there are no effluents and effluent quality objectives that are sensitive to biological activity reductions in cold conditions.

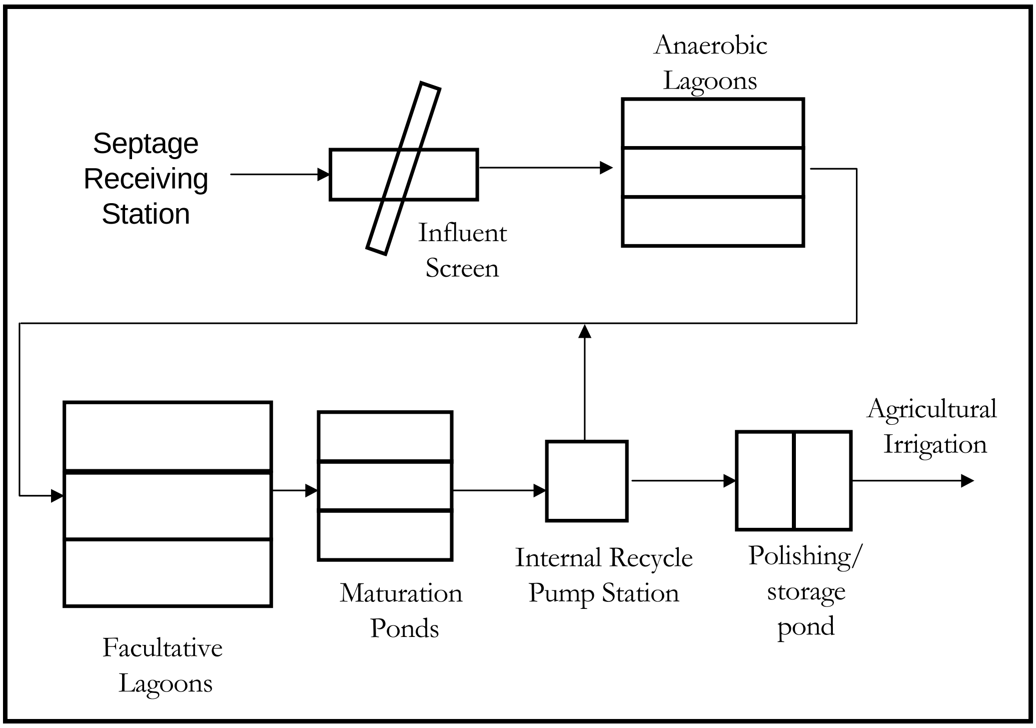
Alternatives 1 and 2

Alternatives 1 and 2 are based on earthen (WSP) lagoons and include the following units (according to the conceptual design):

- One septage receiving/screening station;
- Three anaerobic/settling lagoons;
- Three facultative lagoons;
- Three maturation ponds;
- One duplex internal recycle pump station;
- Storage / polishing pond; and
- Four sludge drying beds (possibly reed sludge drying beds).

A simplified process flow diagram is presented in Figure 4 below.

Figure 4
Simplified process flow diagram for Alternatives 1 & 2



The anaerobic lagoons are sized to provide enough volume for storing septage arriving at the plant in the winter and accumulating sludge over one year. Also, the lagoons must be large enough to keep organic volumetric loading in check in order to reduce the potential for odor generation, as well as for more consistent organic degradation. Anaerobic lagoons would need to be covered to eliminate evaporation losses and odors and to maintain adequate operating temperatures for a longer period during the year.

Alternatives 1 and 2 are identical with the exception that Alternative No. 2 has larger maturation ponds and a higher internal recycle (recirculation) ratio in order to meet the stricter nitrate standards. Alternative 1 would only meet the relaxed nitrate standard.

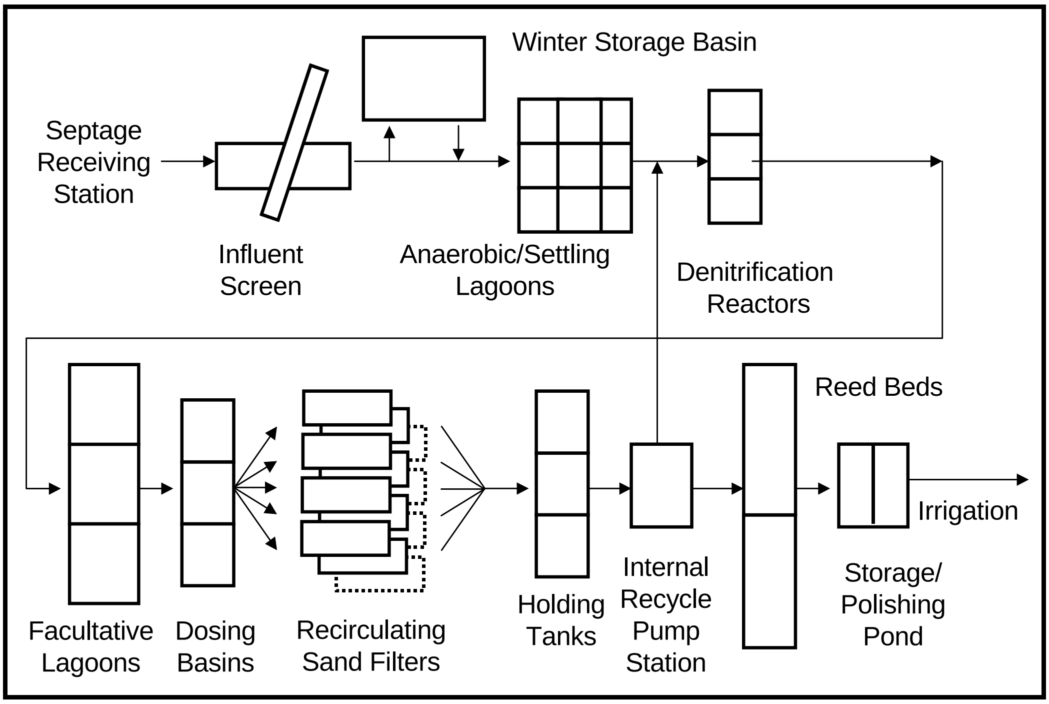
Alternatives 3 and 4

Alternatives 3 and 4 are based on multiple, concrete anaerobic lagoons operated in series, recirculating sand filters and constructed wetlands and include the following units:

- Septage receiving station;
- Winter storage basin;
- Three parallel trains of three concrete anaerobic/settling basins operated in series;
- Three concrete denitrification reactors;
- Three facultative lagoons;
- Three dosing basins;
- Eight to twelve recirculating sand filters (RSF);
- Three flow holding tanks;
- Two constructed wetlands;
- One duplex internal recycle pump station;
- Storage/polishing pond; and
- Four sludge drying beds (possibly reed sludge drying beds).

A simplified process flow diagram is presented in Figure 5 below.

Figure 5
Simplified process flow diagram for Alternatives 3 & 4



Under Alternatives 3 and 4, a separate winter storage basin is provided and concrete structures are used to provide for easier and more frequent sludge removal (e.g., through hydrostatic draining). Multiple basins operated in series are also known to provide a higher degree of treatment under shorter retention times. In addition individual smaller tanks can be isolated for cleaning, repairs or sludge removal without significant impact on the overall performance of the system. Maturation ponds are no longer needed and the facultative lagoons are significantly smaller than those in Alternatives 1 and 2 thanks to the introduction of recirculating sand filters, dedicated (separated) denitrification reactors, and constructed wetlands. Overall, this strategy results in a reduction in the WWTP footprint, the costs of covering of lagoons, evaporation losses, and effluent salinity. While land requirements and associated costs are reduced (relative to Alternatives 1 and 2), capital costs of building the plant are higher; also O&M costs increase because Alternatives 3 and 4 require slightly more sophisticated plant operations (compared to the standard WSPs of Alternatives 1 and 2).

As with the case of Alternatives 1 and 2, Alternatives 3 and 4 are identical with the exception that Alternative No. 4 has more recirculating sand filters, larger dosing basins and flow holding basins, and a higher internal recycle ratio to meet the stricter nitrate standard.

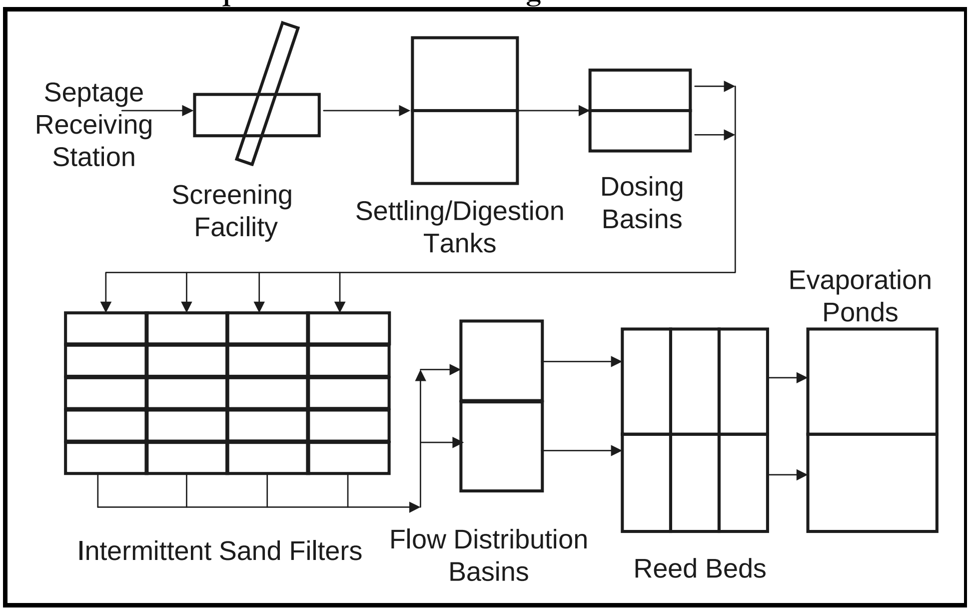
The Reed Beds Alternative (Alternative 5)

The Reed Beds Alternative[2] is based on a sedimentation/digestion tank, recirculating sand filters, and constructed wetlands, and includes the following units:

- Septage receiving/screening facility;
- Two sedimentation and digestion tanks with two compartments each;
- Twenty intermittent sand filters (ISF);
- Twelve reed beds;
- Two evaporation ponds; and
- Four sludge drying beds.

As stated earlier, this alternative has the advantage of producing zero-discharge. This allows for a simplification of the process, since no discharge standards have to be met. The reed beds can be harvested and their by-products used to generate income for the community. A simplified process flow diagram is presented in Figure 6 below. Stabilized sludge will be removed from the sedimentation/digestion tank to four sludge drying beds. Sludge could then be composted for use on farmland. The filtrate from the drying beds will flow back to the reed beds.

Figure 6
Simplified Process Flow Diagram for Alternative 5



Comparison of WWTP Alternatives

Generally, the most important differences between the first set of Alternatives (1 and 2) and the second set (3 and 4) relate to sludge handling and evaporation losses. The main disadvantages of Alternative 3 and 4 pertain to the slightly higher operational sophistication and associated O&M costs. However, the smaller treatment units in Alternatives 3 and 4 provide for better and easier maintenance, added operational flexibility and more options for smaller, fractional upgrading. The main disadvantage of the

[2] Based on the Amendment to the Feasibility Study submitted to USAID and WAJ in October 2005

Reed Beds alternative (Alternative 5) is that it does not provide a source of treated wastewater for reuse. Furthermore, larger land requirements than alternative 4 slightly limits the extent to which the new plant under Alternative 5 could be expanded in the future. On the up side, the Reed Beds alternative combines the advantages of operational flexibility and simple operation/maintenance. Additionally, the Reed Beds alternative could allow any future upgrade to be carried out locally and without the intervention of international experts. The Reed Bed alternative is also easier to replicate in other similar small communities in the Kingdom.

Under alternatives 1 and 2 sludge will need to be removed on an annual basis either through the use of a floating sludge pump and/or out-sourcing contract. Under alternatives 3 and 4, sludge may be removed as frequently as needed which is significantly less costly and greatly improves the treatment process' reliability and the WWTP's financial sustainability. Sludge removal costs are often the second highest O&M cost item in WWTP's in Jordan (M&E, 1999). The Reed Beds alternative also provides easy sludge removal through a sludge pumping station that can be operated as needed without interrupting the normal operation of the plant.

Although building the front-end (upstream) units out of concrete is expected to be costly, the advantages outweigh the potential initial net-savings of using earthen lagoons. The ability to remove sludge cheaply and more frequently means that the lagoons are significantly smaller in size as less volume needs to be allocated to sludge build-up in the lagoons. As a result, the net savings that would be achieved by earthen instead of concrete lagoons are not as great as expected since the lagoons would need to be much larger, would require clay lining/riprap, would need a vehicle ramp access (for maintenance), and would become much more costly to cover. For example, the net savings from using earthen lagoons instead of concrete lagoons in alternative 3 and 4 are estimated at around 100,000 JD. A comparison of some of the key technical and economic data for all of the alternatives is provided in Table 3.

Table 3
Summary comparisons of key technical and economic data for all alternatives

Parameter	Alt 1	Alt 2	Alt 3	Alt 4	Reed Beds
Influent = 127,750 m3/yr	Effluent = 57,000	Effluent = 46,000	Effluent = 87,000	Effluent = 80,000	Effluent = 0
Evaporation losses:	55%	64%	31%	34%	100%
Influent Salinity ~1,300 mg/l	Effluent ~2,900 mg/l	Effluent ~3,600 mg/l	Effluent ~1,900 mg/l	Effluent ~2,000 mg/l	n/a
Potential on-site Rye grass*	52	42	79	73	n/a
Footprint**	90 Dn	100 Dn	63 Dn	80 Dn	90 Dn
Capital Costs***	1.8 – 2.3 M JD	1.9 – 2.4 M JD	2.5 – 3.1 M JD	2.7 – 3.3 M JD	1.2 to 2.2 M JD
Annual O&M Costs****	19,000 – 23,000 JD	23,000 – 26,000 JD	22,000 – 25,000 JD	25,000 – 29,000 JD	15,000 to 19,000 JD
Cost of Covers*****	200,000 - 620,000 JD		110,000 - 330,000 JD		n/a

1 JD = 1.41 USD

* Assumes all irrigation is used for Rye grass at 1,100 m3/Dn/year with unlimited irrigation storage capacity – it should be noted that at significantly higher salinities, yields also start to reduce significantly

** Excluding Setback – treatment plant only (i.e., reuse areas not included)

*** This includes the cost of covers (at 20 JD/m2) and a 20% contingency - ranges estimated with a +/- 10% margin for error and are rounded up / down to the nearest hundred thousand for the high / low range estimates respectively.

**** At full capacity, excludes capital replacement and depreciation. Ranges estimated with a +/- 5% margin of error and are rounded up / down to the nearest thousand for the high / low range estimates respectively. These estimates assume a part-time engineer / supervisor and laboratory cost sharing support from WAJ.

***** Depending on the cover material selected and cost of other required fittings (range from 10 to 30 JD/m2 assumed).

Comparing the first set of Alternatives (1 and 2) and the second set (3 and 4), evaporation losses are significantly lower under Alternatives 3 and 4 because they include a separate, dedicated denitrification reactor, recirculating sand filters and constructed wetlands and therefore do not need maturation ponds and have much smaller facultative lagoons. The resulting reduction in water surface area reduces the risk of odor generation and means that more TWW at a lower salinity is available for reuse, which greatly improves cost recovery prospects through water reuse. In contrast, the Reed Beds alternative does not provide treated wastewater for reuse, but it provides an alternate source of income through reed beds harvesting (see Section 2.5). Nonetheless, the reed beds alternative remains a significantly lower costing option to run in the long-term than the others, even if revenues from reuse are factored in.

Based on the above analysis, the Reed Beds alternative is recommended for the Shobak WWTP.

2.4.c. The design criteria and preferred WWTP treatment trains

Influent quality parameters that have been adopted for design purposes are listed in Table 4. These parameters are based on sampling and analysis of septage from tankers in Shobak, in addition to a review of all other available data on septage from other parts of the country. There are no applicable effluent standards, since this is a zero-discharge plant.

Table 4
Influent Design Criteria for WWTP in Shobak

Parameter	Value	
Design Flow Rate	350 m^3/day	
	mg/L	kg/day
Biological Oxygen Demand (BOD)	1,850	648
Chemical Oxygen Demand (COD)	7,353	2,574
Total Suspended Solids (TSS)	6,424	2,248
Total Kjehldal Nitrogen (TKN)	322	113

The treatment trains and units

The preferred WWTP technology alternative is the Reed Beds alternative and consists of the following main components:

- Septage receiving/screening facility;
- Two sedimentation and digestion tanks with two compartments each;
- Twenty intermittent sand filters (ISF);
- Twelve reed beds;
- Two evaporation ponds; and
- Four sludge drying beds.

Summary specifications of the proposed treatment trains and units under the preferred WWTP technology alternative (Reed Beds) are provided in Table 5. The preliminary WWTP layout and process flow diagrams are presented in Appendix A. The objective is to have a 50 m setback, which should be possible given the characteristics of the selected property.

The sedimentation/digestion tanks are based on providing 30 days of settled solids storage to produce stable sludge. The main reason for including a subsequent sand filtration system in this treatment option was to protect the reed beds from solids accumulation. As a result of the solids removal achieved by the previous units, the reed beds only need to be designed according to the evaporation requirements in conjunction with the subsequent evaporation basins.

The precise dimensions, configuration and build, materials and other fine-tuning factors (e.g. winter, summer flows) will be investigated further during the detailed design. The potential use of zeolite as drain material in the constructed wetlands and sand filters, as a means of improving their efficiency (therefore potentially reducing capital costs), will also be investigated. Provisions for future expansion and will also be considered.

Table 5
Tentative conceptual design elements of proposed WWTP Reed Beds alternative

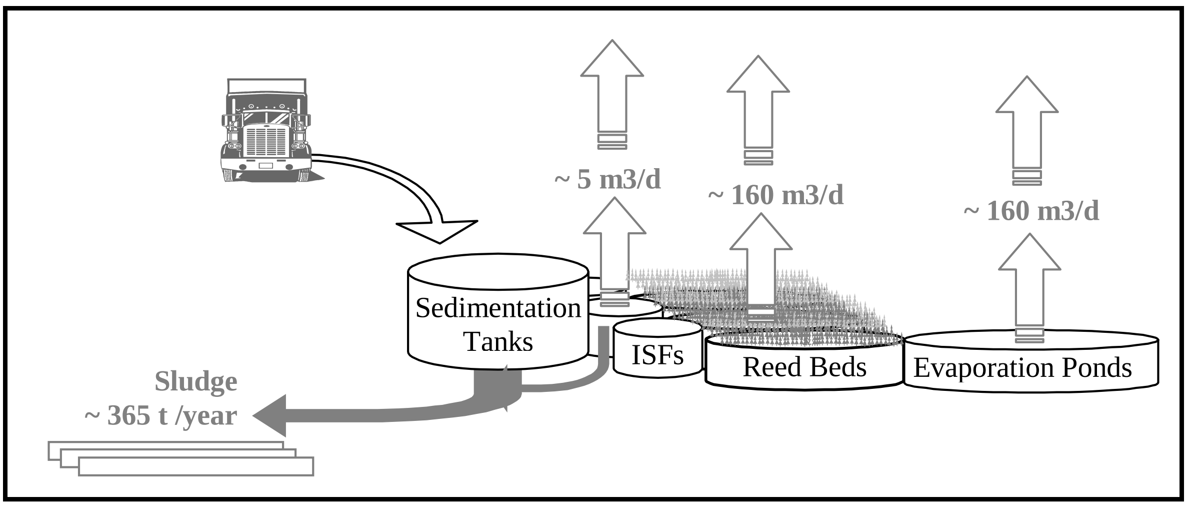
Number of treatment trains	**2**
Footprint (ha)	**~ 9**
Avg. daily accepted flow of septage, m^3	350 m3/day
Sedimentation / Digestion tanks	**4 compartments**
Surface area, m^2	1,400
Dosing basins	**2**
Surface area, m^2	300
Intermittent Sand Filters (ISF)	**20 (concrete**
Surface area of each filter, m^2	150
Total surface area, m^2	3,000
Reed beds	**12**
Surface area of each bed, m^2	5,000
Total surface area, m^2	60,000
Evaporation Ponds	**2**
Total surface area, m^2	20,000
Sludge drying beds	4
Total surface area, m^2	4000

(Final design elements may be different and will be provided as part of the detailed design)

Wastewater, Salts & Sludge Balance

Figure 7 below depicts the inputs and outputs of the WWTP. Up to 10,000 m3 of sludge (96 % water content, 400,000 kg/year of dry sludge) will need to be removed and sent to the drying beds before disposal or additional treatment and reuse as appropriate. The optimal frequency of sludge removal (e.g., monthly, quarterly, etc.) will be assessed in more detail during the detailed design, but will need to be determined once the WWTP is in operation. Reed sludge drying beds will also be investigated.

Figure 7
Wastewater, Sludge and Salts Balance



2.4.d. Built in mitigation measures

Mosquitoes are generally not a problem in properly designed and operated wetland system (Reed bed type). A design that supports a healthy surface-flow wetland ecosystem typically produces conditions that maintain sufficiently low mosquito populations, where the mosquito is simply a component in a balanced food web. More specifically, mosquitoes are usually not a concern when water levels are constantly fluctuating, as they will be in the Reed Beds. If for any unforeseen reason, an imbalance develops, then corrective interventions might be required similar to those for any other alternative (e.g., pest control).

Odors produced in conventional wastewater treatment processes are mostly associated with anaerobic decomposition of human waste and food waste found in sewage. These odors are concentrated in areas of small confinement and point discharge, like influent pumping stations, anaerobic digesters, and sludge handling processes. Wetlands, in contrast, incorporate normal processes of decomposition over a relatively large area. This would tend to dilute odors associated with the natural decomposition of plant material, algae, and other biological solids. Treatment of pretreated wastewater by a wetland system would not emit offensive odors in Shobak, because the most problematic compounds will be removed early in the process (primary solids, sludge, grit, screenings, etc.). Moreover, odors are not an issue with subsurface wetlands, because noxious gases are trapped and are degraded by the microorganisms attached to the gravel and plant root surfaces. Likewise, odor production from sludge handling is not anticipated to be a problem, because the sludge will be stored long enough in the settling/digestion tank to produce a stable product (i.e. most of the decomposition process would have been completed) before disposal on the drying beds.

