Final Report for the Trip to Jordan
December 12-21, 2003

The University of Arizona
Laboratory of Tree-Ring Research

BY

Ramzi Touchan

Table of Contents

Objectives of the Trip

My objectives for the trip were to investigate the possibility of using tree ring and other proxy records, such as archaeological and geological, records in sustaining agricultural wastewater re-use in Jordan. This work was performed for the Sustainable Development of Drylands Project, Jordan Component, as implemented by the International Arid Lands Consortium (IALC) and funded by the U.S. Agency for International Development (USAID).

Program of the Trip

I made contacts and scheduled meetings with scientists from different universities and the Ministry of Agriculture.

Sunday 14-12-2003

I met with Dr. Issa Al-Nsour, Director of Water Resources Monitoring at the Minister of Water & Irrigation.

We discussed the availability of high quality continuous instrumental data (precipitation and temperature) for Jordan. He informed me that the oldest precipitation records in their data bank go back to 1937, while temperature records span 1965-present. During the meeting, I requested a diskette copy of the instrumental data for the stations that had high quality instrumental data since 1937-present.

Mr. M. Shahbaz (Director of the Badia Research and Development Programme) and I met with Prof. Awni Taimeh, Secretary General for the Ministry of Agriculture. We discussed the proxy records that I developed using tree ring growth. We also discussed other proxy records, such as historical documentation, soil, and pollen analysis.

Monday 15-12-2003

I met with Mr. Baker Al Qudah, Director of Rangeland Department at the Ministry of Agriculture. Our discussion concentrated on the importance of wastewater for agricultural crops. We also talked about the importance of using proxy data in understanding long term drought in Jordan.

I met with Dr. Abdel Nabi Fardous, Director General of National Center for Agriculture Research and Technology Transfer (NCARTT). He introduced me to two projects that his institute is involved with. The first one is the Agaba Water Reuse Pilot Project which is supported by USAID (Appendix I). The second is the Water Reuse Pilot Project at the Jordan University of Science and Technology which also is supported by USAID (Appendix II). He also discussed the First Regional Water Reuse Conference held December 7-9, 2003 at the Sheraton Hotel in Amman, Jordan. This conference was implemented by NCARTT and supported by USAID and the Arab Fund for Economic

and Social Development (AFESD) (Appendix III). We also discussed the importance of proxy data in understanding climate variability over decades to centuries and the importance of this information in understanding drought events and the influence of prolonged drought on wastewater resources.

I met with Drs. Akrum Tamimi and Pete Waller to discuss the general objectives of my trip to Jordan.

Tuesday 16-12-2003

I met with Dr. Issa Al-Nsour, Director of Water Resources Monitoring at the Minister of Water & Irrigation regarding the climate data I had requested. He provided me with a diskette copy of the instrumental data for the stations that had high quality instrumental data since 1937-present. These records are available upon request.

I met with Dr. Talal Akasheh, Vice president, Development and Planning and the Dean of Queen Rania's Institute of Tourism and Heritage at the Hashemite University. In our meeting we talked about the use of historical documents in confirming and augmenting tree ring studies. He discussed his institute activities regarding wastewater issues (Appendix IV). He also scheduled a meeting for me with the Dean of the Institute of Land, Water, and Environment (ILWE) at the Hashmite University, Dr. Munir J.M. Rusan.

I met with the dean of ILWE, Dr. Munir J.M. Rusan. The meeting was also attended by all the faculty members from the Institute. He discussed the objectives of their program and their role on solving environmental problems resulting from waste disposal centers (Landfills) in Al-Ruusaifeh, Jordan.

Wednesday 17-12-2003

I met with Mr. Mohammad Samawi, Director of Applied Meteorology-Climate at the Jordan Meteorological Department. He presented me with a copy of all the weather stations that are available in their data bank and the time span of each station (Appendix V).

I had dinner with Drs. Akrum Tamimi, Erin Addison, and Raed Al-Tabini and updated them on my activities in Jordan.

Thursday 18-12-2003

I met with Dr. Nizar Abu-Jaber, Department Chairman and Associate Professor of Earth and Environmental Sciences at the Yarmuk University. We discussed the role of paleo-environmental and paleo-climatological reconstructions in understanding climate variability over many centuries and how we can calibrate tree ring data as proxy records with other proxy records, such as speleological and archaeological approaches.

