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Assessment of Wastewater Reuse Potential in Palestinian Rural Areas

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This thesis was prepared under the supervision of Dr. Maher Abu Madi and has been approved by all members of the Examination Committee**.**

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ABSTRACT

To develop a framework for a national Palestinian strategy for management of rural wastewater it is expected that at least quantity and quality of wastewater is known. For the West Bank there are no annual statistics on the total volume of rural wastewater generated, transported, treated and reused. This study assesses the potential of wastewater reuse as a non-conventional resource in the Palestinian rural areas. The potential of reuse refers to the amount of rural wastewater that is or could be collected and treated and that would possibly add to the national water balance and also the effluent quality needed for each reuse option.

The methodology included developing a framework for assessing wastewater quantities generated from rural areas using three water sources for consumption within households: water network, water vendors and cisterns. Questionnaire form was distributed to the NGOs via e-mail to gather information about implemented wastewater treatment units. Amounts of wastewater generated, treated and reused were calculated for year 2007. Flow generations were projected to different periods till year 2030. Projects quality results for onsite treatment units and collective systems were gathered from several NGO`s and were compared with the Palestinian Standards of treated wastewater 742-2003. Wastewater reuse options were studied using the scenarios of collection suitable for rural areas and water savings under selected reuse options were estimated and discussed. Then, a framework for a national Palestinian strategy for management of rural wastewater was proposed.

It is found that 80% of consumed water quantities in Palestinian rural areas are supplied by water networks, 10% from cisterns, and 10% from water vendors. The 383 implemented onsite treatment units treat 7% of the collected wastewater. The 10 implemented collective systems treat 0.3 % of the wastewater amount. The total wastewater generation rate for 2007 in Palestinian rural areas is 8,975,513.3 cubic meter and is estimated to increase to 13,928,964.5 cubic meter by year 2030. The results for projects` quality analysis compared to Palestinian standards show that: For onsite treatment units fruiting trees could be irrigated with the effluent from treatment plants generating effluent with COD, BOD and TSS values less than 150, 60 and 90 mg/l respectively but with 3 barriers. Unfortunately, the treated effluent from the collective systems is not suitable for even unrestricted irrigation.

The study concludes that given the blooming water resource crisis, wastewater must be recognized as part of the total water cycle. If all of the wastewater generated were to be reused, it would be possible to save 14% of the supply and demand gap. Onsite systems at household level with the effluent used for irrigating fruits and flowers are the proposed systems to be applied in most of the rural Palestinian areas and must be maintained and monitored to control pollution and to recover water for non-potable water uses.

الخلاصة

من أجل تطوير إطار لاستراتيجية وطنية فلسطينية لإدارة مياه الصرف الصحي في المناطق الريفية لا بد عل الأقل من معرفة كمية و نوعية مياه الصرف الصحي ، ولكن للأسف لا توجد إحصاءات سنوية تختص بالمناطق الريفية عن إجمالي حجم مياه الصرف الصحي التي يتم تجميعها ، معالجتها وإعادة استخدامها. تقيم هذه الدراسة امكانية إعادة استخدام المياه العادمة كمورد غير تقليدي في المناطق الريفية الفلسطينية. و تتعلق إمكانية إعادة الاستخدام في هذه الدراسة بكمية مياه الصرف الصحي في المناطق الريفية التي يمكن جمعها ومعالجتها واعادة استخدامها والذي من شأنه أن يضيف إلى الرصيد الوطني للمياه وكذلك بنوعية المياه العادمة اللازمة لخيارات إعادة الاستخدام.

تضمنت المنهجية وضع إطار لتقييم كميات المياه العادمة الناتجة من المناطق الريفية باستخدام ثلاثة مصادر للاستهلاك داخل الأسر وهي شبكة المياه ، وبائعي المياه والصهاريج. و قد تم توزيع نموذج استبيان على المنظمات غير الحكومية عبر البريد الإلكتروني لجمع المعلومات المتعلقة بوحدات المعالجة المنفذة. ثم تم حساب كميات المياه العادمة الناتجة والمعالجة والمعاد استخدامها و تقدير كميات المياه العادمة المتوقعة من العام 2007 حتى العام 2030 اعتمادا على معدل النمو السكاني المتوقع. تم تجميع تحاليل الجودة للمشاريع المنفذة و مقارنة النتائج بالمواصفات والمقاييس الفلسطينية للمياه العادمة المعالجة 742-2003. ثم درست خيارات إعادة الاستخدام باستخدام سيناريوهات الجمع المناسبة للمناطق الريفية واحتسبت كمية التوفير في المياه تحت عدة خيارات. ثم تم اقتراح إطارا لاستراتيجية وطنية فلسطينية لإدارة مياه الصرف الصحي.