Gravity flow will be maximized throughout the WWTP. The only pumps that will be included are in the sludge pumping station which have low power requirements and are only operated as and when needed. Bypass and overflow piping and fittings will be installed on all units to enable bypass or potential overflows to reach downstream units. In addition, all lagoons/reservoirs will have a 1m freeboard. Hence, the risk of overflow is minimal and only a concern at the downstream units (e.g., evaporation ponds), which can be pumped back to the head-works. All units will be either lined with geo-membrane (HDPE liner), a 30 cm thick layer of clay with riprap to protect from erosion or will be built with corrosion-resistant reinforced concrete to minimize the risk of any seepages or leakages from any of the treatment units. Dual-purpose dikes/drainage system, possibly included as part of the road system, will be included as an internal runoff drainage system to protect the units from flooding and to contain any potential spills/overflows.

The sedimentation/digestion tanks will be covered to minimize odors. Odor control at the receiving facility and other locations where it may be required (e.g., for sludge) will also be investigated and included in the detailed design.

The concrete sedimentation/digestion tanks are intended to allow for frequent sludge removal to significantly reduce the sludge removal costs and better guarantee that the WWTP will continue to operate efficiently. The feasibility of hydrostatic sludge removal will be looked into further during the detailed design.

Multiple lagoons and basins operated in series provide more efficient and reliable treatment. Multiple treatment trains provide for added operational flexibility (e.g., can be run in parallel or in series) and improved maintenance ability (e.g., by shutting down one train for maintenance). Smaller multiple units also allow for easier maintenance as well as fractional upgrades as required.

The septage receiving facilities will have a specially designed drainage system and a designated tanker cleaning area, and will be supplied with non-potable water for regular wash downs or dilution of influents if needed.

2.5. By-products reuse

The preferred alternative does not discharge any treated wastewater for reuse. However, the reed beds provide an opportunity for by-product reuse, as does the sludge produced from the WWTP. Different parts of the reeds can be harvested and put to potentially productive use such as:

- Mulches, or carbon source to enhance composting
- Fodder (before maturity or as a feed additive)
- Paper (using the leafs or combined with other pulps)
- Roofing materials, temporary shelters
- Floor mats, brooms, baskets
- Mattresses and/or pillow stuffing (seed heads - flowers)
- Blinds, decorations
- Fencing, wind breaks
- Heating (energy comparison: 1m3 of oil ~ 4t of dry reed)

2.6. Construction & Operational Activities

Starting in the first half of 2006, the project team will supervise construction of the WWTP along with associated facilities and infrastructure (e.g., administration and labor residence buildings, necessary utility and road infrastructure). Construction of the WWTP should be complete by the end of 2007.

The main facilities and infrastructure to be constructed include:

- The WWTP & associated facilities
- Slightly over 1 km of access road (upgrade of existing dirt track), internal roads and parking;
- Slightly over 1 km electricity and water connection;
- Any necessary preparations required to enable future expansion of the WWTP; and
- Temporary housing and facilities for construction labor.

The main construction activities are:

- Land preparation (excavation, filling, compacting, and soil stabilization);
- Quarrying for construction materials ex-situ (sand and gravel from Wadi Unayzeh and Ras An Naqab);
- Transportation of construction materials (sand, cement, pipes, steel, etc.);
- Transportation of construction workers and supervisors; and
- Transportation and operation of construction equipment (bulldozers, loaders, compressors, etc.); and
- Scaffolding, mixing and pouring of reinforced concrete, laying of synthetic liners and piping, etc.

Following commissioning of the WWT&R systems, the main operational activities will include:

- Hauling of septage from the sources (e.g., residential cesspits) to the WWTP in tanker trucks – converging on the WWTP from various directions along different main roads;
- Discharge of the septage from the tankers into the receiving station within the WWTP;
- Use of water and electricity at the WWTP to run pumps, wash equipment, etc.;
- Operation of the WWTP (e.g., opening valves, raking sand filters, sludge drying and treatment, visual inspections, etc.);
- Regular and infrequent maintenance of the WWTP and associated facilities (cleaning, removing sludge, replacing piping, replacing sand/gravel filter materials, etc.);
- Sludge drying, composting and land application;
- Transport of replacement materials (piping, sand/gravel, etc.) and labor; and
- Movement of on-site vehicles (e.g., for sludge dredging/removal, etc.).

3. LEGAL AND INSTITUTIONAL FRAMEWORK

This EIA conforms to both USAID regulation 22 CFR 216 CFR 216 and the Government of Jordan regulations / draft EIA guidelines. USAID environmental regulations are in accordance with sections 118(b) and 621 of the US Foreign Assistance Act of 1961 and can be found under "22 CFR 216 Agency Environmental Procedures" on the USAID website. The relevant Jordanian laws, regulations and institutions pertaining to EIA requirements and implementation of this project are discussed and cited below.

3.1. Relevant laws & regulations

3.1.a. Environmental Protection and EIAs

Article (13) -A of the Temporary Environmental Protection Law number 1 for 2003 which became effective on January 13th, 2003, states that "Every institution, company, plant or any party that, after the enforcement of the provisions of this law, exercises an activity which has a negative impact on the environment, shall be obliged to prepare a study of the environmental impact assessment for its projects, and refer same to the Ministry in order to make the necessary resolution in this effect".

In accordance with Article (23) of the Environmental Law, the Cabinet of Ministers issued on March 15th, 2005 Regulation number (37) for 2005 – Regulation on Environmental Impact Assessment. The Regulation provides direction for conducting environmental impact assessments for all types of projects including the main issues to be covered by an EIA, reporting procedures, and the approval process. Regulation (37) had been used over the previous 18 months, in its draft form, as a guideline in preparing EIA's in Jordan.

The following other regulations have also been issued pursuant to the Environment Protection Law:

- Nature Protection.
- Environment Protection from Pollution in Emergency Cases.
- Water Protection.
- Air Protection.
- Marine Environment & Coastal Protection.
- Natural Reserves & Parks.
- Management, Transport and Handling of Harmful & Hazardous Substances.
- Management of Solid Waste.
- Soil Protection.
- Charges & Wages.

3.1.b. Other Environmental Policies & Controls

Other government laws and regulations are also applicable to the EIA for this project and numerous governmental agencies with responsibility for various aspects of environmental management. These cover issues such as noise, dust from quarrying activities, monitoring and penalties for inappropriate solid waste disposal, safety, labor laws, odors etc. Those of most relevance to issues related to this project are briefly mentioned below. A more comprehensive list of these other laws and regulations is presented in Table 6.

Water & wastewater

Water Authority Law (18/88) – Water (Annex 4) – is described as the most far-reaching statute pertaining to water pollution. Article 3 of this law created Water Authority of Jordan (WAJ), and article 5 provides full responsibility to Ministry of Water and Irrigation (MWI) for all water and sewage systems and for establishing a water policy. Article 6 charges WAJ with its responsibilities.

The Public Health Act (1971) also serves as the basis for the regulation of wastewater discharges and water quality in Jordan. Pursuant to the Public Health Act, standards for the discharge of wastewater have been established. These are discussed in Section 3.2. Article 4 of the Control of Spoiled Sites Regulations (1978) reiterates some of the above Public Health Act provisions and further establishes the right of the president of the municipality, based on the health inspector's recommendation, to take such actions as may be deemed appropriate against the violator. The Town and Country Regulations Act (1966) allows Local or Regional Councils to take action against the operator of any wastewater system that is found to be a nuisance and order that the nuisance be corrected within a specified period of time.

Air quality, noise & waste management

Air quality is regulated under the Public Health Act (1971), The Control of Spoiled Sites Regulations (1978) and The Traffic and Transportation Law (1984). Noise is regulated under the Town and Country Planning Act (1966), the Control of Spoiled Sites Regulations (1978), the Local Authorities Act (1955), the Monitoring and Organization of Public Markets Regulations (1961), the Traffic and Transportation Act (1984), the Public Health Act (1971), and the Environment Law. Solid waste management is regulated under several statutes, including the Public Health Law, Control of Spoiled Sites Regulations, the Town and Country Planning Act, and the Environment Law.

Terrestrial ecology

Terrestrial ecological resources are afforded protection under the Agriculture Law (1973) and the Hunting and Protection of Wild Animals and Birds regulations No 113 (1973). Agriculture Laws No. 20 and No. 113 (1973) contain chapters on plant and forestry protection, registration of crops and pesticides, orchard and nursery regulations, fertilizer use, soil conservation, and range-land administration.

Antiquities

Under Article 9 of the Law of Antiquities, it is unlawful to destroy, disfigure, or cause any harm to antiquities, including causing changes in features, disconnecting any part thereof, altering it, sticking advertisements or attaching any plates to them.

Labor & safety

The construction and operation of the wastewater treatment plants will be affected by Labor Law No. 8 for 1996 including all of its subsequent amendments. Article (12) of Chapter 3 of the Labor Law pertains to nationalities and work permits. Articles under Chapters 4 and 7 relate to contracts and wages. Articles under Chapter 8 specify, among other things, working hours, leave and juvenile employment. Articles under Chapter 9 (titled "Safety and Occupational Health") cover the obligations of the employer to provide a safe working environment for his workers, increased risks on the job and for the public, precautions and measures to be followed in the workplace, and protective and therapeutic medical care. Articles under Chapter 10 (titled "Work Injuries and Occupational Diseases") provide for issues related to work injuries and occupational diseases for those employees who are not covered under the provisions of the Social Security Law of Jordan.

The Jordan National Building Codes also establish design principles and minimum requirements needed to ensure public safety of structures, provide sound and efficient electro-mechanical services and to safeguard against earthquake risks.

Table 6
List of other relevant National Laws and Regulations

National Laws and Regulations	Effective as of
Water Authority Temporary Law No. 62	2001
Jordan Specification Standard No. 893 (Annex 11)	1994
Water Authority Instruction No. 4	1989
Antiquities Law No 31 (Annex 3)	1988
Narcotics and Mental Drugs No. 11	1988

National Laws and Regulations	Effective as of
Water Authority Law No. 18 (Annex 4)	1988
Jordan National Building Codes	various
Rural Development Regulations No. 40	1986
Public Property Administration Law No. 17	1984
Traffic and Transportation Act No. 14	1984
Jordan Specification Standard No. 202 (Annex 5)	1982
Control of Spoiled Sites Regulations No. 1	1978
Public Property Commission and Renting Regulations No. 53	1977
Law of Antiquities, (Provisional) No. 12	1976
Agricultural Law, No. 20	1973
Agricultural Law No. 30	1973
Agricultural Law, No. 113	1973
Public Health Act No. 21	1971
Natural Resources Regulations No 12	1968
Mining Regulations No. 131	1966
Town and Country Planning Act No. 79	1966
Criminal and Justice Law No.16	1960
Civil Defense Law No. 12	1959
Local Authorities Act No. 29 (Municipalities Law)	1955

3.1.c. International Treaties

There are numerous international and regional agreements that Jordan is a signatory to or has reached with other entities, which are of some relevance to the EIA and this project. These include those listed in Table 7.

Table 7
Treaties, Conventions and International Agreements Related to Environment and Resources

Treaties, Conventions and International Agreements	Year (in force)	Description
Convention on Wetlands of International Importance Especially as Waterfall Habitat (Ramsar Convention)	1971	- Protects all characteristic flora and fauna, with emphasis on protection of the waterfall habitats.
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1979	- Regulates export and import of listed endangered species of fauna and flora - Additionally allows Parties to give protection to selected species of flora and fauna within their jurisdiction
Vienna Convention for the Protection of the Ozone Layer (The Ozone Convention)	1985	- Regulates domestic production and consumption of green house gases.
Convention for the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)	1989	- Accompanies declaration that Jordan will not import or transship foreign hazardous wastes
The United Nations Convention on Biological Diversity (Bonn)	1993	- Calls for identification and monitoring of biodiversity components - Calls for establishment of protected areas and emergency response plans
Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	1994	- Combat desertification - Mitigate effects of drought.
The United Nations Framework Convention on Climate Change	1994	- Calls for stabilization of greenhouse gases, and requires Parties to prepare greenhouse gas inventories

3.2. Relevant standards

Although there are no applicable effluent standards for zero-discharge plants, this section provides a cursory review of Jordanian standards for WWT and reuse. At present, there are two approved sets of water and wastewater treatment standards:

- The Jordanian Standard for Reclaimed Domestic Water - No. 893/2002
- The Jordanian Standard for Sludge – Uses of Sludge in Agriculture - No. 1145/1996

Wastewater treatment and reuse

JS298/2002 on "Reclaimed Domestic Water" has two primary components: i) reclaimed water discharged to streams, wadis or water bodies and ii) reclaimed water for reuse. Reclaimed water for reuse standards in turn have three subsets (denoted A, B and C):

a) cooked vegetables, parks, playgrounds and roadside greenery inside city limits
b) fruit trees, roadside greenery outside city limits and landscape
c) field crops, industrial crops and forest trees

Sludge

JS1145/1996 on "Uses of Sludge in Agriculture" describes sludge treatment methods and presents sludge quality standards for reuse in agriculture (see full standards in Appendix B).

Other Standards

There are also several other Jordanian regulation, guidelines and standards pertinent to the EA

- JS 286: 2001 – Drinking water standards
- JS 431: 1985 - Storage precautionary requirements for storage of hazardous material
- JS 1140: 1996 – Ambient air quality (aimed at industries)
- JS1052, 1053 and 1054: 1998 and JS 703: 1990 - Motor vehicle emissions
- JS 1059: 1998 - Motor vehicles noise levels
- JS 1401 and 1404: 1998 - Environment management systems
- JS 1411 and 1412: 1998 - Guidelines for environment auditing
- JS 525: 1997 - Heat levels allowed to be exposed to in the work environment
- JS 524: 1987 - Lighting levels in work environment

3.3. Institutions

Several institutions are likely to be involved in certain stages of the Small Communities Project (planning, O&M) and are discussed further in the feasibility study and further below with a focus on environmental monitoring and management. It is important however to note the main institutions that must be involved throughout the life of the project. These are:

- Water Authority of Jordan
- Municipality of Shobak
- Ministry of Interior (Mutassarif)
- Private Sector Service Providers (e.g. Septage Tanker Operators)
- Local Community based organizations
- Neighboring municipalities

3.3.a. Monitoring and Surveillance

There is some overlap of roles and responsibilities among institutions, especially in the area of monitoring and surveillance. The MOE Law, WAJ Law, and MOH Law all assign their respective institutions with responsibility for water and wastewater quality monitoring. MOE is concerned with environmental protection to ensure public health and long-term environmental sustainability. WAJ is most concerned with protecting water resources, also for public health. Public health concerns are a primary concern of the MOH, and its focus is mainly on testing of microbiological parameters. The MOH and WAJ communicate and coordinate closely on monitoring and surveillance plans, results and responses to those results. The MOH can take appropriate action in relation to wastewater treatment plant operated by WAJ or any of its agents (i.e., LEMA or AWC) if needed. It can also close down any private plants it deems are a danger to public health.

In practice, WAJ monitors wastewater treatment plants connected to the sewer system. For those who recycle their own wastewater, monitoring levels depend on perceived risk. If on-site WWTPs have no connection to the sewer system, the Ministry of Environment takes monitoring responsibility, although WAJ laboratory personnel reported that they do most of the actual testing for the MOE.

Monitoring and Surveillance Concerns of Various Institutions

(Adapted from Ziegelmayer and Jaber, 2003)

Effluent quality monitoring:
- MWI – has central database of all water/wastewater quality monitoring
- WAJ Laboratories
- LEMA, AWC, NGWA
- WWTP operators do regular testing of basic parameters
- MOH (public and private WWTP)
- MOE

Irrigation water monitoring:
- Suitability of TWW for certain crops – MOA
- Environmental control – MOE

Groundwater monitoring
- Regular monitoring - WAJ
- Safe potable water sources - MOH
- Environmental protection – MOE

Soil monitoring:
- Field lab analysis related to agricultural production – MOA
- Environmental protection – MOE

Crop monitoring:
- Protection from disease caused by wastewater – MOH
- Protection of human and animal health – MOA
- Crop quality for export – MOTI

4. DESCRIPTION OF THE EXISTING ENVIRONMENT (AFFECTED AREAS)

This chapter defines the geographical areas potentially affected by the proposed project (the study area) and describes the environmental and social receptors in relation to the potential impacts described in Chapter 5.2. It also details the relevant service area populations, the septage they generate and existing impacts on the environment.

4.1. The study area

The study area can be divided into two potentially affected areas:

1. The "wider area" extends as far as the service area and is generally associated with positive and indirect impacts (e.g. improved sanitary conditions around households, less illegal discharges of tankers into wadis).
2. The more-immediate affected area ("localized area") generally concerns the more direct project impacts that tend to be more localized around the proposed WWTP site shown in Figure 3 (e.g. potential impacts associated with odors, health and safety, dust, water pollution).

The wider zone covers an area from Al Qadissiyeh to the north, several kilometers east to Al Hashmiyeh and Husseiniyeh (north of it), as far south as Adruh and 1 kilometer west to Shimakh (see Figure 1). The extent of the localized area is defined by each impact. For example, with respect to water resource impacts the spatial extents are dictated by watersheds, surface and groundwater flow directions and hydrogeology. Odor and dust affected areas depend on wind speeds and directions. Generally, this localized area ranges from the immediate vicinity of the proposed WWTP site and stretches a few kilometers in all directions, but slightly further to the east and southeast in light of flow directions and prevailing wind directions.

4.2. Human environment

This section describes aspects of the human environment that are of relevance to the potential impacts and associated affected areas of the proposed project. It focuses on populations served, the septage they generate and how it is disposed of, as well as provides information on the economy, land-use, community infrastructure and archaeology/sites of important cultural heritage.

4.2.a. Demographics

Table 8 provides the number of the potentially serviced households and populations of the four municipalities according to the Oct. 2004 general census (see also Appendix A). These include 15 main communities in Shobak, 7 communities in Asha'ari, 4 in Husseiniyeh and 1 community representing Qadissiyeh. In general, population density of the area is low, becoming medium density in residential areas, with the possible exception of Qadissiyeh where population density is the highest in the area.

Table 8 also shows population projections based on the same population growth rates used by the MWI in its National Water Master Plan databases for these areas. Annual population growth rates start at 2.82% and are projected to taper down to 1.62% per annum by the year 2030. The average household size is around 5 to 6 persons. The population growths and household sizes vary significantly from village to village with growth rates ranging from 2.56% to 3.35% and household sizes varying from 5.3 to as high as 9.6.

The highlighted numbers in the table below indicate the potential range of populations served by the WWTP over the life of the project as proposed in Section 2.2.a. During the earlier years, it will serve 32,000 to over 34,000 people when it can cover a large service area, as time progresses this will need to be reduced to somewhere in the order of 20,000 to 25,000 people as it can only service the increased quantities being generated from Shobak and say, half of Qadissiyeh for example in 2028. As such, throughout its entire lifetime the plant should continuously serve between 25,000 to 35,000 people. Appendix A contains a fully detailed list of populations according to each town and municipality considered.

Table 8
Service area households, populations and population projections (2004 – 2030)

Municipality	No. of HH	2004 Population	2008*	2010	2015	2020	2025	2028*	2030
Shobak	1,926	10,869	11,702	12,258	13,693	15,148	16,589	17,425	17,982
Qadissiyeh	1,187	6,933	7,456	7,804	8,699	9,612	10,546	11,121	11,504
Husseiniyeh	1,208	8,300	9,134	9,690	11,201	12,756	14,236	14,986	15,486
Asha'ari	535	3,570	3,886	4,097	4,656	5,227	5,779	6,077	6,275
Total	**4,856**	**29,672**	**32,178**	**33,849**	**38,249**	**42,743**	**47,151**	**49,608**	**51,246**

* The WWTP is planned to begin operation in 2008 and has a 20-year life (2028).

4.2.b. Septage estimates and projections

Table 9 presents the current and projected estimated ranges of septage generated and disposed of from all municipalities that are likely to use the proposed Shobak WWTP. This table presents low and high estimates for each year using the estimation methodology explained after the table below. The numbers referred to in the text that follows are highlighted in the table for reference.

Septage from all these communities increases from a current annual average of around 240 m3/day ([152 + 329] ÷ 2) to around 540 m3/day ([286 +788] ÷ 2) around the year 2030. During the summer, when septage discharges are significantly higher than during the winter, the total septage discharges currently reach as high as 330 m3/day and are likely to increase to over 750 m3/day around 2030. Septage from communities within Shobak makes up slightly less than 50% of the total, with the majority of septage coming from Najil and Muthalath. The town of Qadissiyeh makes up slightly over 25% of the total. On average, the totals correspond to each household pumping out 10 m3 (the average size of a tanker), around 1 to 2.5 times every year. In Najil, Muthalath and Qadissiyeh in particular, the average is closer to 2 times per year, but can be higher than 3.5 times a year for some.

Total summer septage discharges from all communities in Shobak in addition to Qadissiyeh currently reach as high as 245 m3/day (162 + 83 m3/day) and are likely to increase beyond 430 m3/day (286 + 146 m3/day) after 2020. The proposed design capacity, as discussed in Section 2.2.a, of 350 m3/day (average annual) for 2028 would therefore correspond to all of Shobak's septage ([124 + 359] ÷ 2 = 241 m3/day) in addition to an equivalent to around 82% of that generated from Qadissiyeh (0.82 x [80 + 185] = 109 m3/day).