Friday 19-12-2003

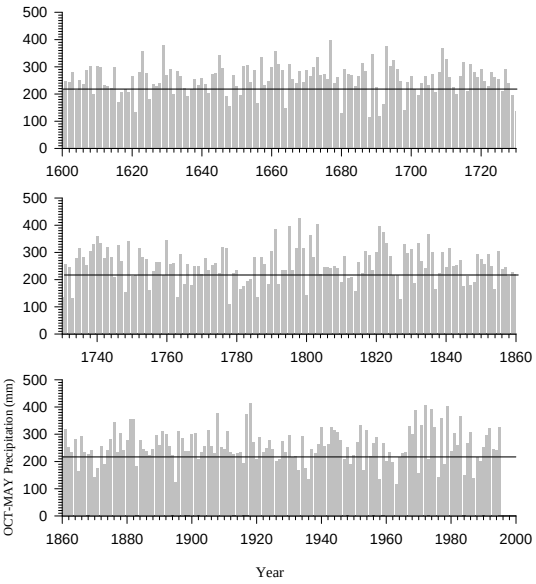
I spent my time writing the outline of my report and preparing for my trip home.

Can we Use Proxy Data to Assist Agricultural Wastewater Re-Use Sustainability in Jordan?

In Jordan, treated wastewater plays a critical role in supplying the agricultural sector with water. The use of treated wastewater in agriculture can serve both the agricultural sector's needs for water and constitutes a sustainable way of disposing of wastewater. The two sources for the wastewater in Jordan are ground water and surface water.

Careful planning and management of water resources in dry land regions requires sufficient information on what series of extreme events, such as prolonged drought, to anticipate. Long term drought in Jordan will greatly affect the availability of wastewater because it simultaneously reduces the amount of available wastewater for agriculture and increases the demand for scarce portable water. The availability of wastewater has a direct connection to the IALC Sustainable Development of Drylands goal to foster sustainable activities.

To understand drought, one must know the variability of an area's climate on time scales of decades to centuries. Touchan et al., 1999 (this research was and continues to be supported by the US National Science Foundation), developed the first dendroclimatic reconstruction in the Near East for southern Jordan, a 396-year-long reconstruction of October-May precipitation based on two chronologies of *Juniperus Phoenicia*. We identified the longest reconstructed drought, defined by consecutive years below a threshold of 80% of the 1946-1995 mean observed October-May precipitation, as four years. The longest drought recorded in the 1946-95 instrumental data is three years. Based on the results of our reconstruction, 7 droughts of 3 or more years have occurred during the past 400 years (Figure 1).

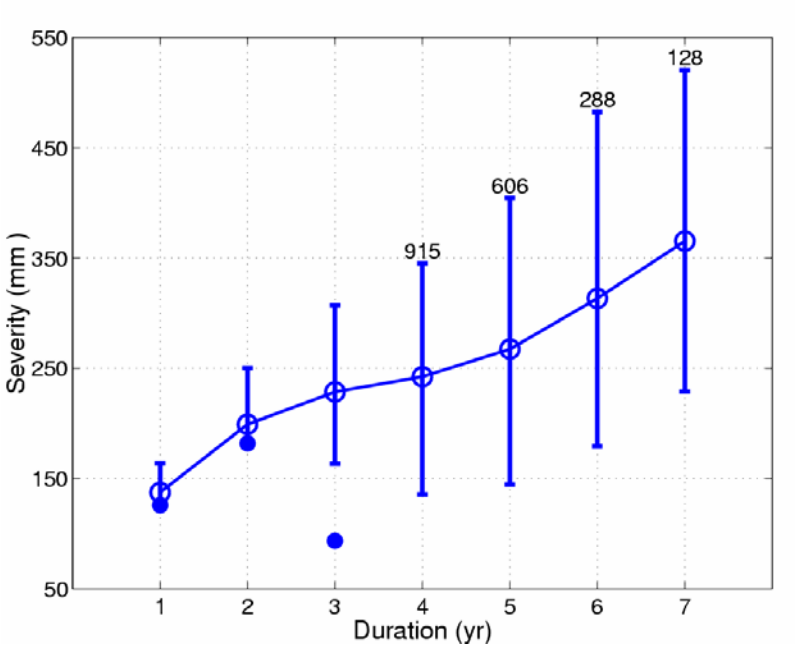


Source Touchan Et al., 1999, Journal of American Water Resources Association, Vol, 35 (1) 49-59 (Fig 4)

Figure 1: Annual values of the reconstruction for Oct-May precipitation for the period from 1600-1995.