بينت نتائج الدراسة أن 80 ٪ من كميات المياه المستهلكة في المناطق الريفية الفلسطينية يتم تزويدها من خلال شبكات المياه ، 10 ٪ من الخزانات ، و 10 ٪ من بائعي المياه. تعالج وحدات المعالجة المنفذة في الموقع على مستوى المنزل و التي يبلغ عددها 383 وحدة 7 ٪ من مياه الصرف الصحي التي يتم جمعها واما وحدات المعالجة الجماعية و التي يبلغ عددها 10 وحدات فتعالج 0.3 ٪ من المياه التي يتم جمعها. يبلغ إجمالي معدل انتاج مياه الصرف الصحي لعام 2007 في المناطق الريفية 8،975،513.3 متر مكعب ، وقدر أن متوسط معدل انتاج مياه الصرف الصحي سيرتفع إلى 13,928,964.5 متر مكعب بحلول العام 2030. أشارت نتائج المشاريع المنفذة بعد مقارنتها بالمواصفات والمقاييس الفلسطينية أنه يمكن استخدام وحدات المعالجة المنزلية و التي كانت قيم الأكسجين الممتص حيويا و كيميائيا و المواد الصلبة العالقة الكلية أقل من 150 و 60 و 90 ملغم / لتر على التوالي ولكن مع 3 حواجز. اما النظم الجماعية فكانت نتائجها ليست مناسبةحتى للري غير المقيد.

هذه الدراسة تخلص إلى أنه في ظل أزمة المياه الحالية يجب النظر الى اعادة الاستخدام كجزء من بنود ادارة المياه المتكاملة وأنه إذا تم اعادة استخدام جميع المياه العادمة المنتجة في الريف الفلسطيني سيكون بالامكان توفير 14 ٪ من الفجوة بين العرض والطلب على المياه. وتوصي الدراسة باتباع المنهج اللامركزي و تطبيق وحدات المعالجة المنزلية في معظم المناطق الفلسطينية الريفية لجمع و معالجة و اعادة استخدام المياه العادمة في ري حديقة المنزل بحيث تكون المحاصيل المروية هي أشجار الفاكهة والزهور.

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LIST OF ABBREVIATIONS

ARIJ	Applied Research Institute of Jerusalem
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EPA	Environmental Protection Agency
FAO	Food and Agriculture organization
GIS	Geographical Information System
GWWTP	Grey Waste Water Treatment Plant
HH	Households
L/c/d	Liters Per Capita Per Day
MENA	Middle East and North Africa
MDGs	Millennium Development Goals
NIS	New Israeli Shekel
NGO	Non-Governmental Organization
OPT	Occupied Palestinian Territories
OWTS	Onsite Wastewater Treatment System
PARC	Palestinian Agricultural Relief Committees
PHG	Palestinian Hydrology Group
PWA	Palestinian Water Authority
SDGS	Small Diameter Gravity Systems
TSS	Total Suspended Solids
UAWC	Union of Agricultural Work Committees
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
US EPA	United States Environmental Protection Agency
WWTP	Waste Water Treatment Plant
WFD	Water Framework Directive
WB	West Bank
WBGS	West Bank and Gaza Strip
WHO	World Health Organization

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Chapter One: Introduction

1.1 Background

The Middle East and North Africa (MENA) region is the most water scarce region of the world and in recent years the amount of water available per person has declined dramatically. The per capita water availability in the MENA is projected to fall by half of what it currently is by 2050 (World Bank, 2008). The countries of this region are using their renewable resources more than any other countries in the world. The lack of water supply services in rural and peri-urban areas caused contamination of surface and ground waters, damaging the environment and public health, hence expanding wastewater collection, treatment and reuse is necessary (World Bank, 2009[a]). The dramatic increase in population, urbanization and water consumption makes water resources insufficient to meet water demands (Sabbah et al., 2004).