Table 9
Shobak septage (m3/day) estimates and projections (2005 – 2030)

Area	Estimate	2005	2008*	2010	2015	2020	2025	2028*	2030
Shobak	Low**	70	78	83	95	107	118	124	128
	High***	162	185	202	241	286	332	359	377
Qadissiyeh	Low**	45	50	53	61	68	76	80	83
	High***	83	95	104	124	146	170	185	195
Husseiniyeh	Low**	22	25	28	33	38	43	45	46
	High***	56	66	72	89	109	129	140	147
Asha'ari	Low**	15	17	18	21	24	26	28	29
	High***	28	32	35	43	51	60	65	68
Total	**Low****	**152**	**169**	**182**	**208**	**237**	**263**	**277**	**286**
	High***	**329**	**378**	**412**	**497**	**592**	**690**	**748**	**788**

* The WWTP is planned to begin operation in 2008 and has a 20-year life (2028).

The methodologies for determining the septage estimates in the table above are explained below. The costs and consequences of current septage disposal practices and the no action alternative are explained previously in Section 2.1.

** The lower ranges provided are based on:

a) Lower-end (average) initial estimates;
b) Winter discharges (usually ranging from 30 – 60 % of the peak summer values); and
c) Are projected on a septage per capita basis along with population projections (see Table 8), increasing annually at the same rate of increase used by the MWI National Water Master Plan in their per capita water supply assumptions.

*** The higher ranges provided in Table 9 are based on:

d) Higher-end (conservative) initial estimates;
e) Summer discharges (when discharges peak); and
f) Are projected in a similar manner, but with an added 5% on top of the rate used in the lower range projections described previously.

With the higher range projections, 5% was added to the rate of increase in per capita water supply to account for cesspit improvements, increasing age of cesspits, better enforcement and regulation of emptying out cesspits over time - all of which result in households having to empty their cesspits more frequently - and to account for other potentially unforeseen factors. Increases in per capita water supply being the basic factor related to increases in water consumption and hence septage generation.

4.2.c. Economy and living standards

According to the latest 2004 DOS figures, average family income in Shobak is around 6,200 JD per annum with 9% of the population living in poverty. On average, this corresponds to two income earners per household on average salaries of 260 JD/month. The Municipal Council of Shobak suggests that average family income is closer to 150 JD/month. Regardless of which figures are correct, Shobak can still be considered one of the relatively better off areas in the country, but the area is still expected to be relatively poor when all of the smaller and surrounding communities are taken into account. DOS reports Al Husseiniyeh Municipality's households' earning around 4,800 JD/yr and the average for Ma'an Governorate (which includes Shobak, Husseiniyeh and Asha'ari) at around 4,440 JD/year. On average, these correspond to two income earners per household on average salaries of 200 JD/month and 185 JD/month respectively. 21% of the Ma'an population and 47% of Husseiniyeh's population are reported to live in poverty. Most families live in poor to moderate houses built out of blocks or concrete. There are also several government-built housing units in the region.

Family expenses drain all income and sometimes drive families into debt. DOS reports indicate that expenditures exceed 100% of reported income in these areas with the exception of Shobak where families are reported to spend in the order of 85% of their incomes. As mentioned above, the situation for most residents of the potential service area are most probably closer to the Ma'an average. For example, the Mayor of Shobak reports several families selling their vehicles and household items in order to help put their children through education. Several households have also tried to develop some small household agricultural activities to help cover increasing living costs and losses in employment opportunities.

Water for use in agriculture is very limited, requiring municipal supplies at high prices or water tankers at even higher prices. This is not the case at the several large apple farms that have their own wells. These apple farms are owned by private investors from outside of the region, employ approximately 1,000 to 1,500 laborers (higher during harvest season) and support a few of the poor local families through direct charity assistance. Most of the agriculture in the area is rain fed, with Bedouins and landowners growing fodder for grazing. Animal rearing (mainly small ruminant systems) is one of the most important economic activities in the Shobak region. Approximately 15,000 local head of sheep and goat graze the area, rising to 80,000-100,000 during the spring and summer when several Bedouins return to the area from the eastern desert and elsewhere. These exert significant grazing pressure and have resulted in significant land degradation in unprotected areas.

The cement factory in Rashadiyeh provides the main source of employment for Qadissiyeh residents. In Shobak there is an agricultural college and an agricultural research center (NCARTT). Elsewhere in the region there are a few olive presses, a water bottling company, a regional Military base, and the Fujaij and Dana reserves. Schooling and the government also account for significant employment as does some of the tourism in the area associated with passers by en-route to Petra and those that occasionally visit the Shobak Castle.

4.2.d. Land-use, community infrastructure & services

The Municipality of Shobak is highly capable and organized as indicated by its ISO 9001 certification. Table 10 lists some of the community facilities available in Shobak. They, like other Municipalities in the area provide solid waste services in addition to many other Municipal services. Generally all residents in the area have access to piped water and electricity. The roads connecting the various scattered settlements are all in excellent condition, just as the main touristic roads in the area.

The MoA plants trees alongside several of the main roads (25 km) and have developed a few fenced areas, wooded area of 5 Dn each. The MoA uses 30 m3/day from an existing well to irrigate tree areas along roads, various tree nurseries, and landscaping - all totaling 20 Dn at present. The MoA suggests that they could increase these irrigated areas to 100 Dn if more water were available. The community has good access to veterinarians and agricultural research carried out by NCARTT.

Table 10
Services and number of facilities in Shobak

Gardens	3
Health centers	3
Sport halls	1
Playgrounds	2
Sport clubs	3
Colleges	1
Kindergartens	14
Mosques	27
Charitable organizations	17
Public schools	34
Public libraries	3
Restaurants	5

Source: Shobak Municipal Website http://www.shoubak.gov.jo/

In the immediate vicinity of the selected site, there is the Fujaij Protected Area (FPA) just to the west, along-side the main road connecting Shobak with Tafileh (via Qadissiyeh). To the south lies the Dessert Highway-Shobak (Petra) main road. To the East of the site lay open, lands, often used for rain fed agriculture, but in significantly decreasing intensity the further one moves to the east. Figure 3 shows the selected site, two main roads mentioned above and limited land-use in the vicinity.

4.2.e. Archeology

The proposed site is located on-route to the world famous Petra monument, which is over 20 km away; UNESCO designated the site as a World Cultural Heritage site in 1993. In 2000, the number of visitors to Petra reached half a million bringing about JD1.2 million in revenues. Shobak Castle ("Mont Royal"), a crusader castle, is located within the Municipality of Shobak, just to the north of Muthalath As Shobak.

Historical civilizations and the remains they leave behind are closely related to climate and biogeography. The selected site is generally characterized by Mediterranean vegetation and limestone bedrock that receives enough rainfall to sustain rain-fed agriculture. The vegetation cover however is sparse and natural springs are rare. Moving west- and northwards into the hills rainfall increases, so does the vegetation cover and the occurrence of springs and perennial water flow. As it is now, so it was in the past, this area has always been occupied. It is good agricultural land, suitable for rain fed agriculture, fruit and olive trees. The rainfall is sufficient to fill cisterns and reservoirs for the dry summer months, allowing settlements to be established.

Where there is limestone bedrock outcropping there is the possibility of encountering caves and rock shelters, which have been used in the past, as well as rock-cut cisterns, burial chambers, wine and olive presses. The larger hilltops and deeper wadi sides are the most favored location for watchtowers, farmsteads, villages, and burial cairns. Rather, the selected site area is characterized by open rolling country typical of areas that tend to have more prehistoric sherd and flint scatters in addition to the odd, isolated buildings. None of these were observed during site visits. The JADIS database does not show any recorded sites either, however this is possibly due to the lack of surveys done in the immediate vicinity of the site. This database however shows several recorded sites in the hilltops and along the edges of mountains to the north-west near Qadissiyeh and Dana Reserve. There are also a few sites recorded further to the south and to the east.

4.3. Physical environment

4.3.a. Climate

Shobak is one of the coldest places in the Kingdom with mean monthly temperature ranging from 4 ^{0}C in the winter up to means of 20 ^{0}C in the summer months, with absolute maximums reaching as high as 38^{0}C and absolute minimums reaching as low as –14 ^{0}C. Total annual rainfall is about 300 mm, dropping substantially further to the east and south (see summary of climatic conditions in Table 11). The Shobak Weather Station is located around 8 km to the west, and slightly to the south, of the proposed WWTP site and is about 200 meters higher in elevation (1,365 masl). Therefore drier and slightly warmer conditions prevail at the proposed WWTP site when compared to this station. Figure 8 overleaf shows a summary of the long-term wind directions and their frequency in a wind rose. Winds are westerly most of the time. Mean annual wind speed is 2.1 knots (3.7 km/hr) climbing to 3.3 knots in January (6.1 km/hr) and maximum wind speeds were recorded in October reaching 40 knots (74 km/hr). Calm wind conditions prevail 38 percent of the time. Appendix C contains details on wind data.

Table 11
Long-term Climatic Data (1977 to 1999) from Shobak Weather Station

Parameter	Value
Absolute max Air Temperature (°C)	38.2
Absolute min Air Temperature (°C)	-14.0
Mean air temperature (°C)	12.6
Mean Maximum Air Temperature (°C)	19.5
Mean Minimum Air Temperature (°C)	5.7
Annual Mean Relative Humidity (%)	59.5
Total Rainfall (mm)	311.6

Source: Jordan Climatological Handbook (2000)

4.3.b. Topography and Soils

The topography of the site and surrounding areas is gently rolling with few seasonal, small wadis dissecting the landscape (refer to Figure 3) – typical of many eastern dessert areas within the Kingdom. A few kilometers to the west, steep cliffs dominating with deep wadis, characteristic of the Jordan Valley escarpment, Wadi Dana and Wadi Musa areas descend to over 1 km, sometimes more, before opening up several kilometers to the west into Wadi Araba. A detailed contour map of the selected site (1 m contours) is available in Figure 9, and shows small wadis bordering the northern and southern portions of the site. The general project area is covered by soils and soils over bedrock. These deposits are relatively thick and consist of "silty clay and gravel of limestone and chert" materials. Topsoil materials are composed of light brown silty clay with gravel of limestone and chert.

Figure 8
Wind rose

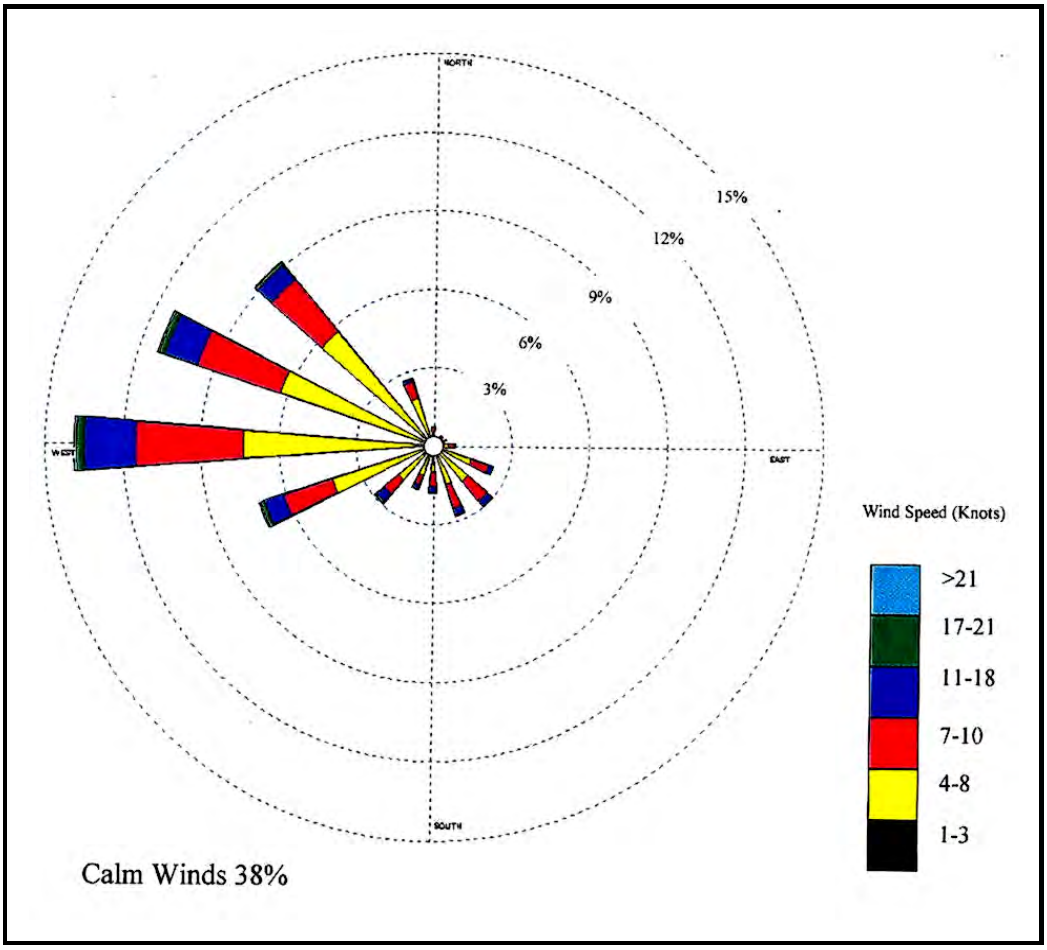
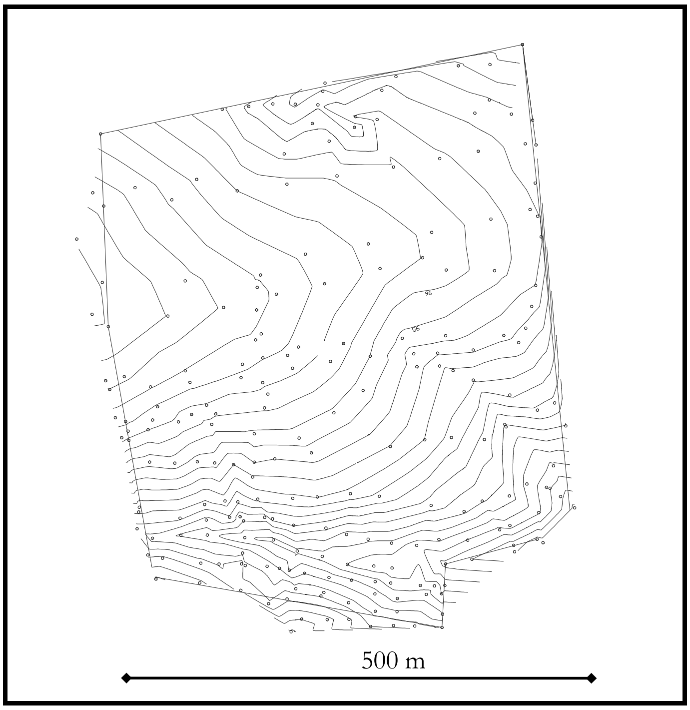


Figure 9
Detailed contour map of the selected site



4.3.c. Water resources and hydrogeology

Geology

The project area is located in the western corner of the east Jordan limestone plateau. This plateau extends over 45,000Km2. It is bound to the west by the Wadi Araba - Jordan Valley Graben, to the south by the sandstone of south Jordan, and by basaltic fields to the north. Geologically, this plateau is dominated by the upper cretaceous and Tertiary carbonate rocks as evidenced by outcrops of the “Balqa” and “Ajloun” groups. A simplified lithological description of southern Jordan geology is presented in Table 12.

The project area is dominated by outcrops of B4-5, B-3 (of the Balqa group) and B2-A7 (of the Ajloun group) as can be seen in Figure 10. At an elevation of approximately 1,250 masl, the project site is gently rolling, without signs of any outcrops, but expected rock formations a few meters below the surface soils. A wadi is located in the southern portion the project site in addition to a group of minor wadis heterogeneously distributed throughout the site, becoming more pronounced near the property boundaries.

Lithological succession

Southern Jordan is characterized by a complex multi-aquifer system, up to 3000 meters thick. It comprises three widely extended aquifer systems separated by intercalated marly and clayey aquitards of very low permeability.

The shallow aquifer system consists of sedimentary rocks from the tertiary and quaternary age. Except for occurrence of water in the alluvial and Wadi deposits, the shallow aquifer consists of limestone and chalk of the B4-B5 formation. At the base of this system lies a marly limestone formation (B3 aquitard) that separates the shallow system from the upper cretaceous hydraulic system.

This upper cretaceous aquifer system (Intermediate Aquifer System) is well represented by the B2-A7 aquifer (formed by limestone and chert of the B2-A7 unit). It also constitutes a major aquifer system for groundwater abstraction. In the project area, the majority of the groundwater wells are tapping this aquifer. The predominantly marly A1-6 aquitard separates the upper cretaceous hydraulic complex from the underlying sandstone aquifer complex.

The deep Sandstone aquifer complex extends over most of Jordan and consists of the lower cretaceous Kurnub sandstone group and the Palaeozoic Ram group (Disi Aquifer). Due to the great thickness of the Disi aquifer (>1000m) it represents a huge groundwater reservoir. To date, unlike the intermediate aquifer system, the deep sandstone aquifer complex has not been exploited but a national water scheme to supply Amman will eventually tap this aquifer.

Table 12
Simplified Lithological Description of the southern parts of Jordan

ERA	Group	Formation	Description
CENOZOIC	Alluvium	RQD	Gravel and sand with marl and silt working as an aquitard
	Balqa Group	B4-B5	Limestone
MESOZOIC		B-3	Marl and Marly Limestone
		B2	Limestone, dolomitic limestone and cherty limestone
	Ajloun Group	A7	
		A1-6	Limestone sandstone with marl and Shale layers working as an aquitard
	Kurnub	K	Mainly sandstone with intercalated layers of siltstone and shale as an aquitard
PALEOZOIC	Kherim	Kh	Mainly sandstone with some intercalated layers of siltstone and shale
	Disi	D	Sandstone and quartzite
PRECAMBRIAN		Basement	Igneous and metamorphic rocks

Groundwater flow direction

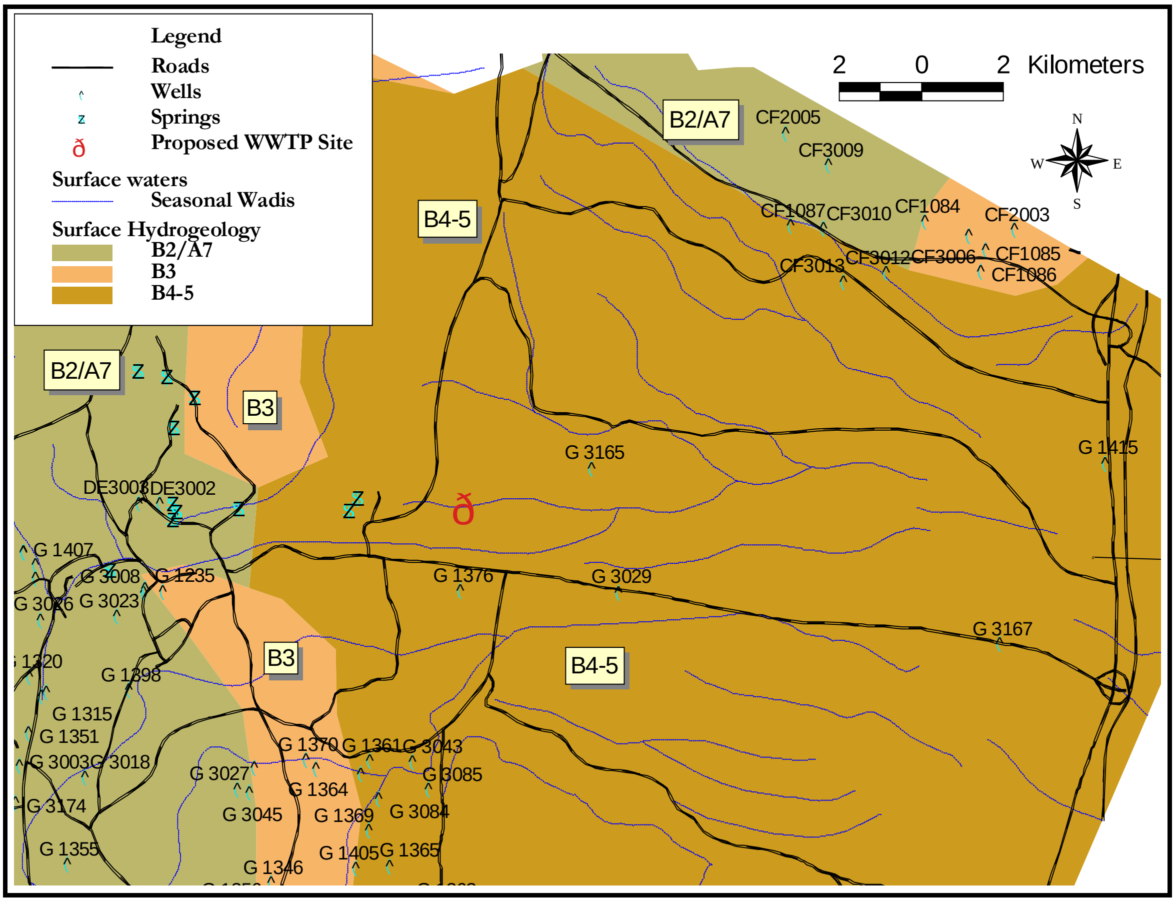
There are no permanent surface water flows in the project area and the groundwater level is relatively deep; 100 m bgl on average and up to 200 m bgl locally, if not deeper (see Table 13, monitoring wells G3146 and G1405 respectively). Groundwater flows near and around the proposed site in Shobak is generally westerly and southwesterly (i.e., from east to west and/or southwest) as is common with the intermediate aquifer system of the area. The directions of flows within the shallow aquifer may follow surface topography and surface water flows, but cannot be determined with any degree of certainty as a result of its limestone nature, relatively low amounts of rainfall and lack of data for the specific area.

Springs and wells

A map showing the distribution of wells and springs within the wider study area around the selected WWTP site is available in Figure 10. Because there are little hydro-geological data near the project site, we have identified groundwater wells in a wider geographic area measuring about 230 km². Within this area, there are at least 39 wells (listed in Table 13), the majority of which tap from the B2-A7 aquifer system but only two (G1405 and G3146) are official monitoring wells. Water level data for the remaining wells indicate the water level during well testing at the time of drilling. It is safe to assume that most of these wells today are either out of service or have been extended deeper. Historical data show that the water levels are dropping – an indication that groundwater pumping is excessive and unsustainable.