Monte Carlo analysis, designed to account for uncertainty in the reconstruction, indicates a less than 50% chance that southern Jordan has experienced drought longer than five years in the past 400 years (Figure 2).

This study indicates that tree ring reconstructions can provide a foundation for studying past climate variability in southern Jordan. Understanding drought characteristics for several centuries will help natural resource managers apply low risk and long-term plans to conserve and sustain water and other natural resources that are the foundations of social, political, and economic systems in the region.



Source Touchan Et al., 1999, Journal of American Water Resources Association, Vol, 35 (1) 49-59 (Fig 6)

Figure 2. Median, 5th, and 95th percentiles of severity of most severe n-year droughts in noise-added reconstructions, 1600-1995.

What Do We Propose?

In collaboration with Drs. Nizar Abu Jaber (Yarmuk University), Talal Akasheh (Hashmite University), and Steve Leavitt (LTTR), we propose a three year study to continue our investigation of long-term climate variability in Jordan. The first step is to extend our tree-ring network in southern and northern Jordan. This will increase the length of our existing southern Jordan reconstruction and develop new reconstruction, if possible, for northern Jordan. The new reconstruction for northern Jordan will help us to understand the drought characteristics in that region and how they co-vary with the southern region. We will also compare the updated and new chronologies with those we have developed from neighboring countries.

The second step is to examine the dendroclimatological data in conjunction with other new approaches to the long-term study of climate variability. Our final goal is to determine the extent to which these different approaches confirm, compliment, and augment each other. These approaches are:

A. Isotopic Analysis of Ancient Paleo-Plant Matter

Vegetation assemblages are tightly linked to climate, and shifting climate contributes to changes in the optimal floral associations. It is possible to obtain plant samples which might be useful in verifying inferences from tree rings, by several means that might be applicable in Jordan: 1. Herbarium collections of plant matter around the world often go back up to 200 years. Stable-carbon and stable-oxygen isotope analysis on small samples of such plant matter can provide information about environmental conditions (eg, moisture stress) at the time the plants were growing. Additionally, because the date of collection is usually recorded, this method is chronologically precise. 2. Certain mammalian fauna (eg, packrats in N. America, and hyrax species in Africa and Middle East) build their nests (middens) with locally available plant fragments. If the middens can be radiocarbon dated, the preserved macrofossils represent a record of the vegetation assemblage at that place and time (and isotopes can be measured as above). The dating is not as precise as tree rings or herbarium specimens. Some packrat midden analysis has been conducted near Petra, both on pollen and macrofossils. The sediment in caves near Petra may also contain pollen records. 3. Floods deposit plant material in addition to sediments. If macrofossils are among the plant matter deposited, they can provide evidence of vegetation assemblages (and climate) and can be dated by radiocarbon.

B. Speleological Analysis

Speleological analysis of stalactites and stalagmites from large caves can also provide information on past climate variability. These formations precipitate mostly calcium carbonate deposits which, like tree rings, form in layers. Unlike tree rings, these layers are not necessarily annual and thus dating is a problem.

As a proxy, stalactites and stalagmites are useful because the stable isotopic composition of oxygen in their structure is largely a function of climate, because rain water composition varies with changing climate. Another, possibly more important factor, is that fractionation between water and the calcium carbonate precipitate is temperature dependent. Thus, studies in the Soreq cave near Jerusalem have provided important insight into climate variation in that area. Here, researchers have used the uranium disequilibrium technique to date changes in climate indicators through time.

In northern Jordan, preliminary studies at the Burghs cave are under way. This cave is large and contains significant deposits of stalactites and stalagmites. Until now, it is difficult to estimate how far back these deposits go, and thus how far back climatic inferences can be made.

C. Archaeological Analysis

Jordan contains large numbers of archeological sites spanning the last 7-8000 years and covering most areas of the country. Within these sites, information on lifestyle, crops and disease can be obtained from artifacts, food remains and bones. Moreover, gradual burial of these sites means that natural proxies (such as pollen) are preserved in the

sediments which envelop these sites. Therefore, there is a potentially very rich source of paleo-climatic information in these sites.

Conclusion

Tree ring reconstructions and other proxy data are valuable tools for studying past climate variability over many centuries. Proxy climate records will provide water resource managers with sufficient information on what series of extreme events to anticipate, such as prolonged drought. An increased frequency of drought in Jordan would have a great impact on the quantity of wastewater. Reduced wastewater availability constrains agricultural development and prohibits planned agricultural expansion and at the same time increases the demand on the scarce portable water.