The only solutions to water shortage are to maximize the efficiency of water management, reuse, desalinate or import water (Durham et al, 2003). Desalination of sea water, importing water or inter-basin transfers by pipeline are technically feasible, but none is affordable or easy since they are capital and energy intensive, many have severe ecological impacts, and all are politically complex (Brooks, 1999 as cited by Abu Madi, 2004).

Water reclamation and reuse are becoming increasingly important as the demand on water grows. They compose one of the parts of integrated water resources management to enhance water supply reliability. In developed countries, the increasing needs for water recycling is practiced to alleviate drought conditions and preserve freshwater resources, to protect the environment, and to economically meet restrictions on the disposal of treated wastewater effluent through reuse leading for planned wastewater reuse projects. In the developing countries, the situation differs, the need for water supplies and the use of untreated or partially treated wastewater due to the lack of sanitation are inducing unplanned wastewater reuse (Jimenez and Asano, 2008; Mekala et al., 2008).

“Some 70 percent of the world’s poor live in rural areas, so a focus on rural water supply, sanitation, and hygiene is needed if the Millennium Development Goals (MDGs) are to be met”

(World Bank, 2009[b]). One of the Millennium Development Goals (MDGs) is to reduce by 50% the number of people without access to safe sanitation by 2015. One strategy may be to encourage more on-site sanitation rather than expensive transport of sewerage to centralized treatment plants: this strategy has been successful in Dakar, Senegal, at the cost of about 400 US$ per household (World Bank, 2005).

The sector of rural sanitation in Palestinian areas could be considered as a neglected sector which lacks adequate sewage systems to dispose wastewater. About 65% of the West Bank population is not served with sewerage networks, and uses mainly cesspits and occasionally septic tanks. The other 35% is served with sewerage networks, but less than 6% of the total population is served with treatment plants (EMWATER, 2004). More than 35% of the total population of the West Bank lives in rural areas distributed in more than 450 towns and villages. Most of the cesspits enable sewage to infiltrate into the earth layers polluting the groundwater, and causing severe environmental problems and health hazards. The wastewater collection component of wastewater management accounts for 80-90% of the capital cost which makes it economically unfeasible for the dispersed pattern of houses in rural areas (Sbeih, 2008). On the Other hand, Political obstacles also stand in the way of centralized reuse progress. The construction of these systems are prevented by the Israeli Authorities and conditioned by connecting the Israeli Colonies to the same system (Rabi, 2009). The small wastewater technology could be the most appropriate solution to replace current cesspit systems in rural areas of West Bank (Sbeih, 2008).

1.2 Problem Statement

Alike many developing countries, Palestine lacks a national wastewater management strategy that can effectively protect public health and environmental quality. This has led the local communities and NGOs to plan and implement their own arrangements for wastewater treatment systems. To develop a framework for a national Palestinian strategy for management of rural wastewater it is expected that at least quantity and quality of wastewater is known. For the West Bank there are no annual statistics on the total volume of rural wastewater generated, transported, treated and reused. Unfortunately there is lack in reliable bench marks on flow generations.

Water scarcity is an issue for rural areas. Today, some 180,000 – 200,000 Palestinians living in rural communities have no access to running water and even in towns and villages which are connected to the water network, the taps often run dry. Consequently, many Palestinians are obliged to purchase additional supplies from water vendors which deliver water at a much higher price and of often dubious quality. As unemployment and poverty have increased in recent years and disposable income has fallen, Palestinian families in the OPT must spend an increasingly high percentage of their income – as much as a quarter or more in some cases – on water (Amnesty, 2009). Environmentally sound application of wastewater reuse protects the environment and allows sustainable use of resources (UNEP, 2004).

In this study the potential of reuse in Palestinian rural areas refers to the amount of rural wastewater that is or could be collected and treated and that would possibly add to the national water balance and also the effluent quality needed for each reuse option.

The boundaries of the study scope are the following:

The study area. The study area which is consisting of the 395 Palestinian communities classified as rural by the Palestinian Central Bureau of Statistics (PCBS). Other urban and peri-urban communities are out of the scope of this study, the focus here is on the rural areas of Palestine.