According to official MWI records, there are 15 springs within a 130 km² area of the project site. In general, these springs either have low discharges, are seasonal or dry. The nearest 2 springs, located within 3 km west of the project site (Ain Fujaij), are dry[3]. All other springs are hydraulically disconnected from the project site by a major fault west of the site, running North-South or are on higher grounds.

Figure 10
Simplified Geologic Map (incl. Aquifers), Wells and Springs in the Wider Project Area



[3] *Pers. com.* Dr. Issa Nsour (MWI), June 2005.

Table 13
Characteristics of Groundwater Wells Located within 230 km² of the Project Area

Well ID	Type	Aquifer	Depth to WL	Date of Measurement
DE3002	Gov	Na	Na	Na
DE3003	Gov	Na	Na	Na
DF3003	Gov	B2-A7	24.75	9/12/1996
G 1235	Gov	B2-A7	82	5/7/1998
G 1315	Gov	Na	80.4	10/10/1989
G 1320	Gov	B2	Na	Na
G 1398	Gov	Na	43.3	12/9/1998
G 1405*	**Gov**	**B2-A7**	**200**	**18/8/2004**
G 1407	Gov	B2-A7	120	10/4/2002
G 3003	Gov	B2-A7	73	4/10/1973
G 3008	Gov	B2-A7	65.3	18-8-1993
G 3018	Gov	Na	Na	Na
G 3023	Gov	Na	62.1	30/5/1988
G 3024	Gov	B2-A7	34.6	15/8/1966
G 3025	Gov	B2-A7	108	21/12/1993
G 3026	Gov	B2-A7	78.5	23/9/1994
G 3027	Gov	B2	52.65	26/10/1993
G 3029	Gov	Na	Na	Na
G 3045	Gov	B2-A7	40.8	12/2/1972
G 3157	Gov	B2-A7	80.8	18/12/1996
G 3162	Gov	B2-A7	113.7	19/8/1998
G 3165	Gov	Na	Na	Na
G 3166	Gov	Na	Na	Na
G 3173	Gov	B2-A7	71.75	21/4/1999
G 3174	Gov	Na	Na	Na
G 1351	private	Na	52.8	12/9/1998
G 1355	private	Na	21.4	12/9/1998
G 1361	private	Na	24	12/9/1998
G 1364	private	Na	16.2	12/1/1985
G 1365	private	Na	164.5	2/11/1985
G 1369	private	Na	11.55	12/12/1985
G 1370	private	Na	14	16-5-1985
G 1372	private	Na	50	26-10-1987
G 1376	private	Na	Na	Na
G 3043	private	B2-A7	161.45	4/12/1993
G 3084	private	B2-A7	140.3	9/7/1986
G 3085	private	Na	Na	Na
G3146**	**Gov**	**B2-A7**	**100**	**22-9-2004**
G3176***	**Gov**	**Ram**	**264**	**8-1-2002**

* Groundwater monitoring well
** Groundwater monitoring well, located about 35 Km to the west of the proposed WWTP
*** Groundwater monitoring well, located 82 Km southeast of the WWTP

4.3.d. Seismicity

According to the Jordanian Code, the proposed site lies within Region B on the map of seismic zones in Jordan (Grade 2/4 according to the recent international code). The topography of Shobak area reflects Neogene regional up-warping and eastward tilting of the area east of Wadi Araba-Dead Sea Rift Transform and down-warping of Wadi Araba floor. The area is affected by faults of different types, ages, extents and trends. The following are the major faults in this area:

- E-W trending faults (Salwan, Dana, others)
- N-S trending faults (Bir Khidad, Wadi Musa, Az Zubayriyya, others).
- NW-SE and NE-SW trending faults

The Dana Horst is the most distinctive structural feature in Shobak area. The structure was developed between E-W Salwan Fault and ENE-WSW to E-W Dana Fault. A major fold zone (part of Petra-Shobak structure), as well as flexures and drag folds are associated with major faults in this area.

Earthquake risk

Earthquake activity in Jordan occurs in the wide zone along the Dead Sea Transform boundary (along the associated major faults). As a result of the differential motion of the Arabian Plate and the Sinai Plate (Palestinian Sub-plate), the distributed pattern of seismicity in the Jordan Rift Valley suggests that shear is accommodated in part by E-W and NW-SE trending faults in a broad zone rather than just along the Dead Sea Fault zone itself. Seismic activities beneath the Shobak area and its vicinity in the central part of Wadi Araba and Petra are recorded as small and medium magnitude earthquakes as a result of the active strain of Wadi Araba Fault to the west.

About 30 earthquakes were recorded by the Natural Resources Seismological Stations with a magnitude ranges between 3-7 on Mercalli scale (2.5 and 5 on Richter scale) in Shobak area since 1983. However, no surface displacement has been recorded. Activity beneath Shobak area is apparently low, with a dominance of 3-3.8 on Richter scale (although the non-detection of low level earthquakes could be attributed to the distribution of the NRA seismic network).

4.4. Biological Environment

Jordan is a signatory to several milestone conventions including Ramsar Convention, Convention on International Illegal Trade with Endangered Species (CITES); Convention for the Conservation of Migratory Species (CMS), Bonn Convention and the Convention on Biological Diversity (CBD).

4.4.a. Habitat and ecosystem description

The area under investigation lies within the most western edge of the Irano-Turanian ecozone at an attitude of about 1267 masl (UTM 36° 75 23 E 33° 81 69 N). The study site is located immediately east (opposite) of the Al-Fujaij Pastor Reserve (FPR). Recently designated by BirdLife and RSCN as an Important Bird Area (IBA), along with the Dana valley, this rangeland reserve enjoys some degree of protection (see box). The southern boundaries of Dana reserve is about 8 km from the project site.

The soil is predominantly loamy calcareous with a mixture of xeric soil elements. The area is flat with gentle slopes towards the eastern side, and marked by two small wadis. Both wadis enjoy relatively rich vegetation cover. The site is heavily eroded due to extensive ploughing, grain cultivation and intensive grazing. Signs of severe degradation from grazing and firewood harvesting were observed in some parts of the study area, evidenced by the presence of dead remains of Noaea mucronata and Artemisia herba-alba. The area's fauna and flora is characteristic of the Irano–Turanian and Sudanian bio-geographical zones.

4.4.b. Overview of Al-Fujaij Pastoral Reserve

Al-Fujaij Pastoral Reserve is located on the western borders of the proposed site. This site has been proposed as an alternative site to the current site. This option has been dropped due to various reasons discussed earlier (Section 2.3). The reserve has been established in 1958 with an area of 10 km^2. The land is owned by the government and comes under the authority of the Ministry of Agriculture. In line with national conservation policies, FPR was established to manage and conserve plant cover by minimizing woodcutting and grazing in general and improving livestock quality in particular. A dedicated livestock/small ruminant program is in place for this purpose.

The eastern and some of the northern edges of FPR are fenced to control access by visitors and herders. The site is used exclusively for improving livestock quality, however, during droughts herds are permitted to enter the reserve for short periods.

The reserve consists of flat meadows interrupted by several wadis that extend from east to west, and steep gorges forming sharp edges. The soil is a mixture of calcareous and terra rosa. Crevices and rocky areas are common along gorges and wadis providing shelter for several medium sized animals. It is characterized by lush vegetation of both Noaea mucronata and Artemisia herba-alba with an abundance of annual flowering plants. In some parts of the reserve, Atriplex numularia has been cultivated as a fodder. FPR exhibits both Irano-Turanian and Mediterranean features, however the Mediterranean elements prevail. It is evident that FPR is not impacted by agriculture or continued grazing; it displays a well established ecosystem with interesting faunal and floral components.

4.4.c. Flora

The flora of southern Jordan has been extensively studied. The mountainous parts of Shobak belong to the Mediterranean bioclimate and occur at altitudes 1200-1600 m above sea level. Although the study site falls under the Irano-Turanian bioclimatic subdivision of Jordan, it is influenced by the Saharo Arabian realm at the eastern parts. The Irano-Turanian region harbors extensive steppe rangelands and is best used as grazing lands. Vegetation can be classified as the Artemisia herba alba and Noaea mucronata brush.

The proposed sites harbors some rare and endangered species, including the Petra Iris, Iris petrana, and the Goat's Beard, Tragopogon collinus. Both species are listed on the 1997 IUCN Red Data List and global classified as "Endangered" and "Rare" respectively. Other locally threatened species found in the proposed site include the Tulipa polychroma, Iris aucheri, and Glaucium grandiflorum.

Common species also observed in the site include Teucrium polium, Helianthemum vesicarium, Matthiola longipetala and others. The occurrence of Anabasis syriaca, Chardaria drapa and Peganum harmalla in the site indicate habitat degradation due to extensive soil tillage. The full list of species of observed and potentially occurring species is presented in Table 18 in Appendix D.

4.4.d. Fauna

Little information on the natural history and fauna of the Shobak area has been published. The available literature reports that several snake species were collected from the vicinity of Shobak (El -Oran et al, 1994); various lizards were also identified in the Shobak area (Disi et al., 2000); one species of amphibians and 42 species and subspecies of reptiles belonging to two orders and 12 families (Disi & Hatough-Bouran, 1999). At least two reptilian species and 11 species of mammals were found to be rare and endangered.

The mammals of southern Jordan, particularly Dana Nature Reserve, have been extensively studied. At least seven carnivorous species have been reported to roam the reserve (Amr et al. 1995), some of which including the Red Fox have a wide home range. The Dana Nature Reserve also harbors the Nubian Ibex, Capra nubiana (Catullo et al. 1996). Finally, 29 species of mammals belonging to 6 orders and 14 families were reported in the area of Petra (Disi & Hatough-Bouran, 1999).

Field observations

Based on field observations, the study site harbors no flagship or indicator species characteristic of rich and viable ecosystems. The area is heavily impacted by agriculture and grazing. Only generalist species with no specific requirements were observed. Mounds of the Palestine mole, Spalax leucodon, were observed in the study site, along with burrows of Trisram jird, Meriones tristrami. Both species are common rodents within the area and are considered agricultural pests. A red fox, Vulpes vulpes, was spotted as well. Only one lizard species was seen, the snake-eyed lizard, Ophisops elegans.

Shells of dead land snails (Xeropicta sp.) were scattered along areas cultivated with cereals and two beetle species, Ademsia sp. and Mesostena sp. were collected from the wadis.

From a zoological point of view, several aspects of faunal assemblage were noted in FPR. Live land snails of the genus Xeropicta were found around thick vegetation, crevices and under rocks. Other elements pointing towards the presence of a sound ecosystem include the diversity of insects. The presence of quills and fecal remains indicate the presence of several carnivores and large and medium-sized mammals, including the Indian Crested Porcupine, Hystrix indica. A list of the mammalian and amphibian species recorded and observed in the study area are available in Table 19 and Table 20 in Appendix D.

4.4.e. Avifauna

The area represents an important part of the Sharah mountain range SW of Jordan. This important top laying part of the Sharah series of highlands overlooks the southern Rift Valley, and provides the vast plain where the unique Dana gorge that extends EW and cuts the Rift, ends. The Rift Valley in general is part of the major routes for annual bird migrations between Asia and Europe and Africa. The Dana area provides crucial habitat for birds crossing the migration corridor. It serves as a resting stop during their fall migration to Africa and their spring migration north to nesting grounds.

Ornithological Importance

Although many bird species migrate across board fronts, many aggregate along established corridors while migrating. As a result, enormous concentrations of tens of thousands of birds regularly and predictably occur at specific geographical features, especially along mountain ridges and passes, narrow coastal plains, isthmuses, and peninsulas. Migration corridors usually occur along so called "leading lines", which are geographic or topographic features such as mountain ranges and coastlines that are oriented along or near the preferred direction of travel.

The Great Rift Valley forms an important corridor for migration, where the adjacent mountain ridges are important and crucial leading lines for soaring migratory birds and Sharah Mountains are indeed and excellent example of that.

At least 500 million birds of over 230 species pass through Jordan twice a year. Many of these species breed in mid and Eastern Europe and a significant portion of their entire population pass through the region. Indeed, the entire population of some species such as the Lesser Spotted Eagle and White Stork passes through the area twice a year. Moreover, dozens of theses species are listed as globally threatened by the International Union for the Conservation of Nature (IUCN).

Important Bird Areas and Bottleneck Sites

Based on the above, Dana reserve is considered an Important Bird Area (IBA), and a bottleneck site for migratory birds. IBAs are critical sites for the conservation of birds and biodiversity and provide practical targets for conservation action. IBAs are designated by BirdLife International based on globally agreed criteria. For example, candidate sites should provide essential habitat to one or more species of breeding, wintering, and/or migrating birds. The sites vary in size but are usually discrete and distinguishable in character, habitat, or ornithological importance from surrounding areas.

There are four main categories by which a site may qualify as an IBA, one of which "Congregations" includes the following criterion: a site known or thought to be a bottleneck where more than 20,000 storks, pelicans, raptors or cranes, or a combination thereof regularly pass during migration.

Bottlenecks are recognized as valuable or sensitive sites where migratory birds are perceived to be vulnerable by congregation while on passage. This category also embraces sites over which migrants congregate before gaining height on thermals. In addition to being sites where high concentrations of flying migrants pass, some sites are important staging or roosting for large numbers of birds.

The bulk of the birds form a mass flyway through Jordan, the Jordan valley is particularly important part of the corridor, which starts from the northern tip of the Gulf of Aqaba. Al Sharrah highland is an important part of this flyway. The Fujaij area, along with its adjacent wadis and gorges overlooking Wadi Dana represents a great example of a bottleneck site. In the area, more than 230 bird migrant species have been observed. Many of them have been recorded in huge numbers. Additionally, the ecology of the area provides important habitats for a wide variety of bird species of restricted range to our region.

This highland plateau supports a wide array of breeding and migratory birds. FPR is a feeding area to the majority of breeding birds occurring in the area including: the Lesser Kestrel, Bonelli's, Short-toed and Verraux's Eagles, Griffon Vulture, Eagle Owls, Hooded and Isabelline Wheatears, Short-toed Larks, Woodlark, Tawny and Long-billed Pipit, Upcher's and Orphean Warblers, Palestine Sunbird, House and Cretzchmar's Bunting, Sinai Rosefinch and Fan-tailed Raven. The site is also an important feeding area of the globally threatened Syrian Serin.

There is huge raptor migration in spring (noticed during the field visit), which may total up to 100,000 birds per season including Egyptian Vulture, Imperial, Steppe and Lesser Spotted Eagles, but most numerous are Levant Sparrow Hawk, Honey and Steppe Buzzards. During the field visit many soaring birds (Storks and Raptors) were observed resting at the FPR area, indicating an important staging area for migrants. The proposed Site No.5 however is species poor and none of the key bird species of the Sharrah highlands were observed. The globally threatened Syrian Serin is dependent on Artemisia sp. and Achillea sp. for forage. The proposed site does not contain Achillea sp. and Artemisia sp. cover is severely eroded. Both species however are found FPR (Alternative Site No. 6) making it on of the most important foraging habitat for the Serin.

Migration in this area involves as many as 31 raptor species many of which are migrants. Many species of Passerines and allies also pass through this area in significant numbers. Dana reserve is a well-known bottleneck along the eastern European migratory flyway. This place has been identified as a stopover site available for migrants on the way from Southern Sahara to the south Mediterranean coast, between the African winter quarters and the Palaearctic breeding areas. Additionally, the ecology of this IBA provides important habitats for a wide variety of bird species of restricted range to our region (see list of species in Table 21 in Appendix D).

5. ASSESSMENT OF IMPACTS AND PROPOSED MITIGATION MEASURES

This chapter provides an overview of positive and potential adverse project impacts. It shows that, overall, the net project impact on the environment in the area will be positive. Potential adverse impacts, mostly limited to the area immediately surrounding the WWTP, have nonetheless been comprehensively identified and assessed. Specific, practical mitigation measures are proposed and discussed under each impact heading, designed to ensure positive impacts are enhanced and potential adverse impacts are minimized. These mitigation measures are incorporated in the Environmental Management and Monitoring Plan detailed in Chapter 6.

5.1. Positive impacts and their enhancements

The project will generate a number of positive impacts. It will provide a controlled sink for the collection and treatment of septage in the area and thereby replace the current unsafe disposal practices and associated environmental and health impacts. The most significant positive impacts are described below and generally pertain to the wider study area as indirect, but very likely impacts.

5.1.a. Reduced tanker charges relative to the no-action alternative

The proposed site provides the least total cost for septage transportation for residents in the proposed service areas. During the summer months and at average current private tanker transport rates, the total septage transport savings in the service area associated with the selected site may reach as high as 30,000 JD per month when compared with the no-action alternative where tankers should be requiring to discharge at the Ma'an WWTP. These saving can be expected to increase beyond 70,000 JD per month by 2028 without considering inflation in transport costs.

Overall, the proposed site location will optimize travel distances and help keep tanker transport charges to reasonable levels. Minimizing transport costs also helps ensure that cesspits are not allowed to overflow as frequently and that tankers do not discharge illegally. Although a new tanker fee may be required for discharging into the WWTP, this increase will be less than what tanker drivers would charge customers if they had to discharge septage at the Maa'n treatment plant, 30 to 80 km away depending on the village/town. Although the proposed project is limited to the treatment plant per se, it will also indirectly enhance and streamline the work of tanker drivers.

The choice of a WWTP alternative with the lowest running costs and maximizing revenues from the productive use of WWTP byproducts (reeds and sludge) will also help minimize tanker fees charged by the WWTP. The WWTP should also be operated and maintained as efficiently as possible.

5.1.b. Improved public health, sanitation, and pollution prevention of the wider area

As a result of the project, the incidence of overflowing cesspits will significantly decline. Cesspits may still overflow; however overall, the project will improve sanitation and maintain a cleaner environment throughout the wider project area. Sanitary conditions in and around residential communities will improve and the incidence of disease outbreaks should decrease. The on-site tanker cleaning facility should eliminate the environmentally damaging practice of cleaning septic tanks in various locations throughout the service area.

The plant will confine the collected septage in one location and thereby discontinue the current practice of open dumping in wadis and on open land. As a result, contamination of surface waters, ground water and open lands will significantly diminish. It is important to note that the project however will not directly resolve the problem of leaking cesspits and the resulting groundwater contamination.

While the WWTP and reduced transport costs will encourage this improvement (as people will be less likely to let their cesspits overflow and tankers will be less likely to discharge illegally as mentioned above), however additional enforcement and awareness raising of appropriate cesspit pumping and prevention of illegal tanker discharges will be required to enhance this positive impact.

5.1.c. Employment opportunities

Construction will result in the additional employment of some local people (e.g. as guards and labor). The WWTP will employ 5-7 people, some on shifts (e.g. guards). Additional workers will also be required to operate and manage the productive use of WWTP byproducts. The project team has selected labor-intensive WWTP technology in favor of more mechanical or low labor requiring technologies. The WWTP&R operator(s) should make a concerted effort to hire local workers except if certain skills are required that are not available locally (e.g. WWTP manager). During the design of the activities for productive use of the WWTP byproduct, preference will also be given to labor intensive farming technology in so far as it does not negatively affect feasibility. The construction contractor will also be encouraged to hire local workers to the extent possible.

5.1.d. Change in land value

The effect on the value of lands surrounding the WWTP cannot be predicted. Over the long-run however, it is expected that land values will improve. A paved access road to the site will increase the value of lands along side the new road. As reuse of sludge for soil conditioning becomes realized, the project will likely have a positive impact on the value of surrounding lands as a result of improved soils. An improvement in the organic matter content of the soils in the area, which are generally very poor, from such conditioning is expected to increase soil moisture retention and will likely improve rain-fed fodder crop yields. The WWTP with 60 Dn of reed beds will also improve the visual aesthetics of the area and soft landscaping including ornamentals and trees will be planted along the site's perimeter.

5.1.e. Demonstrating the use of WWTP byproducts and improved public perception

The productive use of sludge will provide a unique and real opportunity to demonstrate the benefits and limitations of sludge reuse to landowners. Harvesting of reeds from the WWTP and their productive use in a range of potentially income-generating activities (see Section 2.5) and/or as a carbon source to enhance sludge composting, will further improve public perceptions pertaining to such activities. Such reuse will highlight important environmental, technical and health and safety issues.

In addition to the potential socio-economic benefits, a successful and participatory reuse activity can also serve as a platform for improving communication between various community stakeholders and facilitate replication in other areas of the Kingdom. Providing safe reuse training for farmers and broader awareness campaign in relation to reuse, coupled with effective monitoring and enforcement of Jordanian reuse standards and safe reuse practices should help maximize these project benefits.

5.1.f. Improved habitat for wildlife and biodiversity

A series of water bodies and reed beds will potentially attract birds and serve as a resting site. Bird congregation in the vicinity of man-made open water bodies is common and has been widely reported in the past. These may attract wintering species such as thrushes and allies as well as an increased number of Gold and Green Finch to the Shobak area.

5.1.g. Prospect for sewage system in the future

One of the criteria for site selection included the ability to connect the proposed WWTP with a sewer system to residential areas. This involved giving preference to sites that were downstream (for gravity flow sewers – less costly to construct and operate) and not too far from the larger, higher density residential areas that would benefit from sewer systems. In principle therefore the proposed WWTP site could in the future receive wastewater by sewers built and operated with minimal costs. The environmental and socio-economic impacts of such a future sewer system are not part of the scope of this project and EA.

5.2. Potential adverse impacts during construction and their mitigation

A number of potential impacts are noticeable during construction including potential air quality deterioration, noise, the disposal of wastes and potential health and safety risks as described next.

5.2.a. Air quality deterioration and noise pollution

Several activities may impact air quality. Excavation and land leveling can generate significant dust especially since the site lies in a relatively windy area with loose topsoils and little vegetation cover. Air quality may also deteriorate for brief periods as a result of transporting some of the excavated material off-site. The activities mentioned above will also generate noise and some emissions. Such impacts will be infrequent and of short duration during the summer. These impacts are considered insignificant in light of prevalently dusty conditions in the area and the lack of nearby permanent human settlements.