Finally, proxy climate records can be used by other researchers to answer the following questions:

1. What is the relative balance of surface to groundwater as input to each wastewater plant where there are re-use projects?

2. What are the effects of drought on the relative balance of surface to groundwater?

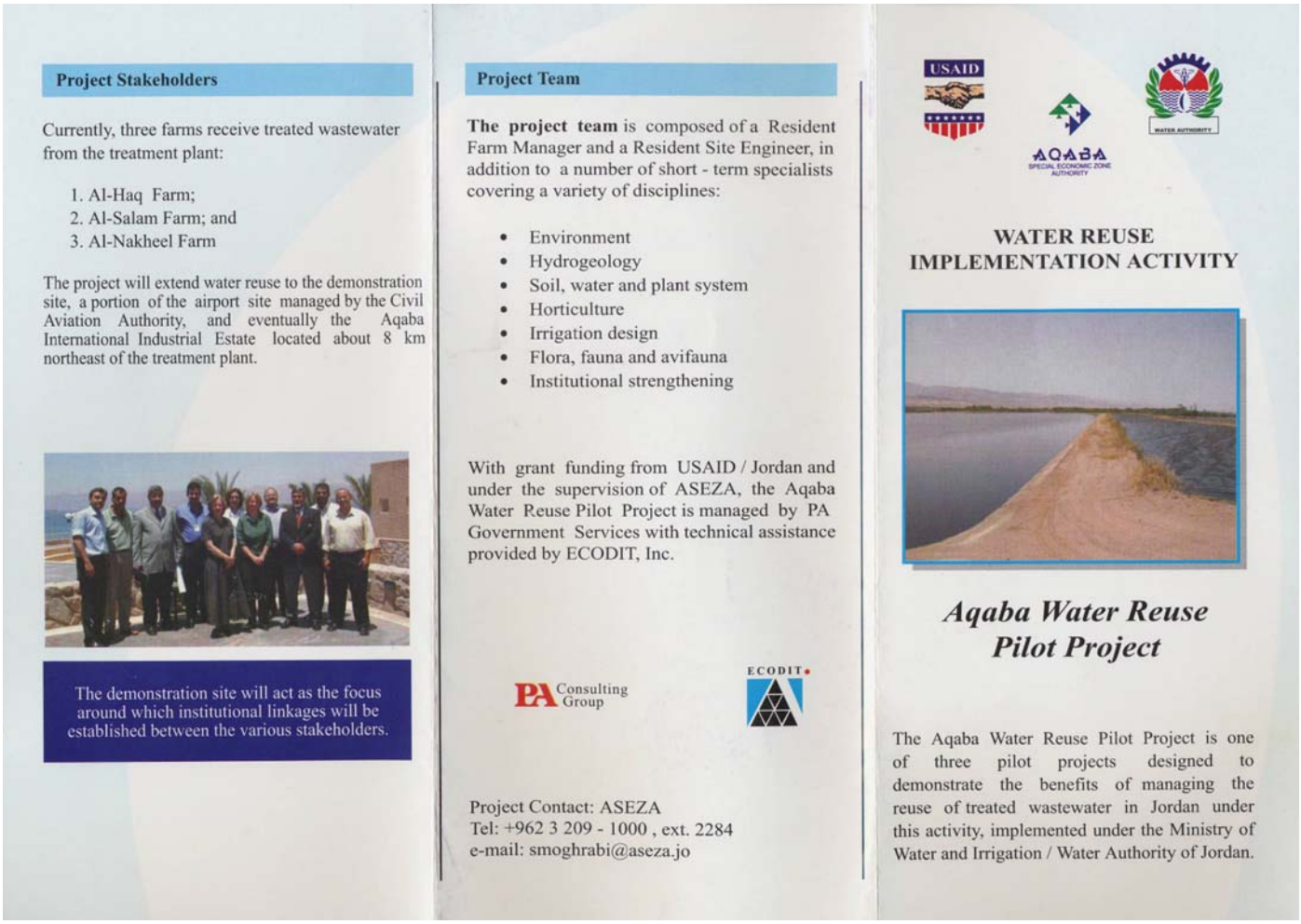
3. How is wastewater flow affected by this balance?

Acknowledgements

I would like to thank all the scientists from the various institutes for contributing their valuable time, advice, help, and support. I would like to thank Esther Miklofsky from ILAC for her help in preparing all the required documents for my trip. Special thanks to Mr. Mohammad Shahbaz, Director of the Badia Research and Development Programme, for his great support, encouragement, and believing in my research and ideas and for his help in facilitating my stay in Jordan. Finally, my sincere thanks to Mr. Bob Freitas, Project Director & Associate in Extension (ABE) Sustainable Development of Drylands Project IALC-Office of Arid Lands Studies, for his incredible support, and for understanding the vision I have for the sustainability study. Funding for the trip was provided by USAID via the IALC.

APPENDIX I

NCARTT operates according to special By-law as a semiautonomous institution with administrations and financial independence. It consists of a main headquarter located at Al-Hussein, the Agricultural Experiment Station at Baqa'a and six Regional Centers in Deir Alla, Ramtha, Khaldieh, Mushaqar, Rabba, and Shoubak. It operates 12 research stations representing different agro-ecological conditions in Jordan. It is mandated to conduct and/or coordinate applied agricultural research and transfer of technological activities at the national level in collaboration with public and private agricultural stations. It's mandate also provides for identification, testing, transfer and adoption of improved technologies. NCARTT implements research and transfer of technology activities through different programs. These programs are: Rained and Irrigated Agriculture, Integrated Livestock, Water Management and Environment, and Genetic Resources and Low Rainfall Areas.



Project Stakeholders

Currently, three farms receive treated wastewater from the treatment plant:

1. Al-Haq Farm;
2. Al-Salam Farm; and
3. Al-Nakheel Farm

The project will extend water reuse to the demonstration site, a portion of the airport site managed by the Civil Aviation Authority, and eventually the Aqaba International Industrial Estate located about 8 km northeast of the treatment plant.

Project Team

The project team is composed of a Resident Farm Manager and a Resident Site Engineer, in addition to a number of short - term specialists covering a variety of disciplines:

- Environment
- Hydrogeology
- Soil, water and plant system
- Horticulture
- Irrigation design
- Flora, fauna and avifauna
- Institutional strengthening

With grant funding from USAID / Jordan and under the supervision of ASEZA, the Aqaba Water Reuse Pilot Project is managed by PA Government Services with technical assistance provided by ECODIT, Inc.

PA Consulting Group

ECODIT

Project Contact: ASEZA
Tel: +962 3 209 - 1000 , ext. 2284
e-mail: smoghrabi@aseza.jo

USAID

AQABA SPECIAL ECONOMIC ZONE AUTHORITY

WATER AUTHORITY

WATER REUSE IMPLEMENTATION ACTIVITY

Aqaba Water Reuse Pilot Project

The Aqaba Water Reuse Pilot Project is one of three pilot projects designed to demonstrate the benefits of managing the reuse of treated wastewater in Jordan under this activity, implemented under the Ministry of Water and Irrigation / Water Authority of Jordan.

APPENDIX I (continued)

Project Background

Sustainable use of water resources ranks high among the priorities of the Kingdom of Jordan, where renewable water resources are scarce and unevenly distributed.

In the Aqaba region, reusing treated wastewater would reduce demand on scarce freshwater supplies. Water reuse would promote sound agricultural practices, supply large quantities of water to industry, and improve urban landscaping, all in a sustainable manner.

The Aqaba Special Economic Zone Authority (ASEZA) is the autonomous government entity responsible for the regulation and development of the Aqaba Special Economic Zone (ASEZ). ASEZA exercises full environmental responsibilities over ASEZ and aims to establish a delicate balance between economic development and the protection of the environmental and natural resource base.

The Water Authority of Jordan (WAJ) manages the Aqaba wastewater treatment plant. The plant serves about 40,000 people receives approximately 10,000 m^3 of raw sewage per day. About 60 percent of this effluent is either lost to seepage in the stabilization ponds or evaporated in shallow ponds following treatment because environmental regulations prohibit its discharge into the Gulf of Aqaba. The remaining 40 percent is delivered to adjacent farms for irrigation of mostly date palms.

Water meters are essential for managing water resource

Project Approach

The goal of the pilot project is to increase the percentage of treated wastewater utilized in agriculture and urban landscaping, with due consideration for environmental impacts and other competing water uses (e.g., industry).