If significant quantities of dust are generated during periods when winds are northwesterly to northeasterly (less than 15% of the time, and mostly during winter: refer to Appendix C), then driving visibility along the important Shobak-Desert Highway (Petra) main road may be affected. Bedouins occasionally reside in areas to the east and south east of the site and usually during the spring and summer: these areas can be downwind up to 40% of the time. When at high levels, dust along with noise could pose a risk to workers' health and be a significant nuisance to Bedouins if they are residing downwind and in close vicinity to the site.

The only other potential receptors in the area lie to the west to north-northwest: including the Military base that is almost 5 km north-northwest of the site; Fujaij nature reserve and the Shobak-Qadissiyeh main road, both located around 1.5 km to the west and northwest of the site. These are all prevalently upwind. The Military base is also far enough to be of little concern in relation to dust and noise. The infrequent and short-term nature of dust generation will be reversible insofar as the Fujaij rangeland's flora is concerned and the Shobak-Qadissiyeh main road is characterized with relatively low traffic flows.

Mitigation measures

As a means of dust impact control, the contractor will be expected to avoid excavations and earthworks during times of high-wind conditions and when winds are northwesterly to northeasterly (only avoid excavations if winds are westerly if Bedouins are residing to the east of the site). To the extent possible, vegetation cover should be maintained within the construction site and along roadsides as another means of dust control. The detailed design will also seek to minimize excavations (cut & fill) and off-site materials transport. Trucks hauling excavated materials will be covered.

Loud construction activities and off-site transportation will be prohibited in the very early morning and late in the evening if Bedouins are residing near the site. Bedouin families of the area should be notified in advance of potential noise and dust generation so that they may choose to set up their residences in areas that will not be prone to dust or high levels of noise (e.g., not directly downwind and not too close to the site).

In the event that significant volumes of excavated materials must be hauled off-site, a carefully thought out transportation and disposal plan will be developed that minimizes travel distances and trucking frequency to disposal sites. The disposal site should be carefully selected to reduce travel distance and avoid dust impacts in light of wind directions.

5.2.b. Disposal of construction waste and handling of hazardous materials

Workers and construction activities will generate solid waste. Construction will require a lot of materials including cement and/or ready-mix concrete, steel, geomembranes, pumps, sand and gravel, etc. While

most of the materials will be used on site, some of it will require safe disposal (e.g., defective materials, packaging waste). This impact is potentially significant if the waste is inadequately separated or stored in an area that is visible from major tourist roads.
Quantities of excavate requiring disposal and other construction-related transport are expected to be relatively low and in light of the good condition of roads in the area, are therefore not expected to damage any of the existing roads.

Mitigation measures

When fuels or solvents are required in construction areas, they should be transported in small quantities as hazardous materials. Hazardous materials should be stored safely in designated locations preferably away from sleeping and resting quarters for workers. The storage area should be well-ventilated and have an impervious floor (e.g., concrete slab) with a sump or retaining walls sufficient to contain spills. Materials and equipment should be provided to clean up and properly dispose of spills. Vehicle fuelling and maintenance areas should have impervious floors and materials for spill cleanup.

Any hazardous wastes, or wastes potentially contaminated with hazardous materials must not be stored and/or disposed of with non-hazardous materials. Non-hazardous materials may be disposed of in local dumpsites in consultation with the Municipality. Hazardous wastes must be disposed of separately, at a designated dumpsite. Store excavated materials separately in order to be able to use them on site for fill. Sanitary facilities must have appropriately designed cesspits, to be pumped regularly and disposed of at the existing Shobak dumpsite.

5.2.c. Health & Safety (H&S)

WWTP construction in Shobak will entail all the usual occupational risks associated with construction operations. Excavation and trenching operations will expose the workers to the risk of injury from falling debris. Collapse or parts falling from loose scaffolding could harm construction workers. Exposed electric cables or fittings may cause electric shock. Other potential hazards will be associated with the use of heavy construction machinery and risk of bites from venomous animals. Although construction impacts on health and safety may be significant, most tend to be of short duration and can be mitigated by appropriate construction practices.

Mitigation measures

Occupational health and safety is critical to avert accidents. Required occupational health and safety standards should be followed during all construction activities in accordance with the "Code of Safety for Construction Works." The code defines working conditions such as lighting, ventilation, noise and emissions. It also presents personal protection measures for face, arms, legs, hearing and vision. At minimum, the construction contractor should provide on-site workers with gloves, noise attenuators, steel-tipped shoes and hard hats, in addition to sanitary facilities and clean water. Plant operation should also respect the Jordanian Labor Law (Law No. 8), which includes articles concerning protection, treatment and compensation of employees working in Jordan.

Informing construction teams of possible hazards and suitable precautions will significantly reduce the occupational risks during the construction phase. The contractors should therefore provide awareness seminars/sessions for their workers and implement them. These plans should not be confined to the inception of on-site activities, but rather extend over the entire construction period. The contractor should provide on-site capability to treat affected individuals (first-aid, anti-venom, medical kits) and ensure the entire workforce know where the nearest hospital/clinic is.

Use of clear and visible warning signs inside the construction site in Shobak will warn the workers of potential hazards and alert them to the need for extra caution at areas of particular risk (e.g. trenches and excavated areas, heavy equipment paths, falling debris). The contractors may have to provide protective railings, where needed, in order to prevent workers from falling into trenches and excavated areas.

Off-site transport / disposal plans will carefully consider public safety / traffic accident risks and be approved by the local traffic department, ministry of health and/or municipality. The construction site will be closed off to public access and any heavily used transport routes should be fitted with appropriate "construction activity" warning signs.

5.2.d. Change in local hydrology, soil erosion, structural and earthquake risks

Little land leveling is envisioned in light of the gently sloping topography and its suitability to the WWTP's hydraulic profile. Excavations and the erection of facilities however, will alter the topography of the site. This is not expected to cause significant changes to the downstream hydrology, as the site presents relatively small sub-catchments in relation to the catchments of the area. Flooding of low-lying portions of the site (small wadis at the northern and southern boundaries of the site) is however likely from upstream areas if construction persists through to the rainy season. Flash flooding is common in the wider area as a result of the dessert-nature of the lands, however the selected site lies in the upper parts of the larger catchments and is therefore not expected to be under any major flash flooding threat. These lower lying areas are also more prone to erosion as a result.

The project site lies within Region B on Jordan's map of seismic zones where there is a relatively low earthquake risk as discussed in Section 4.3.d and 5.4.a. The probability of experiencing an earthquake during the construction phase is extremely low.

Mitigation measures

If construction activities are occurring during the winter, hydrological alterations from land leveling and excavations will be carefully considered and proper flood control measures will be taken and/or temporary drainage channels will be built to avoid washing away of stored materials and damage to excavations.

The WWTP design and construction will adhere strictly to the requirements stipulated in the National Building Code for Loads and Forces (for Region B)

5.2.e. Archaeological disturbance

The risk of disturbing or destroying any archaeological sites is low. Limestone bedrock outcrops, larger hilltops and deep wadi features do not exist in or around the immediate vicinity of the site. Rather the site area is characterized by open rolling country typical of areas that tend to have more prehistoric sherd and flint scatters in addition to the odd, isolated buildings. None of these were observed during several site visits and the JADIS database consulted showed no records of any sites in the immediate vicinity of the selected site. From the information currently available, there are no known major sites directly within the proposed site or its immediate vicinity that may be impacted by construction activities.

Mitigation measures

Although the risk of disturbing or destroying an archaeological site is low, it is nonetheless beneficial to request that representatives from the Directorate of Antiquities (DOA) carry out a rapid survey of the site to confirm these conclusions or to determine appropriate action if any sites of potential importance do appear. After this, the DOA may also want to decide if they should carry out random spot-checks during excavations. The DOA will determine what needs to be done in the unlikely event that any sites of potential importance are discovered during construction.

5.2.f. Ecological disturbance

It is important to note that the project site is located in a habitat that is already severely degraded the result of decades of intensive grazing. Plant cover removal, during land leveling and excavation will reduce the density, within the site only, of several threatened species namely Iris petrana, Iris aucheri, Tragapogon collinus and Tulipa polychrome.

Construction will have minimal to no impacts on mammalian and reptilian species within the study site. Most mammals observed in the wider area rodents. If construction activities overlap with bird migration seasons (spring and autumn) then migratory species (especially soaring birds) would become easy prey for hunters and workers.

Mitigation measures

Construction activities are not expected to generate any significant impact on either flora or fauna and therefore no mitigation measures are proposed except for prohibiting construction workers from trapping any birds.

5.2.g. Reduction in aesthetics/landscape degradation

The construction site and WWTP that results may be considered intrusive in the overall landscape. This impact is of short duration and will not be significant in light of the location of the selected site (not in open view of any main roads and in an already degraded area). Therefore, no mitigation measures are proposed.

5.3. Potential adverse impacts from WWT&R operations and their mitigation

5.3.a. Soil and water resource contamination in general

Although the project is expected to have an overall positive impact on soil and water resources in the wider project area as explained in Section 5.1.b, the presence of a WWTP presents new hazards to these resources in the immediate vicinity of the proposed site (localized area). Some of these potential adverse impacts may extend further than others. The main impacts to soil and water resources may occur from: accidental spills, overflows and seepages; or from sludge reuse and/or disposal. These impacts and proposed mitigation measures are discussed separately in the sections that follow under their respective headings.

In general, these impacts are potentially significant unless treatment units are appropriately lined, overflows can be accommodated for (and ultimately contained) and appropriate emergency response procedures are put in place. Sludge reuse/disposal must also conform to standards, with proper soil management to minimize groundwater percolation. Section 5.4 discusses relevant impacts and mitigation measures related to emergencies and unplanned events that will also minimize the risk of such impacts.

5.3.b. Contamination from accidental spills, overflows and seepages

Accidental spills or overflows on-site could potentially contaminate soils within the site, make their way to surface water streams or percolate through to contaminate groundwater. Seepage from the WWTP itself could pollute groundwater; however, in light of prevailing groundwater flows (westerly to south westerly) and groundwater levels (in the order of 200m bgl) in the area, the chance of any seepage reaching deeper aquifers or any springs is relatively low as they are either dry, hydraulically disconnected or on higher grounds as explained in Section 4.3.c. Seepages could occur in case of cracks in concrete or tears in liners. Such seepages however would be relatively small in flow volumes and short-lived with appropriate and regular monitoring and maintenance.

Mitigation measures

The built-in mitigation measures described in Section 2.4.d will further minimize the risk of accidental spills or overflow events happening and ensure that if such an event occurs, they can be adequately contained. These built-in mitigation measures include on-site drainage, overflow precautions, protection from surface run-off and appropriate lining to minimize the risk of seepages. Liners and concrete will be inspected on a regular basis and routine tests on units will also be performed. An appropriately located groundwater monitoring well will be put in place for WAJ to monitor groundwater quality if needed.

This will be determined with WAJ, bearing in mind the potential of using an appropriately located existing well, during and after the detailed design. Seepage/leakage detection piezometers will also be put in place around main units as necessary. See also Section 5.4 for additional mitigation measures relating to emergencies and unplanned events and the associated contingency plans.

5.3.c. Contamination from sludge reuse and disposal

At full capacity, the plant will generate up to 400 tonnes of dried sludge per year, mostly removed from the sedimentation/digestion tanks as and when needed. Unless properly treated and disposed of, the sludge could pose environmental and health and safety concerns. Sludge is primarily a source of biological contamination, unless the WWTP influents also contain industrial discharges. Septage sampling and analysis results have also indicated insignificant levels of heavy metals. Industrial septage is also unlikely given the lack of industrial activity in the area and will nonetheless be prohibited as explained in Section 5.4.b.

Mitigation measures

Taking into consideration that sludge will mostly be stable (as it is coming from cesspits and would have spent at least 30 days at the bottom of the sedimentation / digestion tanks) and is then sent to drying beds, the sludge produced can be considered treated to the first level according to JS 1145/1996. This allows it to be sent for use in the Badia as a soil conditioner. In addition, approximately 1 Dn of land will be allocated for sludge storage within the site that will allow for composting (involving staking, turning, wetting under specific temperature requirements) – this will generate sludge treated to the 2^{nd} level for use as soil conditioner within the area. Sludge samples will be taken on a regular basis and appropriate means of disposal and/or composting will be developed in strict adherence to JS 1145/1996 and carried out only after the approval of the relevant authorities.

5.3.d. Odors

The front-end (upstream) units (septage receiving station and settling/digestion tanks) can potentially generate the most odors. The receiving station is dealing with infrequent discharges and flows that are comparatively low and therefore are not expected to generate significant odors. The sand filters and reed beds operate under predominantly aerobic conditions and involve subsurface flows and are therefore not prone to generating odors. By the time the wastewater flows into the only open portions of the WWTP, namely the evaporation ponds, it has been sufficiently treated so that odors will not be a problem. These ponds will also be shallow and therefore dominated by aerobic conditions, which do not result in odors. Sudden surges in odors however have been experienced in WWTPs without specific abnormalities in operations.

Most importantly there are few sensitive receptors in the area. With respect to the Shobak-Dessert Highway (Petra) main road: it is 1.5 km away to the south, over 2 km to the southeast and approximately 5 km to the east-southeast. Winds carrying potential odors across the shorter distances (i.e., from the north and northwest) are rare (refer to Figure 8). Although winds coming from the west-northwest are more frequent, the distance to the road in this direction is quite far.

Mitigation measures

Several mitigation measures will be incorporated into the detailed design in order to ensure minimal odor emissions from the WWTP. For example, the settling/digestion tanks will be covered; the septage receiving station will be designed to minimize odors through use of hose connections that discharge directly into in-ground receiving pits instead of into the open air and non-potable water will be available for regular wash downs. Windbreaks will be planted around the site perimeter to further minimize winds and odors. Plant operators will also be provided with protective masks in the event that sudden odor surges within the WWTP occur and/or for duties that involve getting very close to or inside units for maintenance purpose. See also Sections 5.4 for other mitigation measures that will help ensure sound plant operation and also reduce odor potential considerably.

5.3.e. Ecological disturbance

No significant adverse impact is foreseen during operation and maintenance on flora and fauna. On the contrary, important birds could congregate near the reed beds and open water bodies including thrushes and allies as well as the Gold and Green Finch. These birds could however become easy prey for workers.

Mitigation measures

Instruct workers not to hunt any birds congregating around the site. Enforce existing hunting regulations in the region.

5.3.f. Inequality of socio-economic benefits

Neighboring landowners may oppose the proximity of a WWTP to their lands. The overall impact on potential changes in the value of these properties is discussed and mitigated under Section 5.1.d. As a result of site location choices, with one of the main objectives being to reduce the aggregate costs of septage transport for residents, there will be some households that may have to pay more for septage transport (tanker charges) than others. These are the households that are furthest from the proposed WWTP sites.

Mitigation measures

Since site location minimizes overall costs, by being located nearer to the largest numbers of households that pump their cesspits most frequently, then a geographical cross subsidy in tanker charges should be feasible. A small additional charge on the nearest households that generally pump a lot of septage, should translate into a larger subsidy for distant households that generally pump less. The need for cross subsidies and means of implementing them will be investigated further through the participatory work under Task 4's Institutional and Cost Recovery report and Institutional Agreements.

5.3.g. Impacts on tourism

Normally, WWTPs may be considered a degradation of visual aesthetics and the overall landscape depending on their design and location. The use of significant areas of reed beds however, is expected to improve the natural and aesthetic value of the area. Ecological enthusiasts such as bird-watchers are likely to frequent the area more since the WWTP is expected to attract birds. The immediate area of the site is neither a uniquely aesthetic, ecological nor touristic area nonetheless. The site is also not in full, open view from the main roads. Potential odors are discussed and mitigated in Section 5.3.d.

Mitigation measures

As long as the WWTP operates well and odors are minimized as discussed in Section 5.3.d., the plant should have no adverse impact on tourism activity in the area. To the contrary, a potential to benefit from the improved ecological value of the area exists and should be built upon, for example through cooperation with the RSCN and providing field trips for students to see an ecologically engineered and environmentally sound WWTP with effective utilization of by-products.

5.3.h. Health & Safety (H&S)

During operation and maintenance, both skilled and unskilled workers are potentially exposed to risks. Plant operators could fall into open basins (e.g. settling/digestion tanks, dosing basins and evaporation ponds). Working with WW and sludge may also carry health risks to plant operators through accidental contact and spills/releases. Maintaining security and preventing public access to the WWTP are also important.

Exposure to sludge may also pose a health risk to workers. This risk would increase if sludge quality does not meet relevant reuse standards and/or reuse practices are unsafe. The potential congregation of venomous animals including snakes, scorpions and spiders would also pose a serious health hazard to workers and plant operators. This incidence of dangerous animals will significantly drop during the winter. The reed beds are not expected to generate significant mosquito populations, as they operate with subsurface flows and present ecologically balanced systems. Open evaporation ponds, as with any other WWTP with open basins, however can present a mosquito breeding ground and may attract snails that could potentially carry diseases.

Tanker traffic is not expected to reach very high levels and the selected site does not result in a significant portion of traffic funneling through any sensitive areas or intersections. This could nonetheless present traffic accident risks to the general public along tanker routes.

Mitigation measures

Although the impacts on occupational H&S during plant operation are not significant, safe practices and standard operating procedures should be followed. Skilled plant operators will receive training in the safe and efficient operation of the wastewater treatment plant. Unskilled workers will also be instructed to follow basic safety practices for plant operation and water reuse.

The settling digestion units will be equipped with protective railings. Signs will be posted at locations that pose specific risk of falling or other injury to plant operators. These signs will be designed to be clear and visible at night.

Plant operators should be warned in advance of any maintenance work to be conducted on any facility/location within the plant. Warning signs should be posted where planned maintenance has a potential to cause injury. It is preferable that these signs also classify the type of risk posed by such works. Plant operators should wear protective clothing at all times.

It is recommended to inspect worker health prior to plant operation (i.e., pre-employment medical check-up) and provide regular medical check ups for plant operators. The WWTP operator should provide on-site capability to treat affected individuals (first-aid, anti-venom, medical kits) and ensure the entire workforce know where the nearest hospital/clinic is. Anti-coagulants may need to be applied to control black rats and house mice, biological insecticide (e.g., BT Bacillus thuringiensis) to control mosquitoes, and molluscides to control snail intermediates (carriers of schistosomiasis). The WWTP should liaise with the MoH on such activities.

The entire site will be fenced off to prevent public access. Speed restrictions and safe intersection crossings along tanker routes must also be clearly agreed to, posted and monitored.

5.4. Risks to WWTP structures, its operation and mitigation measures

This section deals with various risks that may jeopardize the WWTP structurally and the ability to properly operate it. These cover emergencies and unplanned events and include sudden changes in influent/effluent quality and quantities, earthquakes, floods and power failures that could arise during the construction or operational phases of the WWTP. Several of the potential impacts discussed here will be covered in emergency and contingency plans discussed in Section 6.2.

5.4.a. Earthquake risk

While the proposed site in Shobak is considered relatively calm seismically, the nearby Petra area is considered tectonically-active. As a result of the active strain of the Wadi Araba Fault, seismic activity beneath the Shobak area and its vicinity in Petra and central Wadi Araba reveals earthquakes of small to medium magnitude. Since 1983, the Natural Resources Seismological Stations recorded about 30 earthquakes in the Shobak area with a magnitude of 3 to 7 on the Mercalli scale (2.5 to 5 on Richter scale). However, no surface displacement has been recorded.

It is safe to conclude that the probability of experiencing a severe earthquake during the lifetime of the WWT plant remains very low. In the unlikely event of a high-magnitude earthquake however, the WWTP facilities could sustain partial or total damage (e.g. buildings, holding basins, pipes).

Mitigation measures

Adhere strictly to the requirements stipulated in National Building Code for Loads and Forces (for Region B) in WWTP design and construction. It is also necessary to consider additional mitigation measures in case of structural failures due to earthquakes. These include developing an emergency response plan (see Section 6.2) including, identifying intact basin(s) within the WWTP where flows may be diverted to.

5.4.b. Non-residential septage

The WWTP is not designed to treat septage or wastewater from non-domestic sources such as industries, olive presses, slaughterhouses, mechanic shops or hospitals. The probability that septage from non-residential source arriving at the WWTP is low due to the relative lack of such sources in relation to residential customers.

Mitigation measures

The municipality/Mutassarifieh should advise septage tanker operators that they will be heavily fined if known to have discharged non-residential septage at the WTTP. Random sampling of septic tanker discharges will also be carried. Community awareness will be raised about the implications of such discharges to help prevent this from happening and involve the community in tanker monitoring and enforcement. Targeted awareness raising for non-residential septage generators should also be carried out to inform them of the types of septage that cannot be discharged at this WWTP, how to separate blood, chemicals, fats and grease from normal, domestic-type WW (e.g. at slaughter houses, restaurants, mechanic shops, hospital and even some industries) and other best practices.

5.4.c. Volumetric flow imbalance and sub-optimal operating capacity

Maintaining the proper volumetric flow of sewage at the different treatment stages is critical for the proper operation of the WWT plant. Situations could arise whereby the treatment plant receives more septage than it can handle (i.e., community or political pressure to accept septage discharges from communities that fall outside the appropriate service area). Within the WWTP, a sudden interruption in flows caused by clogged pipes or pump failures may also have serious consequences on plant operation and treatment efficiency. Such stoppage may render the WWT plant unable to receive and process WW. Such impacts are expected to be unlikely, short in duration and reversible.

Mitigation measures

The WWTP design includes sufficient equalization capacity, multiple units and treatment trains (that could be operated in series or in parallel) offering operational flexibility as explained in Section 2.4.b and 2.4.d therefore, the WWTP operators should be able to respond to the shorter-term volumetric imbalances in influents. Such alternate operating procedures will be included in the emergency response plan (see Section 6.2) to be developed as part of the operating manual. If such imbalances are expected to be longer-term, then regulatory actions must be taken such as restricting tanker licensing, access to the WWTP and /or fee adjustments. Public awareness-raising to help regulate pumping (provide more balanced discharges) can also help mitigate such risks.

Routine maintenance and immediate access to spare parts in case of a localized failure will reduce the probability of a volumetric flow imbalance as a result of internal problems. In case of a severe interruption in the flow, incoming septage should be accommodated in a separate basin for a reasonable duration while the cause of the problem is being remedied.