Section of airport fence (left) and storage pond for treated wastewater (right)

To achieve this objective, the project is establishing a demonstration site on 100 dunums of land owned by ASEZA and run by the project staff. It is also providing technical and institutional support to other stakeholders interested in reusing the treated water. The project is helping integrate science and technology with field practices, taking into account local conditions such as:

- Climate
- Environment
- Market for crops
- Other opportunities for water reuse

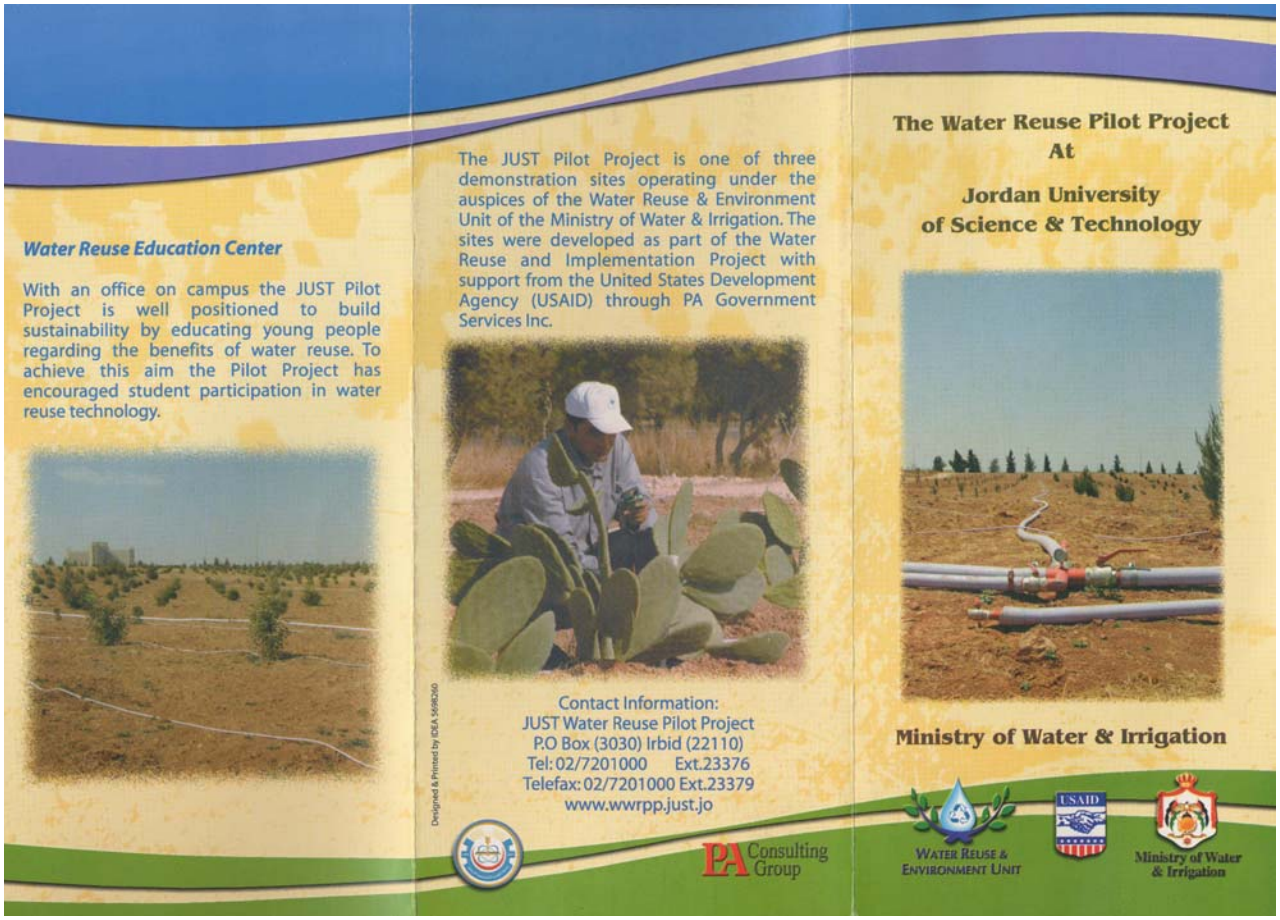
Aqaba receives about 50 mm of rainfall per year. Occasional flash floods can cause soil erosion and damage to unprotected infrastructure

Project Activities

Started in May 2003, the Aqaba Water Reuse Pilot Project is undertaking the following activities:

1. Demonstration site
   - Establish a 100 - dunum demonstration site including land preparation, fencing, and the installation of a water conveyance and irrigation system.
   - Develop and implement an Irrigation and Crop Management Plan, including crop selection, planting and irrigation.
2. Technical Assistance to Project Stakeholders
   - Design system to deliver treated wastewater from the wastewater treatment plant to the Civil Aviation Airport site and the Aqaba International Industrial Estate.
   - Plant and irrigate selected crops along the Civil Aviation Airport fence.
   - Identify and describe alternative water reuse allocation options.
   - Provide technical assistance and on - the - job training in crop selection, water irrigation scheduling and irrigation network design.
3. Environmental Monitoring
   - Assess baseline groundwater and soil quality in the sites targeted for irrigation with treated wastewater.
   - Monitor the potential impacts of treated effluent reuse on fauna and flora as well as soil and groundwater quality.

APPENDIX II



Water Reuse Education Center

With an office on campus the JUST Pilot Project is well positioned to build sustainability by educating young people regarding the benefits of water reuse. To achieve this aim the Pilot Project has encouraged student participation in water reuse technology.

The JUST Pilot Project is one of three demonstration sites operating under the auspices of the Water Reuse & Environment Unit of the Ministry of Water & Irrigation. The sites were developed as part of the Water Reuse and Implementation Project with support from the United States Development Agency (USAID) through PA Government Services Inc.

Contact Information:
JUST Water Reuse Pilot Project
P.O Box (3030) Irbid (22110)
Tel: 02/7201000 Ext.23376
Telefax: 02/7201000 Ext.23379
www.wwrpp.just.jo

PA Consulting Group

The Water Reuse Pilot Project At

Jordan University of Science & Technology

Ministry of Water & Irrigation

WATER REUSE & ENVIRONMENT UNIT

USAID

Ministry of Water & Irrigation

APPENDIX II (continued)

Our Water Is Our Life, Let's Reuse It

The JUST Water Reuse Pilot Project, a demonstration farm located at Jordan University of Science and Technology's Irbid campus north of Amman, was officially inaugurated on September 3, 2003.

The JUST pilot is designed to enable experts working with students to plan, manage and monitor reuse of treated wastewater in agriculture as a model for future initiatives throughout the Kingdom.

The JUST Pilot Project consists of five sites. To date approximately 200 dunums of land have been cultivated. An additional 500 dunums is scheduled to be cultivated using reclaimed water by the end of 2003.

The demonstration sites are experimenting successfully with a highly diverse array of crops including animal fodder, field crops, cactus, landscaping trees (pines), and cash crop trees such as pistachios, almond, olives, carobs, and citrus.

Scientific Research

As this demonstration site is situated on university lands, the largest campus in the world, the project is uniquely positioned for scientific experimentation. While the sites are typically equipped with drip irrigation systems, the JUST Pilot is conducting a trial with a floppy sprinkler system for field crops that may prove to be safe for irrigation with treated wastewater.

Generating Funds for Needy Students

The JUST Water Reuse Pilot Project has taken a novel approach in its use of the income generated from the harvest of crops grown with treated wastewater. Proceeds from the first cropping season were donated to the JUST University Needy Students Fund. Since its establishment in 1987, the Fund has provided support for hundreds of students who would otherwise have been unable to study due to financial need. The Fund is currently covering around 21 per cent of the students in need of financial assistance studying at JUST.

APPENDIX III

APPENDIX IV

The Hashmite University is located in the city of Al-Zarqa, Jordan. It was established on June 19, 1991 as the fifth official public university.

APPENDIX IV (continued)

programs between the specialties of the (ILWE) and other scientific faculties.

4- Developing learners abilities in collecting, summarizing, analyzing, interpreting geological, agricultural, environmental, and water data with the utilization of modern technologies.

The Institutes Departments: The (ILWE) includes three departments:

1-Department of Earth and Environmental Sciences.
2- Department of Land Management.
3-Department of Water Management and Environment.

Academic Programs: The (ILWE) offers three academic programs all of which are at the undergraduate level:

1- Bachelor in Land Management and Water.
2- Bachelor in Earth and Environmental Science.
3-Bachelor in Water management and Environment.

In 2002 a new Master Program was established in the area of Applied Geology/ Department of Environmental and Earth Science.

Admission Requirements Applicants must have the Jordanian General Secondary Certificate or any equivalent certificate.

Degree Program Requirements (132) credit hours for each of the three aforementioned programs.

* The Institute Correlation With The Community The (ILWE) keeps a very close relation with the community through conducting scientific researches, which are of great aid in solving many problems in terms of Water, Environment and

Pollution, specifically speaking within the Governorate of Zarqa, which suffers from problems of air, soil as well as surface and ground water pollution.