5.4.d. Total power failure

Although rare, total power failure is not uncommon in Jordan. Over the past 5 years a few such failures took place, sometimes lasting for hours and without an apparent cause found.

Mitigation measures

The WWT plant should have the necessary power generation means to sustain its basic operations for a reasonable time (e.g. 12 hrs) before power from the national grid is restored. The necessary emergency power generation required will be determined during the detailed design and will be dependant on plant layout, pumping requirements and hydraulic profiles. With or without power, the plant will be very energy efficient. Examples of energy efficiency for the WWTPs may include high-efficiency motors and lighting, and passive heating and cooling in building designs. An emergency response plan (see Section 6.2) should be developed as part of the operating manual.

5.4.e. Flooding and erosion

Flooding or flash floods may occur at the site due to sudden and intense rainfall. 100 mm of rainfall in 24hrs is the maximum recorded at Shobak, the selected site may experience a similar rainfall event however it is most likely less than this in light of the drier conditions there (refer to Section 4.3.a). Such floods could develop inside the WWT plant or travel through the WWT plant and may cause soil erosion and/or damage to some of the WWTP structures. This potential impact is also discussed in Section 5.2.d in relation to the construction phase.

Mitigation measures

The proposed site should be adequately designed and engineered to divert and/or discharge sudden surface flows resulting from flash floods without causing damage to the plant facilities. An emergency response plan (see Section 6.2) should be developed as part of the operating manual allowing the surface flows to be directed to the nearest wadi.

6. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

The environmental management and monitoring plan provides the tools for ensuring adequate implementation of the proposed mitigation measures so that all potential impacts are minimized. It also spells out special monitoring requirements in detail and assigns responsibilities for implementation and monitoring.

The EMMP Summary table at the end of this section (see Table 15) summarizes all of the relevant mitigation measures presented in previous sections according to impacts, proposes an allocation of responsibility for their implementation and specifies the timing required for implementation and/or the frequency required for monitoring. This summary table must be continuously revisited by the project team, contractor, Municipality and other concerned stakeholders to ensure it remains up to date and is adjusted where and when necessary.

The most important aspects of environmental monitoring requirements are discussed in the next section. The emergency response and contingency plans that need to be developed at various stages of the project are discussed in 6.2 and the construction transport plan is discussed in Section 6.3.

6.1. Monitoring requirements

Monitoring is critical to ensure good plant operation and maintenance and to prevent accidents. The most important monitoring parameters normally include effluent quality (not relevant for the proposed zero-discharge WWTP) and quantity, sludge quality and quantity, groundwater quality, and occupational health and safety as described next.

Sludge quantity and quality

The plant operator should monitor sludge quantity and quality. Preliminary estimates indicate that the plant will generate about 400 tonnes of sludge each year which would require treatment and disposal in accordance with the Jordanian sludge treatment and reuse standards (JS1145/1996). These standards define a number of restrictions related to sludge reuse.

Sludge quality monitoring should target each batch of sludge produced. Sludge samples should be homogenous and composite; test parameters should cover all chemical (11 total) and biological parameters (4 total) listed in JS1145/1996, reproduced in Appendix C-3.

Groundwater level and quality

Depth to water table should be monitored to assess aquifer vulnerability. A downstream groundwater monitoring well should be should be used to collect monthly fecal coliform and nitrate samples. The need for such additional monitoring and potential use of an appropriately located existing well will be determined by WAJ. Groundwater monitoring is the responsibility of WAJ and groundwater sampling and analysis will be conducted by WAJ central laboratory. Test results should be interpreted based on the Jordanian drinking water standards (JS286/2002).

Health and Safety

Occupational health and safety during construction and operation is critical to project success and sustainability. The project team (chief supervising engineer and his team of resident site supervisors) should supervise the construction contractor to monitor his adherence to the safety precautions agreed and to document and address any violations (e.g. failure to provide and make sure that workers use adequate personal protection on site during working hours). Workers must also undergo a basic health exam before joining the site crew to make sure they are not infected with malaria, leichmania or schistosomiasis. Monitoring for these diseases and their vectors should be carried out in cooperation and under the direction of the MoH.

6.2. Emergency response measures

In case of an emergency, plant workers should immediately report to the municipality. Table 14 provides an indicative emergency response checklist. Specific plans and procedures must be further developed as part of the WWTP operating manual and refined and revisited regularly by the WWTP operator in consultation with the relevant authorities (e.g. MoH, WAJ, civil defense, police, etc.). These plans should include simple, clear instructions and procedures, contact telephone numbers and be placed in easily accessible and clearly visible locations around the WWTP as appropriate. All WWTP personnel and reuse workers should be trained in the implementation of each plan.

Table 14
Preliminary Emergency Response Procedures

Type of Emergency	Response Measures
Spill accident	• Activate spill prevention plan including containment and clean-up procedures
Snake/scorpion/spider bite	• Retrieve first-aid kit and administer the treatment • Call for help
Leichmaniasis, Schistosomiasis or Malaria reported	• Request a medial exam for all the workers • Contact relevant authorities (incl. Department of Malaria and Schistosomiasis at MOH)
Volumetric flow imbalance and sub-optimal operating capacity	• Implement alternate operating procedures (switch to idle treatment train). • If imbalance is expected to be longer-term, take appropriate regulatory actions such as restricting tanker licensing, access to the WWTP and or fee adjustments. • In case of a severe interruption in the flow, incoming septage should be accommodated in a separate basin for a reasonable duration while the cause of the problem is being remedied. • Contact WAJ
Flash flood	• Bar site access to tanker trucks; monitor all installation and water bodies • Conduct a complete site inspection when the flood subsides • Direct storm water to either a holding pond or to the nearest wadi
Earthquake	• Stop all mechanical equipment; inspect all installations immediately after earthquake and report structural failure, if any; anticipate follow-up tremors • identify intact basin(s) within the WWTP where raw sewage or treated effluent may be diverted
Total power failure	• Activate back-up system; investigate source of power failure

6.3. Construction transport / waste disposal plans

The construction transport and waste disposal plans are very important to ensure timely completion of construction activities, minimize public health and safety risks as well as to ensure various other environmental mitigation measures are easily included during the construction process.

The construction transport plan will be specified in the bid documents. These plans will then need to be reviewed and possibly modified by relevant local authorities including representatives from the MoH, municipality, MoPW&H, the police department, the project team and other local community representatives prior to construction. The plans need to spell out along what routes and when heavy machinery or regular construction traffic can be moved and where disposal sites are taking into account the following considerations at a minimum:

- Public health and safety;
- Road quality before and after construction;
- Generation of dust (affecting road visibility); and
- Appropriate waste disposal sites.

6.4. Environmental management and monitoring plan summary table

The comprehensive and fully detailed EMMP table overleaf details specific mitigation measures for each impact, proposes assigned responsibilities for implementation and monitoring as well timing required for implementation. The project team will incorporate these various mitigation measures and responsibilities into one or more of the following binding project documents:

- The detailed design;
- The construction contract bid documents;
- The WWTP operating procedures; and/or
- The various cooperative institutional agreements being drafted as part of the work under Task 4 of this project;

The various key stakeholders will be actively involved in the review and finalization of relevant documents listed above during Task 4 and Task 5 of the project, agreeing to the most appropriate allocation of responsibilities and details entailed therein.

Table 15
EMMP Summary Table

Potential impact		Mitigation measures	Responsibility	By when / frequency
1.	**Positive Impacts**			
1.a.	Reduced tanker transport charges on residents	• Select WWTP site closest to the largest septage generating residential area	• Project team and municipality	• Completed
		• Select the WWTP alternative with the lowest running costs; ensure the WWTP is operated and maintained as efficiently as possible.	• Project team	• Incorporated during planning, to be further develop & refined during initial operations
		• Maximizing revenues from the productive use of WWTP byproducts	• WWTP&R operator	• Annually
1.b.	Improved public health, sanitation and pollution prevention of the wider area	• Enforcement and awareness raising of appropriate cesspit pumping	• Municipality, MoH and/or other local civil society	• During construction (awareness) • Continuously during operations (awareness & enforcement)
		• Prevention of illegal tanker discharges • See also mitigation measures under 1.a	• Municipality, local civil society, residents, police, etc.	• Continuously during operations
		• Provide a septic tanker cleaning station on site and encourage its use	• Project team and WWTP operator	• Detailed design
1.c.	Employment opportunities	• Give preference for labor intensive WWTP technology and reuse activities • Give preference for local workers during construction and operation	• Project team and WWTP&R operator • Construction contractor	• Incorporated, to be further develop during bid document preparation and in institutional agreements
1.d.	Change in land values	• Make sure plant design includes soft landscaping including ornamentals and trees along site perimeter • Encourage reuse of sludge on nearby and adjacent lands	• Project team and WWTP&R operator	• During detailed design and institutional agreements
1.e.	Demonstrating the use of WWTP byproducts and improved public perception	• Provide safe sludge reuse training to landowners • Broader awareness campaign in relation to sludge reuse	• Project team, MoA, NCARTT, Municipality and/or other local civil society	• Prior to sale to byproduct utilization • Continuously during operations
		• Effective monitoring and enforcement of Jordanian sludge reuse standards and safe reuse practices • Ensure all reed harvesting and handling is safe	• MoA, MoE, MoH, WWTP operator	• Continuously during operations
1.g.	Prospect for sewage system in the future	• Select WWTP site that is downstream and not too far from larger, higher density residential areas	• Project team and municipality	• Completed
2.	**Potential adverse impacts during Construction**			
2.a.	Air quality and noise pollution	• Avoid excavation during high-wind conditions and when winds are blowing 1) NE to NW; and 2) W if Bedouins are residing to the east of the site • Maintain/enhance low-lying vegetation inside project site and along dirt roads to trap dust	• Construction contractor	• As and when needed during construction
		• Minimize excavations and maximize on-site fill	• Project team during detailed design	• During detailed design
		• Develop a transportation and disposal plan to avoid passing through sensitive residential areas • Avoid excavation disposal sites that are to the east or south east of the main Shobak-Dessert Highway main road • Ensure all trucks are covered • Bedouin families of the area should be notified in advance of potential noise and dust generation	• Project team, construction contractor and municipality	• Prior to construction (included as part of the bid documents)
		• Loud construction activities and off-site transportation should not be allowed to start in the very early morning nor to persist into the late night when Bedouins are residing nearby	• Construction contractor, monitored by the Military and Municipality	• Daily, during construction
2.b.	Disposal of construction wastes and handling of hazardous materials	• Avoid cross-contamination of non-hazardous wastes with hazardous wastes • Store non-hazardous construction wastes separately from excavated materials, and in a designated and approved area • Ensure proper storage of hazardous materials, if any • Materials and equipment should be provided to clean up and properly dispose of any spills of hazardous materials • Vehicle maintenance areas should have impervious floors and materials for spill cleanup • Use approved dump-sites for each type of waste • Provide appropriate on-site sanitary facilities • Construction transport plans (e.g. for excavated materials) should take into account access routes and road quality	• Construction contractor • Waste specific dump-sites to be approved by the Municipality and ministry of environment	• During construction, monitored on a monthly basis by the municipality and ministry of environment

Potential impact		Mitigation measures	Responsibility	By when / frequency
2.c.	Health & safety risks	• Off-site transport / disposal plans developed should carefully consider public safety / traffic accident risks • Any heavily used transport routes should be fitted with appropriate "construction activity" warning signs • Inform nearby farmers and residents of potential risks to them and inform them about the construction/transportation schedules	• Construction contractor, approved by the local traffic department, ministry of health and municipality – the municipality should share the plans/relevant H&S information with relevant members of the public and advise them to be careful	• Prior to construction – specified in the bid documents by the project team
		• Occupational health and safety standards should be followed during all construction activities in accordance with the "Code of Safety for Construction Works" • Provide on-site workers with gloves, noise attenuators, dust masks, steel-tipped shoes and hard hats, in addition to sanitary facilities and clean water • Use of clear and visible warning signs inside the construction site and protective railings where needed • Provide sufficient, clean water for drinking purposes	• Contractor, in cooperation with / under the monitoring of the MoH	• During construction
		• Provide on-site capability to treat affected individuals (first-aid, anti-venom, medical kits) • Investigate nearest hospital/clinic for treatment of snake and scorpion bites • Provide H&S awareness and contingency plans for workers	• Construction contractor in cooperation with the MoH	• Prior to construction
2.d.	Change in local hydrology, structural and earthquake risks	• Adhere strictly to the requirements stipulated in National Building Code for Loads and Forces (for Region B) in WWTP design and construction • Ensure proper flood control measures are taken and/or temporary drainage channels are built and that top soils storage locations are away from potential surface runoff areas	• Project design team and construction contractor	• During detailed design and prior to construction
2.e.	Archeological disturbance	• Carry out a rapid survey of the site and determine the risk of encountering any potentially undiscovered sites and determine any follow-up (e.g. training of workers, random spot-checks during excavations)	• DoA in cooperation with the project team and construction contractor	• At least 3 months prior to construction
2.f.	Ecological disturbance	• Prohibit construction workers from trapping birds	• Construction contractor	• During construction
3.	**Potential adverse impacts during WWT&R operation**			
3.a.	Soil and water resource contamination in general	• See 1.b, 3.b and 3.c		
3.b.	Contamination from accidental spills, overflows and seepages	• Incorporate various built-in design mitigation measures	• Project team	• During detailed design
		• Install a groundwater monitoring well as needed in consultation with WAJ • Install seepage/leakage detection piezometers	• Project team and contractor, in cooperation with WAJ	• As early as possible (for wells) • Piezometers after construction/prior to operation
		• Carry out regular inspections and routine tests • See also 4.	• WWTP operator	• Regularly during operations, frequency TBD during development of O&M manual by project team
3.c.	Contamination from sludge reuse and disposal	• Treat sludge to first or second level in accordance with JS 1145/1996 • Carry out sampling and analysis in accordance with 1145/1996 • Plan and obtain approval for reuse • In case of sludge disposal, identify nearest suitable disposal site/landfill • See also 4.b	• Project team and WWTP operator, monitoring by relevant authorities	• Develop treatment / reuse/disposal plan during initial year of operation • Continuously as required thereafter
3.d.	Odors	• Incorporate various built-in design mitigation measures including installation of covers on sedimentation/digestion tanks • Plant windbreaks around site perimeter (about 2km) to minimize wind/odors	• Project team	• During detailed design, ensure implementation after construction
		• Ensure sound plant operation overall (see 4.b, 4.c and 4.d) • Provide protective masks for worker in the event of sudden odor surges	• WWTP operator, monitored by WAJ	• During operation
3.e.	Ecological disturbance	• Prohibit employees from trapping and hunting birds	• WWTP operator, MoA, RSCN	• During operation, especially during the spring and fall (migration seasons)
3.f.	Inequality of socio-economic benefits	• See 1.a and 1.d.		
		• Investigate the need for cross subsidies to reduce tanker chargers for distant households, and means of implementing them	• Project team and relevant stakeholders, including tanker drivers	• During Task 4
		• Tanker charges should be openly discussed and revisited on a regular basis to ensure fair tanker charging systems	• WWTP operator, Municipality/village councils and tanker drivers	• Annually
3.g.	Impacts on tourism	• Build upon the increased ecological value of the area and encourage eco-tourism to the WWTP and its area (e.g. student trips, bird-watching) • See also 1.d, 1.e and 3.d	• WWTP operator in cooperation with RCSN and other organizations (e.g. schools)	• During operation

Potential impact		Mitigation measures	Responsibility	By when / frequency
3.h.	Health & safety	• Follow safe practices and standard operating procedures, including the provision of basic protective clothing • Provide basic safety training to all workers and managers • Fence off the entire site, provide protective railings and appropriate warning signs were needed • • Provide on-site capability to treat affected individuals (first-aid, anti-venom, medical kits) • Investigate nearest hospital/clinic for treatment of snake and scorpion bites • See also and 4.	• Project team and WWTP operator	• During operation
		• Ensure advance warning of all workers of upcoming maintenance works and ensure proper maintenance signage is put up	• WWTP operator	• Prior to maintenance activities
		• Routes need to be designated and committed to appropriate use by the tanker drivers • Impose speed restrictions and ensure safe tanker crossing of intersections	• Project team, municipality, tanker drivers and traffic police	• Prior to completion of construction • Monitoring throughout operations
		• Inspect worker health prior to plant operation (i.e., pre-employment medical check-up) and provide regular medical check-ups • As and when needed, use anti-coagulants to control black rats and house mice, apply biological insecticide (e.g., BT Bacillus thuringiensis) to control mosquitoes and molluscides to control snail intermediates (carriers of schistosomiasis)	• WWTP operator in cooperation with MoH and the Malaria and Schistosomiasis Dept at Ministry of Health	• Prior to WWTP operation • Frequencies to be determined by relevant authorities for disease control
4.	**Risks to the WWTP structures and its operation**			
4.a.	Earthquakes	• Adhere strictly to the requirements stipulated in National Building Code for Loads and Forces (for Region B)	• Project team and construction contractor	• During detailed design and construction (supervision and testing)
		• Incorporate various built-in design mitigation measures • Develop emergency response procedures	• Project team	• During detailed design • Revisited and refined if needed after initial operation
		• Implement emergency response and contingency plans	• WWTP operator	
4.b.	Non-residential septage	• Raise community awareness and involve them in tanker monitoring and enforcement (including random tanker discharge sampling and analyses) • Implement targeted awareness raising for non-residential septage generators	• WWTP operator and/or other local civil society	• During construction (awareness) • Continuously during operations (awareness & enforcement)
4.c.	Volumetric flow imbalance and sub-optimal operating capacity	• Incorporate various built-in design mitigation measures • Develop emergency response procedures	• Project team	• During detailed design • Revisited and refined if needed after initial operation
		• Public awareness raising to help regulate pumping (provide more balanced discharges)	• WWTP operator and/or other local civil society	• Continuously during operations
		• Develop tanker regulations	• Project team/WWTP operator and relevant stakeholders	• During Task 4, revisited annually by WWP operator and relevant stakeholders
		• Carry out routine maintenance and ensure immediate access to spare parts	• WWTP operator, monitored by WAJ	• Regularly during operations, frequencies TBD during development of O&M manual by project team
		• Implement emergency response and contingency plans	• WWTP operator	
4.d.	Total power failure	• Investigate emergency power needs and incorporate into design as needed • Develop emergency response procedures	• Project team	• During detailed design • Revisited and refined if needed after initial operation
4.e.	Flooding and erosion	• Incorporate various built-in design mitigation measures • Develop emergency response procedures	• Project team	• During detailed design • Revisited and refined if needed after initial operation
		• Carry out routine inspection • Implement emergency response and contingency plans	• WWTP operator	• Inspections after every summer

7. CONCLUSIONS

The WWT&R project will generate a number of positive impacts. The overall **net impact of the project on the environment in the affected area will be positive**. Several enhancements are proposed that will further maximize the project benefits. The project planning process included measures to enhance the positive impacts. The design will provide further enhancement of positive impacts as will the EMMP, which will need continuous revisiting, through long-term operations.

7.1. Positive impacts

The most significant of the positive impacts are that the project will:

- **Improve public health and sanitation and protect soil and water resources in the region by minimizing current cesspit overflows and curbing current unsafe tanker disposal practices**
- **Reduce the costs borne by households to empty cesspits** by providing a nearby, long-term WWTP solution that will receive and treat septage in an environmentally friendly manner; and

The project will also:

- Strengthen local institutions and community participation and will provide an opportunity to demonstrate the safe and productive utilization of WWTP byproducts, thereby improving public awareness and acceptability of such byproduct utilization activities, while creating new employment opportunities.

7.2. Potential adverse impacts and their mitigation

Despite the overall net environmental benefit expected from the project, potential adverse impacts, **mostly limited to the area immediately surrounding the WWTP** (the localized study area), have been comprehensively identified and assessed. **All of the potential adverse impacts can be considered insignificant, as they will be minimized with the proper implementation of the EMMP**. The EMMP must be continuously revisited by the project team, contractor, Municipality and other concerned stakeholders to ensure it is being implemented, remains up to date and is adjusted where and when necessary to keep potential adverse impacts at a minimum.

7.2.a. During construction

Potential adverse impacts during construction include:

- **Noise and air quality deterioration** from earthworks and transportation;
- Impacts from the **disposal of excavated materials and construction waste**; and
- **Health and safety hazards**.

With the application of mitigation measures proposed, all residual adverse impacts during construction will be insignificant. These measures include carefully designing and planning earth works and a construction transport management plan; implementing various measures to minimize dust generation and noise; ensuring appropriate separation, handling and disposal of wastes; health screening of labor for infectious diseases as well as requiring various other health and safety measures to be implemented. Potential disturbance of archaeological sites and risks to the construction site itself from erosion have also been considered and appropriate mitigation measures proposed.

7.2.b. During operation

Potential adverse impacts during operation include:

- **Odor emissions**;
- **Pollution of soil and water resources** from sludge disposal as well as potential contamination from accidental spills, overflows and seepages; and
- **Health and safety hazards.** WWTP operation will entail all the usual occupational risks. It is important to respect and enforce relevant provisions of the Jordanian Labor Law and specific procedures that will be included in the operating manual.
- **Biodiversity and ecosystem:** the proposed site is not considered important from a biodiversity point-of-view. On the contrary, it is already severely eroded and degraded due to intensive grazing, and the construction of vast areas of reed beds is considered an environmental improvement to the area, ecologically and aesthetically.

With the mitigation measures proposed, all residual adverse impacts during operation will be insignificant. These measures include a major focus on odor minimization and control in the WWTP design, conservative design with high operational flexibility, hydraulic safeguards as appropriate, contingency plans, disease vector and pest control management well as requiring various other standard health and safety procedures. Planned groundwater monitoring and early warning systems will help protect the water resources in the immediate area from any leaks or seepages. These systems and other mitigation measures (discussed below), including emergency and contingency plans will also assure rapid remediation of any unanticipated adverse effects. Changes in ecology, namely a potential increase in the occurrence of pests, were also considered and mitigation measures proposed.