Furthermore, the (ILWE) works constantly on solving environmental problems resulting from the waste disposal centers (Landfills) in AL-Rusaifeh, as well as carrying out studies and geophysical consultation in such areas as constructing dams, landfills and exploring for underground water.

Projects and Future Aspirations

- Conducting applied research in the area of water utilization, earth, and geological resources along with working out environmental solutions for problems related to the various agricultural, industrial and urban activities.
- Holding seminars and training workshops which aims at developing the qualifications of workers both in the private and public sectors in all the aforementioned fields.
- Conducting consultative studies for production and service sectors by means of co-operating with the center for studies, consultation and community services at the Hashemite University.
- Establishing data bases on Land, water and Environmental Management in Al-Zarqa area.
- Provide graduates that are highly qualified and skilled

هاتف (٠٥)٣٨٢٦٦٠٠ فاكس (٠٥)٣٨٢٦٦١٣
ص.ب ٣٣٠١٢٧ مكتب بريد الجامعة الهاشمية
الزرقاء -الأردن
مع تحيات دائرة العلاقات الثقافية والعامة
Tel: 05(3826600) Fax 05(3826613)
P.O.Box: 330127 The Hashemite University Post Office
Zarka - Jordan
e- mail : huniv@hu.edu.jo
with compliments of Dep. of cultural & Public Relations

APPENDIX V

The Hashemite Kingdom of Jordan
Meteorological Department

المملكة الاردنية الهاشمية
دائرة الارصاد الجوية

Phone +962 6 4892 408
Fax +962 6 4894 409

Station Description

No												
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APPENDIX V (continued)

The Hashemite Kingdom of Jordan
Meteorological Department

المملكة الاردنية الهاشمية
دائرة الارصاد الجوية

Phone +962 6 4892 408
Fax +962 6 4894 409

Station Description

	Station-Id	Name	District	WMO-No	Latitude N		Longitude E		Elevation m	Open Date	Close Date	المحطة
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0	PURP0033	Daba'a	KARAK		31	36	036	3	750	01/02/1967	31/12/9999	ضبعة
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0	PURP0037	Mazar South	KARAK		32	06	036	11	1250	01/12/2000	31/12/9999	المزار الجنوبي
0	CLIM0045	Dhana	TAFILEH		30	40	035	37	1250	01/10/1997	31/12/9999	ضانا
0	CLIM0046	Khanasry	TAFILEH		32	24	036	03	863	01/10/1997	31/12/9999	القناصري
0	RAIN0039	Al Rashadiah	TAFILEH		30	42	035	38	1500	01/01/1991	31/12/9999	الرشادية
0	CLIM0048	Al-Hashimiah	ZARQA		32	06	036	11	575	01/01/1999	31/12/9999	الهاشمية
0	PURP0021	Al Kasemiya	MA'AN		30	06	035	28	1510	01/05/1967	01/02/1995	القاسمية
0	CLIM0051	Al Fjaij	MA'AN		30	33	035	38	1263	01/03/1999	31/12/9999	الفجيج
0	RAIN0041	Al Khalediah	MAFRAQ		32	10	036	21	630	01/01/1991	31/12/9999	الخالدية
0	PURP0010	Taybeh	IRBID		32	32	035	43	373	01/01/1973	01/03/1995	الطيبة
1	AGRO0001	Baqura	IRBID	40253	32	40	035	37	-170	01/01/1965	31/12/9999	الباقورة
2	CLIM0003	Wadi El-rayyan	IRBID	40256	32	24	035	35	-200	01/01/1961	31/12/9999	وادي الريان
3	AGRO0004	Deir Alla	BALQA	40285	32	13	035	37	-224	01/01/1952	31/12/9999	دير علا
4	AGRO0002	University Farm	BALQA		32	10	035	37	-230	01/01/1986	31/12/9999	مزرعة الجامعة
5	AGRO0005	Ghor Safi	KARAK	40296	31	2	035	28	-350	01/01/1975	31/12/9999	غور الصافي
6	SYNP0006	King Hussien International Aerdrome	AQABA	40340	29	33	035	0	51	01/01/1959	31/12/9999	مطار الملك حسين الدولي
7	AGRO0008	Irbed	IRBID	40255	32	33	035	51	616	01/01/1955	31/12/9999	إربد
8	PURP0009	Ramtha	IRBID	40252	32	30	035	59	590	01/01/1976	31/12/9999	الرمثا
9	SYNP0011	Ras Muneef	AJLON	40257	32	22	035	45	1150	01/01/1977	31/12/9999	رأس منيف