7.2.c. Risks to the WWTP structures and its appropriate operation

In combination with the impacts and mitigation measures discussed above, several risks to the safe and appropriate operation of the WWTP were also considered:

- The project area is within a **moderately active earthquake zone in Jordan** and will therefore be designed and built by adhering to the relevant Jordanian building codes (Zone B).
- Several other risks that may hinder normal operations include:
  - **Receiving non-residential septage**
  - **Volumetric flow imbalances and sub-optimal operating capacity;**
  - **Flooding and soil erosion; and**
  - **Power failures.**

The project design will include several safeguards and operating procedures as well as **emergency response procedures and specific contingency plans** in relation to the above potential risks to assure environmental protection.

7.3. Environmental management and monitoring plan

A detailed environmental management and monitoring plan (EMMP) has been developed as a tool to help ensure environmentally sound project implementation. It details specific mitigation measures for each impact, proposes assigned responsibilities for implementation and monitoring as well timing required for implementation.

Implementation of the EMMP will ensure the mitigation of potential adverse impacts and the enhancement of positive impacts. The EMMP will need to be revisited on a regular basis to ensure it remains up to date, addresses emerging issues and remains as effective as possible.

The project team will use this **EMMP as a basis for incorporating various mitigation measures and responsibilities into one or more of the following binding project documents:**

- **The detailed design;**
- **The construction contract bid documents;**
- **The WWTP operating procedures; and/or**
- **The various cooperative institutional agreements** being drafted as part of the work under Task 4 of this project that will be agreed to and signed prior to construction.

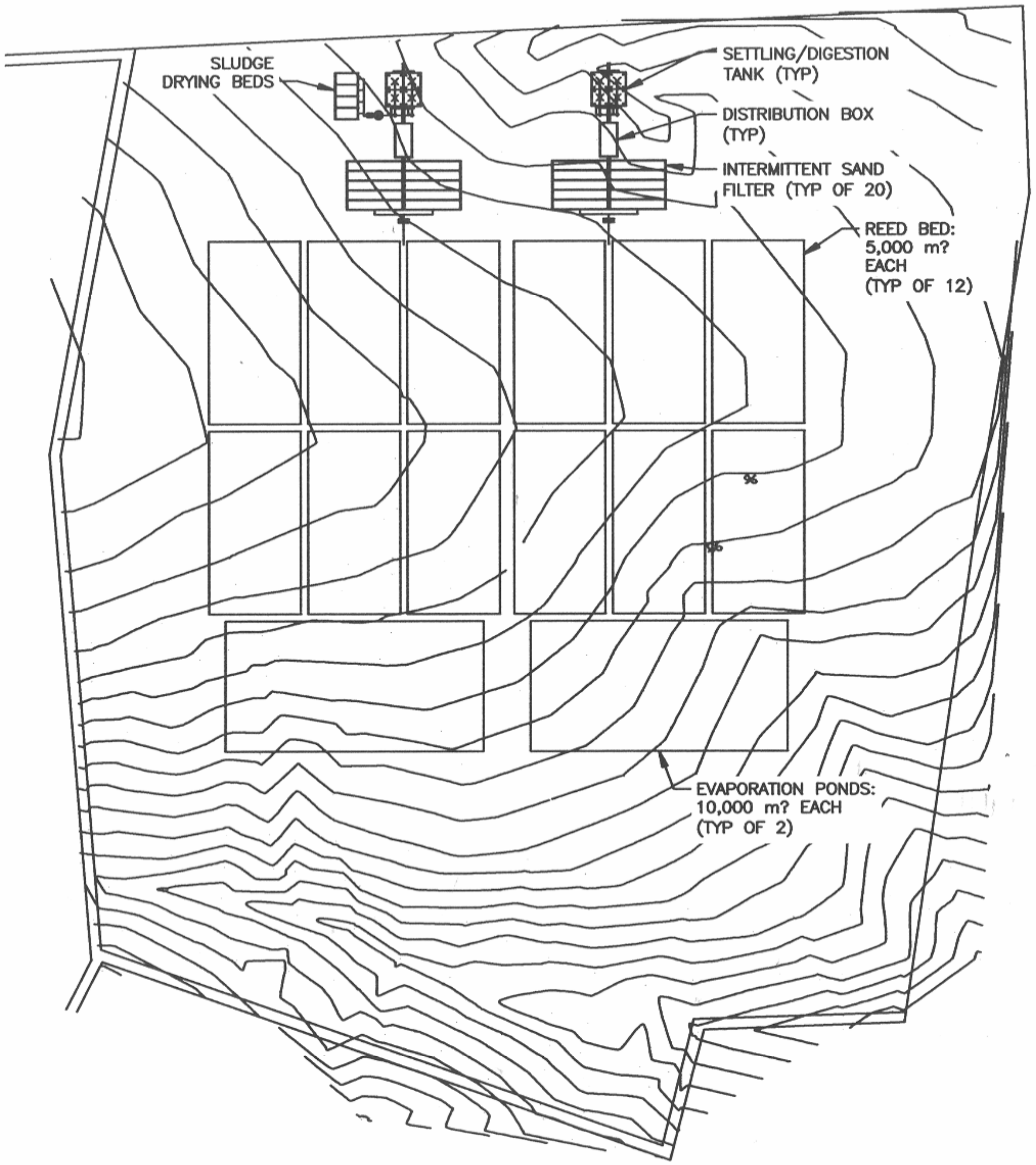
The EMMP's construction transport plan will be specified in the bid documents. This plan will take into account public health and safety; road quality; dust and exhaust emissions; traffic; noise; and waste disposal sites. Other specific plans and procedures will be developed as part of the WWTP operating manual and refined and revisited regularly by the WWTP operator.

Several specific monitoring requirements are also spelled out and will be referred to in the cooperative agreements. These cover effluent and sludge quality monitoring, groundwater monitoring and disease monitoring and prevention. The construction bid documents and supervision of construction activities will also contain health and safety requirements and inspection details.

Appendix A

WWTP conceptual layouts,
Process flow sheets
&
Hydraulic profiles

Figure 11
Preliminary WWTP layout



PLAN

Stearns & Wheler, PLLC Environmental Engineers and Scientists RALEIGH, NORTH CAROLINA	SHOBAK, JORDAN WASTEWATER TREATMENT PLANT
SEPT 2005 **JOB No.:** 40295	FIGURE 7 SITE PLAN AND GRADING

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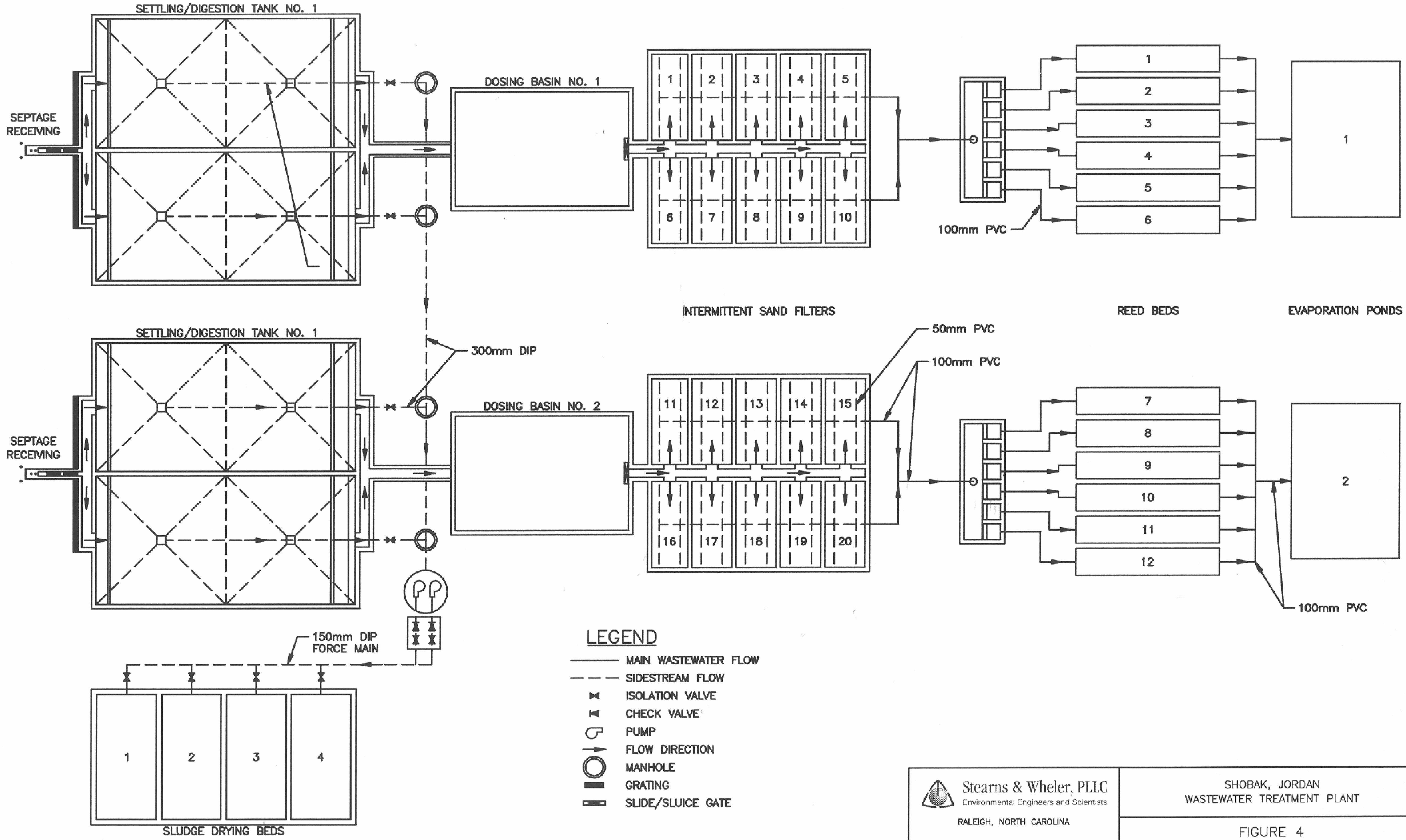
Figure 12
Preliminary process flow diagram



Stearns & Wheler, PLLC
Environmental Engineers and Scientists
RALEIGH, NORTH CAROLINA

SEPT 2005 JOB No.: 40295

SHOBAK, JORDAN
WASTEWATER TREATMENT PLANT

FIGURE 4
PROCESS FLOW DIAGRAM

Appendix B

Sludge Standards
JS 1145/1996

Jordanian standard No. 1145/1996

Sludge: Uses of treated sludge in agriculture Specifications and Standards Organization

1- Scope

This standard is concerned with the conditions that must be available in the sludge resulting from the stations for the treatment of sewage water intended to be used in agricultural land.

2- Definition

Sludge: The solid substance which are characterized by a damp or dry texture resulting from the treatment process of sewage water treatment stations.

Sewage water: The water resulting from domestic uses, and which may intermix with industrial water waste having a quality which conforms to the linking instructions issued by official authorities.

Treated Sludge: Sludge that has been exposed to one of the treatment methods indicated in the appendix to this standard.

Dry Sludge weight: The weight of the totally solid substances after dehydration of the sludge at a temperature of (103 – 105) C for a period of 24 hours

3- General Conditions

3.1- It shall not be allowed to use untreated sludge for agricultural purposes.

3.2- The uses of sludge treated to **the first level** (as indicted in the attachment).

3.2.1- It shall be allowed to use the sludge for the purpose of improving the properties of the Badiya soil not used for agricultural provided that it will be immediately ploughed, in the lands set for forestation.

3.2.2- The treated sludge shall be added during the period between the beginning of April and the end of June.

3.3- The use of the sludge treated to the second level (as indicated in the **attachment**).

3.3.1- It shall be permitted to use the sludge in the cases indicated in item (3-2).

3.3.2- It shall be allowed to use it at the beginning of soil preparation until the planting of fruit trees, fodder, and field crops, taking into account not to harvest the fodder and field crops, or grazing before the lapse of three months from the date of fertilization.

3.3.3- It shall not be permitted to use it for fertilizing the vegetables, green areas, parks, nurseries, and greenhouses, and the lands situated between residential compounds.

3.4- When adding the sludge, the sensitivity of the water reservoirs and their susceptibility to contamination must be observed. The distance of the land to which the treated sludge is intended to be added, from the water of dams and valleys as well as surface water, and water harvest projects, must be also observed.

3.5- The sludge treated for agricultural purposes must not be added, unless approval of the competent official authorities has been obtained.

4- Standard Conditions

- The following standard conditions must be available in the treated sludge, when it is used for agricultural purposes.
- The maximum limit for the sludge properties must be as shown in schedule No. (1).
- The quantity of the treated sludge added to the soil annually shall be calculated according to the concentration of the element of lesser value, in accordance with the following formula :

$$\text{Average of the annual sludge addition (Metric ton/Hectare/365 day)} = \frac{\text{Average of addition to the elements level (kg/Hectare/365 day)}}{\text{Element concentration in the sludge sample (mg/kg-dry)} \times 0.001}$$

- The bio-contaminants, when using the sludge treated for agricultural purposes, must be as shown in schedule No. (2).
- The geometrical average must be taken for seven different samples of the treated sludge before using it or disposing thereof immediately.

Schedule No. (1) – The Maximum of the Chemical Elements Concentration in the Treated Sludge:

Particularity	Concentration of Elements in The Sludge (Mg/Kg-dry) (1)	Addition rate to the elements level Kg/Hectare */ 365 days) (2)	Maximum Limits of the Elements Accumulation in soil (Kg/Hectare) (3)
As (Arsenic)	75	2	41
Cd (Cadmium)	85	1.9	39
Cr (Chromium)	3000	150	3000
Cu (Copper)	4300	75	1500
Pb (Lead)	840	15	300
Hg (Mercury)	57	0.85	17
Mo (Molybdenum)	75	0.9	18
Ni (Nickel)	420	21	420
Se (Selenium)	100	5	100
Zn (Zinc)	7500	140	2800
Co (Cobalt)	150	1.8	36

* One hectare = 10 dunums

Schedule No. (2) – The limits of Bio Contaminants of the sludge when used for Agricultural Purposes

Bio-contaminants	Limits of Contaminants in sludge treated to the first level	Limits of contaminants in sludge treated to the second level
Colon fecal bacteria (the most probable number)	2 X 10^6 bacilli per gram	1 X 10^3 Bacilli per gram
Salmonella (The most probable number)	Unlimited	< 3 bacilli per 4 dry grams*
Worm live ova	Unlimited	<1ovum per 4 dry grams*
Intestinal viruses	Unlimited	< 1 (one) per 4 day grams*

* Dry: The totally dry solid substances

5- References

- USEPA, Code of federal regulation, criteria for classification: of solid waste disposal practices (1992).
- USEPA, "Standards for the use or disposal of sewage sludge 1992".
- The European community "council directive on the protection of the environment, and in particular the soil, when sludge is used in agriculture, 1989".
- FAO paper No. 47 Wastewater treatment and use in agriculture 1992.

Appendix (1) Sludge Treatment Levels

(1) The first level aims at largely reducing the sludge content of pathogenetics. This can be achieved through one of the following processes:

1- Aerial:
Digestion:
This process shall be performed by stirring the sludge in the existence of air or oxygen, while maintaining the air conditions for a period of 40 days at a temperature of 20° C, or for a period of 60 days at a temperature of 15° C, with a decrease of not less than 38% for the volatile solid substances.

2- Aerial dehydration:
The liquid sludge shall be allowed to infiltrate and / or to be dried up in sand infiltration basins, or in paved or unpaved (tiled) basins, provided that the thickness of the sludge will not exceed (23 cm). However, the sludge must remain in the said basins at least for a period of 3 months, provided that the daily temperature will be above zero degree centigrade for a period of two months out of three months.

3- Non – aerial digestion:
This process shall be performed in the absence of air, provided that the sludge will remain for a period of 15 days at a temperature of (30 – 33) °C or for 60 days at a temperature of 20° C and with a reduction of not less than 38% of the volatile solid substances.

4- Fermentation:
This process shall be performed by using a container with a fixed ventilation shaft, or by placing the fertilizer in heaps, where the solid mass shall remain at a temperature of 40°C for a period of (5) days, provident that the temperature will reach more than 55°C for a period of not less than four hours during that period.

5- Treatment by raising the figure of interaction (the hydrogen exponent) of the liquid sludge.
This process shall be performed by adding a sufficient quantity of lime, in order to give a basic degree equal to 12(PH= 12) for a period of no less than two hours.

6- Other methods:
Any method which is capable of achieving the levels indicated in the previous methods, concerning the reduction of the volatile solid substances, or presenting the attraction of the pathogenetics thereto.

2) The second level aims at a larger reduction in the sludge content of the pathogenetics than that of the first level this can be achieved through one of the following processes:

1- Fermentation / This method may be performed as follows:
A- By using the containers method, where by the sludge will be kept at temperature of not less than 55° C for a period of three days.

B- By using the method of fixed ventilation tube, whereby the sludge will the kept at temperature of not less than 55° C for a period of 3 days.
C- By using the method of finding (stacking) the sludge, whereby it will be kept at temperature of not less than 55° C for a period of 15 days during the sludge fermentation period.
(Stirring must be maintained for at least 5 times during the high temperature period).

2- Thermal dehydration:
the sludge shall be dried up by removing the water there from through direct or indirect it contact with hot gases, where by the rate of humidity will be decreased to 10% or less, so that the sludge temperature will exceed 80°C, or that the damp temperature of the sludge heating gas will not be less than 80°C at the end of the heating process.

3- Thermal operation:
The liquid sludge shall be heated to a temperature of 180°C for or period of 30 minutes.

4- Thermal Arial digestion:
The liquid sludge must be stirred in the existence of air or oxygen, while maintaining the air condition for a period of 10 days at a temperature of (55 – 60) °C, with a reduction for the volatile solid substances at rate of not less than 38%.

5- Other methods:
Any method which is capable of achieving the abovementioned levels, concerning the reduction of the levels of volatile solid substances and prevention of the attract on of the pagthogenetics thereto.

The following methods, when added to the above-mentioned treatment methods, will reinforce the reduction of the pagthogenetics:

A- **Treatment by beta rays:** The sludge shall be exposed to beta rays from the nuclear accelerator with doses of not less than (1) megarad at room temperature (20°C).

B- **Treatment by gamma rays:** The sludge shall be treated by gamma rays from specific isotopes, such as Cobalt 60 or Cesium 137 with doses of not less than (1) megarad at room temperature (20°C).

C- **Pasteurization:** The sludge shall be kept for a period of 30 minutes at a temperature of not less than 70°C.

D- **Other methods:** Any other methods or acceptable operating conditions, if they lead to a reduction in the pathogenetics to the extent that we obtain by using any of the aforementioned methods.

<u>Reference:</u>
USEPA, code of federal regulation, criteria for classification of solid waste disposal peacetimes (1992).

Appendix C

Population & Monthly Wind Data

Table 16
Population and household data by community

Settlement Name	Sub-district / Liwa'a	2004 Population	No. of Households
Najil	Shobak	1,837	347
Muthalath		1,370	268
Al Jaya		9	2
Mansourah		877	157
Abu Katoub		141	24
Al Muqariyya		595	105
Shamakh		1,184	213
Juhair		633	105
Hdada		217	38
Bir Dabbaghat		786	135
Beir Khdad		709	122
Huwalleh		691	120
Zbairieyyeh		832	179
Zaytouneh		122	21
Faisaliyeh		866	90
Udruh	Asha'ari	938	145
Tumai		79	12
Jerba Kabeera		446	71
Asha'ari		50	8
Jerba Sagheera		178	28
Manshiyyeh		1,714	246
Ber Abu Al Alaq		62	10
Mohammadieh		103	15
Husseiniyeh	Husseiniyeh	5,851	859
Hashmiyeh		2,341	328
Hudaira		32	7
Tell Burma		76	14
Qadissiyeh	Tafileh	6,933	1,187
Total		**29,672**	**4,856**

Source: October 2004 Census, Department of Statistics

Table 17
Long-term Monthly Wind Data

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Prevailing Monthly Wind Direction (Degree*)	255	255	239	278	282	293	296	292	287	257	263	247	274^{o}
Mean Monthly Wind Speed "Knot"	5.4	5.6	5.6	4.7	4.2	4.3	4.4	3.6	2.8	3.2	4.2	4.6	4.4

*0 = North, 90 = East, 180 = South, 270 = West

Source: Jordan Climatological Handbook, 2000, The Hashemite kingdom of Jordan, Meteorological Department, Climate Division

Appendix D

Jordan Archaeological Data Information System (JADIS)

JADIS / Jordan Antiquities Database and Information System

Full JADIS Report

1. Site no.: 2099-024
2. English Name: DUSAQ
3. UTM zone: 36
4. UTM east: 751100 5. UTM north: 3379500
6. UTM calculated
7. UTM sited
8. PG calculated
9. PG sited
10. Palestine grid east: 209,000 11. Palestine grid north: 992,300
12. K737: 3151.3. 13. Other map no.:
14. Air photo series:
15. Air photo no.:
16. Satellite photo no.:
17. Site size:
18. Max elevation:
19. Type of Site and 20. Period and Type of Use
UNSPECIFIED PERIOD STRUCTURE
19)PALACE
UNSPECIFIED PERIOD STRUCTURE
25)OTHER/UNSPECIFIED STRUCTURE OR WALL
21. Topographic location: 0)UNKNOWN LOCATION
22. Site condition: 00)NO INFORMATION
23. Disturbances: 00)NO INFORMATION
Other Disturbances
24. Inventory rating:
Dam:
Quarry:
25. Type & level of threat of destruction by: Cultivation:
Other:
Erosion
Construction:
Road work:
Development:
26. Archaeology of Jordan References:
BRUENNOW R. & VON DOMASZEWSKI A.
1904 98 99 VOL.I
GLUECK N.
1933 a 76 SITE 10
32. Other reference:
BISHEH G. & QOB'AIN N. UNP.REPORT 1972,SITE 16
27. Visited by:
28. Visit date:
29. Encoded by:
30. Encoding date: 20-02-1994
31. Notes:

Appendix E

List of Observed and Known Species

Table 18
Plant Species Recorded/Observed in Study Area

Scientific name	Family	English name	Arabic name	Status/Remarks
Leontice leontopetalum	Berbiridaceae	Lion's leaf	Tqaiá	R
Alkanna tinctoria	Boraginaceae	Dyer's Alkanet	Hawaá jawi	C
Silene conoida	Caryophyllaceae	Catchfly	Semsim	C
Anabasis syriaca	Chenopodiacea	Anabasis	Shnan	C/P
Noaea mucronata	Chenopodiacea	Thorny Saltwort	Ssir	C/F
Helianthemum vesicarium	Cistacea	Sun rose	Ward el-Shams	R
Achillea santolina	Compositae	Yarrow Santolina	Jaádh Sebyan	C/M
Artemisia herba-alba	Compositae	Wormwood	Shiih	C/M
Anthemis melampodna	Compositae	Chamomile	Oqhowan	C
Gymnarrhena micrantha	Compositae	Gymnarrhena	Khof el Kalb	C/F
Scorzonera judaica	Compositae	Yellow Viper's Grass	Qaáfor, Thabah	E
Senecia glaucus	Compositae	Buck's horn Groundsel	Quraeé	R
Tragopogon collinus	Compositae	Goat's Beard	Thabah	R*
Cardaria draba	Cruciferae	Hoary Pepperwort	Qnaibra	C
Eruca sativa	Cruciferae	Garden Rocket	Jarjeer	C/Ed
Mathiola longipetala	Cruciferae	Evening Stock	Manthoor	C
Erodium hirtum	Geraniaceae	Strok's Bill	Ibret el Ajooz	C/ Ed
Aegilops crassa	Gramineae	Wild	Qmaha	R
Avena sterillis	Gramineae	Wild Oat	Shofan	Ed/F
Hordeum glaucum	Gramineae	Wild Barley	She'er Barri	F
Hordeum spontaneum	Gramineae	Wild Barley	She'er Barri	R/F
Piptatherum holciforme	Gramineae	Grass		F
Schismus barbatus	Gramineae			F
Hypecoum procumbens	Hypecoaceae	Hypecom	Qrain	R
Gynandriris sisyrinchium	Iridaceae	Gynandriris	Zanbaq	C
Íris Edomensis	Iridcaeae	Edom Iris	Qarn El Kabsh	E
Iris petrana	Iridaceae	Petra Iris	Sawsan El Patraá	E/En*
Iris aucheri	Iridaceae	Iris	Sawsan El Sahraá	T
Ajuca chia	Labiatae	Chian Bugle	Oshbet El Dam	C
Salvia palaestina	Labiatae	Palestine Sage	Kharnah	C/M
Salvia lanigra	Labiatae	Desert Sage	Araim	C
Teucrium pollium	Labiatae		Jaádeh	M
Astragalus cretaceus	Leguminoseae	Milk Vetch	Borj El Aroos	C
Astragalus spinosus	Leguminoseae	Milk Vetch	Kdad	C/ F
Astragalus sparsus	Leguminoseae	Sleber's Milk Vetch	Khonsor EL Aroos	C
Gagea reticulata	Liliaceae	Gagea	Ze'aitman	C
Tulipa polychroma	Liliaceae	Desert Tulip	Zanbaq Sahrawi	R
Glaucium grandiflorum	Pappaveraceae	Poppy	Nannon	C
Roemeria hyprida	Pappaveraceae	Roemeria	Náymeh	C
Plantago cylindirica	Plantaginaceae	Plantin		C
Adonis aestivalis	Rananculaceae	Pheasant's eye	Hannon El Bis	C
Reseda lutea	Resedaceae	Yellow Mignonette	Hasadi	C
Hyoscyamus reticulatus	Scrophulariacea	Egyptian Henban	Banj/Sakran	C/M
Peganum harmala	Zygophyllaceae	Peganum	Harmal	C/P

Notes: E: Endemic, C: Common, R: Rare, R*: Rare/IUCN, En*: Endangered/IUCN, M: Medicinal, F: Forage, P: Poisonous, Ed: Edible

Table 19
Mammal Species Recorded/Observed in Study Area

Species	Common name	Arabic name	observed	presumed
Family Erinaceidae				
Erinaceus concolor	European Hedgehog	القنفذ الاوروبي	•	
Family Rhinolophidae				
Rhinolophus ferrumequinum	Greater horse shoe bat	خفاش حدوة الفرس		•
Family Leporidae				
Lepus capensis syriacus	Arabian Hare	الأرنب البري السوري		•
Family Cricetidae				
Gerbillus dasyurus				•
Meriones tristrami	Tristram jird	جرذ ترسترام	•	
Meriones libycus	Libyan jird	الجرذ الليبي		•
Family Spalacidae				
Spalax leucodon	Palestine mole	الخلد	•	
Family Hystricidae				
Hystrix indica	Indian crested porcupine	النيص		•
Family Canidae				
Vulpes vulpes	Red fox	الثعلب الأحمر	•	
Family Hyaenidae				
Hyaena hyaena	Striped hyena	الضبع المخطط		•
Family Felidae				
Felis silvestris tristrami	Tristram wild cat	القط البري		•

Table 20
Land Amphibians Species Recorded in the Study Area (Reptiles)

Species	Common name	Arabic name	observed	presumed
Family Gekkonidae				
Ptyodactylus hasselquistii	Fan-footed gecko	الوزغة مروحية الاطراف		•
Family Chamaeleonidae				
Chamaeleo chamaeleon	European chameleon	الحرباء الأوروبية		•
Family Agamidae				
Laudakia stellio	Starred agama	الحرذون البرتقالي	•	
Family Lacertidae				
Acanthodactylus boskianus	Bosk's fringe-toad lizard	السحلية شوكية الاطراف		•
Ophisops elegans	Snake-eyed lizard	السحلية ذات العيون الشبيه بالحية	•	
Family Scincidae				
Chalcides ocellatus	Ocellated skink	السحلية اللامعة		•
Family Colubridae				
Coluber jugularis	Large whip snake	الحنيش		•
Coluber rubriceps	Red whip snake	الحية السوطية الحمراء		•
Coluber nummifer	Coin snake	الحية المرقشة		•
Eirenis rothi	Roth's dwarf snake	الحية القزمة		•
Eirenis coronella	Crowned dwarf snake	الحية القزمة المتوجة		•
Malpolon monspessulanus	Montpellier snake	حية مونتبلير		•
Telescopus nigriceps	Black-headed cat snake	حية القط سوداء الرأس		•

Table 21
Bird Species in Project Area

Globally threatened species

Common Name	Scientific Name
Corncrake	Crex crex
Imperial Eagle	Aquila heliaca
Houbara Bustard	Chlamydotis undulata
Lesser Kestrel	Falco naumanni
Syrian Serin	Serinus syriacus

species or population on Appendix 1 of the Bonn Convention

Regionally Threatened Species

Common Name	Scientific Name
Levant Sparrowhawk (1)	Accipiter brevipes
Honey Buzzard (1)	Perinus apivorus
Saker Falcon (1)	Falco cherrug
Egyptian Vulture	Neophron percnopterus
Griffon Vulture	Gyps fulvus
Lesser Spotted Eagle	Aquila pomarina
Lanner	Falco biarmicus
Sooty Falcon	Falco concolor
White Stork (1)	Ciconia ciconia

(1) Species or population on Appendix 1 of the Bonn Convention

Species restricted wholly or largely to ME

Common Name	Scientific Name
Hume's Tawny Owl	Strix butleri
Hooded Wheatear	Oenanthe monacha
Arabian Warbler	Sylvia leucomelaena
Arabian Babbler	Turdoides squamiceps
Tristram's Grackle	Onychganthus tristramii
Dead Sea Sparrow	Passer moabticus
Sand Partridge	Ammoperdix heyi
White-crowned Wheatear	Oenanthe monach
Finch's Wheatear	Oenanthe finchii
Sinai Rosefinch	Carpdacus synoicus

Bird species known to occur within the study area

Common name	Scientific name	Arabic name	Observed
1) Black Stork	Ciconia nigra	اللقلق الأسود	
2) White Stork	Ciconia ciconia	اللقلق الابيض	×
3) Honey Buzzard	Pernis apivorus	صقر العسل	
4) Black Kite	Milvus migrans	الحدأة السوداء	×
5) Egyptian Vulture	Neophron percnopterus	الرخمة	
6) Griffon Vulture	Gyps fulvus	النسر البني	
7) Short-toed Eagle	Circaetus gallicus	عقاب الحيات	×
8) Marsh Harrier	Circus aeruginosus	مرزة البطائح	
9) Hen Harrier	Circus cyaneus	مرزة الدجاج	
10) Pallid Harrier	Circus macrourus	المرزة الباهتة	×
11) Montagu's Harrier	Circus pygargus	مرزة مونتاكو	
12) Goshawk	Accipiter gentilis	الباز الصداح	

Common name	Scientific name	Arabic name	Observed
13) Sparrowhawk	Accipiter nisus	الباشق	
14) Levant Sparrowhawk	Accipiter brevipes	البيدق	
15) Buzzard	Buteo buteo	الصقر الحوام	×
16) Long-legged Buzzard	Buteo rufinus	الحميق	×
17) Lesser Spotted Eagle	Aquila pomarina	العقاب الأسفع الصغير	
18) Spotted Eagle	Aquila clanga	العقاب الأسفع الكبير	
19) Steppe Eagle	Aquila nipalensis	عقاب البادية	
20) Imperial Eagle	Aquila heliaca	ملك العقبان	
21) Golden Eagle	Aquila chrysaetos	العقاب الذهبي	
22) Verreaux's Eagle	Aquila verreauxii	العقاب الأسود	
23) Booted Eagle	Hieraaetus pennatus	العقاب المسير الشاحب	
24) Bonelli's Eagle	Hieraaetus fasciatus	عقاب بونللي	
25) Lesser Kestrel	Falco naumanni	العويسق	
26) Kestrel	Falco tinnunculus	العوسق	×
27) Merlin	Falco columbarius	اليؤيؤ	
28) Hobby	Falco subbuteo	الشويهين	
29) Sooty Falcon	Falco concolor	صقر الغروب	
30) Lanner	Falco biarmicus	الحر العربي	
31) Saker	Falco cherrug	صقر الغزال	
32) Peregrine	Falco peregrinus	الشاهين	
33) Barbary Falcon	Falco pelegrinoides	الشاهين المغربي	
34) Chukar	Alectoris chukar	الشنار	
35) Rock Dove	Columba livia	الحمام الازرق	
36) Collared Dove	Streptopelia decaocto	الحمامة المطوقة	×
37) Turtle Dove	Streptopelia turtur	الحمامة الرقطية	×
38) Laughing Dove	Streptopelia senegalensis	حمامة النخيل	×
39) Great Spotted Cuckoo	Clamator glandarius	الوقواق المنقط الكبير	
40) Cuckoo	Cuculus canorus	الوقواق	
41) Barn Owl	Tyto alba	البومة البيضاء	
42) Eagle Owl	Bubo bubo	البومة النسارية	
43) Little Owl	Athene noctua	البومة الصغيرة	×
44) Tawny Owl	Strix aluco	الخبل	
45) Hume's Tawny Owl	Strix butleri	الخبل الصخري	
46) Long-eared Owl	Asio otus	البومة الاذناء	
47) Short-eared Owl	Asio flammeus	البومة الصمعاء	
48) Swift	Apus apus	السمامة	×
49) Pallid Swift	Apus pallidus	السمامة الباهتة	
50) Alpine Swift	Apus melba	السمامة الجبلية	
51) Little Swift	Apus affinis	السمامة الصغيرة	
52) Blue-cheeked Bee-eater	Merops superciliosus	الوروار ازرق الخد	
53) Bee-eater	Merops apiaster	الوروار	×
54) Roller	Coracias garrulus	الشقراق	
55) Hoopoe	Upupa epops	الهدهد	×
56) Desert Lark	Ammomanes deserti	قبرة الصحراء	×
57) Calandra Lark	Melanocorypha calandra	قبرة مطوقة	×
58) Bimaculated Lark	Melanocorypha bimaculata	قبرة الشرق	
59) Short-toed Lark	Calandrella brachydactyla	فبرة السهوب	×
60) Lesser Short-toed Lark	Calandrella rufescens	قبرة السهوب الصغيرة	
61) Crested Lark	Galerida cristata	القبرة المتوجة	×
62) Woodlark	Lullula arborea	قبرة الغاب	

Common name	Scientific name	Arabic name	Observed
63) Skylark	Alauda arvensis	الزرعي	
64) Temminck's Horned Lark	Eremophila bilopha	قبرة الصحراء المقرنة	×
65) Sand Martin	Riparia riparia	خطاف الشواطئ	
66) Rock Martin	Ptyonoprogne fuligula	خطاف الصخور	
67) Crag Martin	Ptyonoprogne rupestris	خطاف الشواهق	×
68) Swallow	Hirundo rustica	السنونو	×
69) Red-rumped Swallow	Hirundo daurica	السنونو احمر العجز	×
70) House Martin	Delichon urbica	خطاف البيوت	
71) Richard's Pipit	Anthus novaeseelandiae	ابو تمرة شرقي	
72) Tawny Pipit	Anthus campestris	ابو تمرة الاصفر	
73) Long-billed Pipit	Anthus similis	ابو تمرة طويل المنقار	
74) Tree Pipit	Anthus trivialis	ابو تمرة الشجر	
75) Meadow Pipit	Anthus pratensis	ابو تمرة الحقول	
76) Red-throated Pipit	Anthus cervinus	ابو تمرة احمر الزور	
77) White Wagtail	Motacilla alba	الذعرة البيضاء	×
78) Yellow-vented Bulbul	Pycnonotus xanthopygos	البلبل	×
79) Dunnock	Prunella modularis	عصفور الشوك	
80) Radde's Accentor	Prunella ocularis	المختبئ الايراني	
81) Rufous Bush Robin	Cercotrichas galactotes	الحمرة	
82) Robin	Erithacus rubecula	ابو الحن	
83) Thrush Nightingale	Luscinia luscinia	الهزّاز	×
84) Nightingale	Luscinia megarhynchos	العندليب	
85) Bluethroat	Luscinia svecica	المسهر	
86) White-throated Robin	Irania gutturalis	ابو الحن ابيض الزور	
87) Black Redstart	Phoenicurus ochruros	الحميراء السوداء	
88) Redstart	Phoenicurus phoenicurus	الحميراء	×
89) Blackstart	Cercomela melanura	االشحيتي	
90) Whinchat	Saxicola rubetra	القليعي الاحمر	
91) Stonechat	Saxicola torquata	القليعي المطوق	×
92) Isabelline Wheatear	Oenanthe isabellina	الابلق الاشهب	×
93) Wheatear	Oenanthe oenanthe	الابلق	×
94) Black-eared Wheatear	Oenanthe hispanica	الابلق اسود الاذن	×
95) Desert Wheatear	Oenanthe deserti	ابلق البادية	×
96) Finsch's Wheatear	Oenanthe finschii	الابلق العربي	×
97) Mourning Wheatear	Oenanthe lugens	الابلق الحزين	×
98) White-crowned Black Wheatear	Oenanthe leucopyga	الابلق الاسود ابيض القنة	
99) Rock Thrush	Monticola saxatilis	سمّنة الصخر	×
100) Blue Rock Thrush	Monticola solitarius	سمّنة الصخر الزرقاء	×
101) Blackbird	Turdus merula	الشحرور	×
102) Fieldfare	Turdus pilaris	سمنّة الحقول	
103) Song Thrush	Turdus philomelos	السمّنة المطربة	
104) Redwing	Turdus iliacus	السمّنة المغردة	
105) Mistle Thrush	Turdus viscivorus	سمنّة الدبق	
106) Cetti's Warbler	Cettia cetti	هازجة ستي	
107) Graceful Warbler	Prinia gracilis	الهازجة طويلة الذنب	×
108) Scrub Warbler	Scotocerca inquieta	هازجة الشجيرات	×
109) Upcher's Warbler	Hippolais languida	الخنشع الشجري	
110) Spectacled Warbler	Sylvia conspicillata	الدُخلة ذات النظارة	
111) Subalpine Warbler	Sylvia cantillans	دُ خلة الصرود	
112) Ménétries's Warbler	Sylvia mystacea	دُخلة الطرفاء	

Common name	Scientific name	Arabic name	Observed
113) Sardinian Warbler	Sylvia melanocephalus	هازجة سردينيا	×
114) Cyprus Warbler	Sylvia melanothorax	هازجة قبرص	
115) Rüppell's Warbler	Sylvia rueppelli	دُخلة روبيل	
116) Orphean Warbler	Sylvia hortensis	الدُخلة المغنية	×
117) Barred Warbler	Sylvia nisoria	الدّخلة الموشمة	
118) Lesser Whitethroat	Sylvia curruca	زريقة فيرانية صغرى	
119) Whitethroat	Sylvia communis	زريقة فيرانية	×
120) Garden Warbler	Sylvia borin	دُخلة البساتين	
121) Blackcap	Sylvia atricapilla	عصفور التين	×
122) Bonelli's Warbler	Phylloscopus bonelli	نقشارة بونلي الشرقية	
123) Wood Warbler	Phylloscopus sibilatrix	نقشارة الغابة	
124) Chiffchaff	Phylloscopus collybita	النقشارة	×
125) Willow Warbler	Phylloscopus trochilus	نقشارة الصفصاف	×
126) Spotted Flycatcher	Muscicapa striata	خاطف الذباب المنقط	×
127) Semi-collared Flycatcher	Ficedula semitorquata	خاطف الذباب القوقاسي	
128) Collared Flycatcher	Ficedula albicollis	خاطف الذباب المطوق	
129) Pied Flycatcher	Ficedula hypoleuca	خاطف الذباب الابقع	
130) Great Tit	Parus major	القرقف الكبير	×
131) Penduline Tit	Remiz pendulinus	قرقف القصب	
132) Palestine Sunbird	Nectarinia osea	التمير الفلسطيني	×
133) Golden Oriole	Oriolus oriolus	الصفّير	×
134) Isabelline Shrike	Lanius isabellinus	الصرد الاشهب	
135) Red-backed Shrike	Lanius collurio	الصرّد احمر الظهر	
136) Lesser Grey Shrike	Lanius minor	الصرّ د الرمادي الصغير	
137) Southern Grey Shrike	Lanius meridionalis	الصرّد الرمادي	×
138) Woodchat Shrike	Lanius senator	الصرّد احمر القنة	×
139) Masked Shrike	Lanius nubicus	الصرّد المقنع	
140) Raven	Corvus corax	الغراب الاسود الكبير	
141) Fan-tailed Raven	Corvus rhipidurus	الغراب مروحي الذنب	
142) Tristram's Grackle	Onychognathus tristramii	السوادية	×
143) Starling	Sturnus vulgaris	الزرزور	
144) House Sparrow	Passer domesticus	العصفور الدوري	×
145) Spanish Sparrow	Passer hispaniolensis	العصفور الاسباني	×
146) Rock Sparrow	Petronia petronia	العصفور الصخري	
147) Chaffinch	Fringilla coelebs	العصفور الظالم	
148) Brambling	Fringilla montifringilla	الشرشور الجبلي	
149) Red-fronted Serin	Serinus pusillis	النعار احمر الجبهة	
150) Serin	Serinus serinus	النعار الاوروبي	
151) Tristram's Serin	Serinus syriacus	النعار السوري	
152) Greenfinch	Carduelis chloris	الحسون الاخضر	×
153) Goldfinch	Carduelis carduelis	الحسون الذهبي	×
154) Linnet	Carduelis cannabina	التفح	×
155) Desert Finch	Rhodospiza obsoleta	العصفور الوردي الصحراوي	
156) Sinai Rosefinch	Carpodacus synoicus	العصفور الوردي السينائي	×
157) Yellowhammer	Emberiza citrinella	درسة صفراء	
158) House Bunting	Emberiza striolata	الدُرّسة المنزلية	
159) Ortolan Bunting	Emberiza hortulana	دُرّسة الشعير	×
160) Cretzschmar's Bunting	Emberiza caesia	دُرّسة زرقاء الراس	
161) Corn Bunting	Miliaria calandra	دُرّسة المحاصيل	×

Appendix F

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Appendix G

The EA Team

ECODIT, IRG and MWHAJ mobilized a multi-disciplinary team of core specialists with significant EA experience in Jordan and internationally to conduct the EA and produce the EA report, under the direction of Mr. Bob Katz, the Chief of Party on the Small Communities Project. The team leader for this task was Mr. Karim El-Jisr. The table below presents the core assessment team including degrees, qualifications and proposed position.

Name	Proposed Position	Qualifications	Years Experience
Nazih Bandak	Quality Control, Health/Safety & Emergency Specialist	MSc Environmental Engineering BSc Civil Engineering	20
Karim El-Jisr	EIA Team Leader	MSc Environment BE Agricultural Engineering	7
Zuheir El Amr	Fauna Specialist	PhD, MS, BSc Zoology	20
Ahmad Abu Hijleh	Hydro-geologist	MSc, BSc Geology & Water Resources	18
Ibrahim Al Khader	Flora & Biodiversity Specialist	MSc Plant Taxonomy BSc Biological Sciences	8
Sherif Al Jbour	Avifauna Specialist	BSc Biological Sciences	5
Osama Abu Rayyan	Project Technical Coordinator and Economist	MSc Environmental Economics BSc Resource Conservation	8

Appendix H

Stakeholder consultations and approvals

Documents attached (to be included with the Final EA):

- Scoping Brief provided to stakeholders prior to the Scoping Session
- Scoping Statement and Scoping Session Report submitted to USAID and the MoE (plus list of attendee signatures)
- Comments received from the MoE on the Scoping Statement
- USAID BEO approval of the Scoping Statement
- Site selection approval letter from WAJ based on Inter-ministerial site visits
- Highlights of the Workshop on the Draft Feasibility, Environmental Assessment and Institutional & Cost Recovery Reports (plus list of attendee signatures)
- USAID comments on the Draft EA
- MoE comments on the Draft EA
- The Consultants responses to USAID and MoE comments received on the Draft EA