Rural domestic wastewater treatment and reuse. This study focuses on domestic wastewater. The industrial wastewater is excluded considering the limited industrial activities in the West Bank, light industries are prevailing. The industrial zones -according to the national vision in reference to different studies carried out by MOPIC and MOIn is the establishment of 9-13 Palestinian industrial estates of which eight are distributed between the different Governorates of the WB which will be located far away from rural areas.

1.3 Aim and Objectives

This study aims at identifying, characterizing and analyzing the potential of wastewater reuse as a non-conventional resource in the Palestinian rural areas. The specific objectives are:

1. To assess the quantities of wastewater that is produced by the Palestinian rural communities that are available for disposal and reuse options.
2. To identify potential uses of reclaimed water and associated water quantity and quality

requirements.

3. To study water consumption categories.
4. To develop a framework for a national Palestinian strategy for management of rural wastewater.

1.4 Thesis Outline

This study consists of seven chapters as follows:

Chapter One: introduces and defines the problem, specifies the aims and objectives of the study and clarifies the scope of it.

Chapter Two: presents a literature review on wastewater reuse and its applications, benefits and incentives as well as risks and constrains, it also presents the international guidelines and regulations concerning wastewater reuse such as WHO guidelines and EPA guidelines and compares between the two of them, the national wastewater guidelines or Palestinian Standards is also enlightened and also the Jordanian standards. Centralized vs. decentralized approaches and some international and local case studies of projects were wastewater reuse are successfully implemented are presented as well.

Chapter Three: the methodology chapter represents a conceptual framework for assessing wastewater generation, disposal, treatment and reuse in Palestinian rural areas.

Chapter Four: presents background information and data about the study area, its physical, social and demographic features, wastewater status and water use patterns.

Chapter Five: analyzes, discusses and assess the factors promoting or discouraging reuse options in terms of wastewater quantity, quality, water tariff, supply and demand deficit, it also discusses each reuse option in terms of effluent quality needed.

Chapter Six: presents a framework for a national Palestinian strategy for management of rural wastewater.

Chapter Seven: conclusions and recommendations are presented in this chapter.

Chapter Two: Literature Review

2.1 Overview

Applications of wastewater reuse have long history in agriculture, and additional areas of applications, including industrial, household, and urban, are becoming more prevalent (UNEP, 2004). Literature review shows that the number of countries investigating and implementing water reuse program other than the United States of America has increased over the past decade not only in water scarce areas such as Mediterranean region, Middle East, Latin America but also in densely populated areas as in Japan, Australia, Canada and North China (EPA, 2004). Water reclamation has been practiced in California since 1890 for agriculture; by the end of 2001 the quantity of recycled water has reached 648 million m^3/y (Asano, 2006). In the developing countries most of the reuse is for agricultural purposes (Asano, 2006), the reuse program in Sharja, one of the most water- poor states in the United Arab Emirates, enabled it to expand its green areas and to conserve ground water supplies (Kretschmer et al., 2002). For the past two decades Jordan has relied on waste stabilization ponds (WSP) to treat wastewater for reuse in agriculture (Ammary, 2007). The use of reclaimed wastewater for irrigation of landscape, public parks, sport fields, and recreational sites has become a widespread practice in Kuwait, United Arab Emirates, and Tunisia (Abu Madi and Al Sa`ed, 2010).

On the European level, most countries exhibit a water stress index of less than 20%; however Italy, Germany, Spain, Belgium, Bulgaria Malta and Cyprus exceed this value. The water Policy framework incorporated the sustainable use of water resources into the water framework directive (WFD) 2000/60/EC which might favor wastewater reclamation and reuse as a viable option (Hochstart et al., 2006).

Water reuse can be planned through specifically designed projects to treat, store, convey and distribute treated wastewater for irrigation. Examples of planned reuse can be found in Tunisia. Indirect reuse can also be planned as in Jordan and Morocco where treated wastewater is discharged into open watercourses. Wherever available, farmers prefer to rely on freshwater, which is usually very cheap and socially acceptable. But if no other source of water is available especially in arid and semiarid regions such as the case in the Middle East, farmers throughout the region would be encouraged to use wastewater for irrigation (EMWATER, 2004).

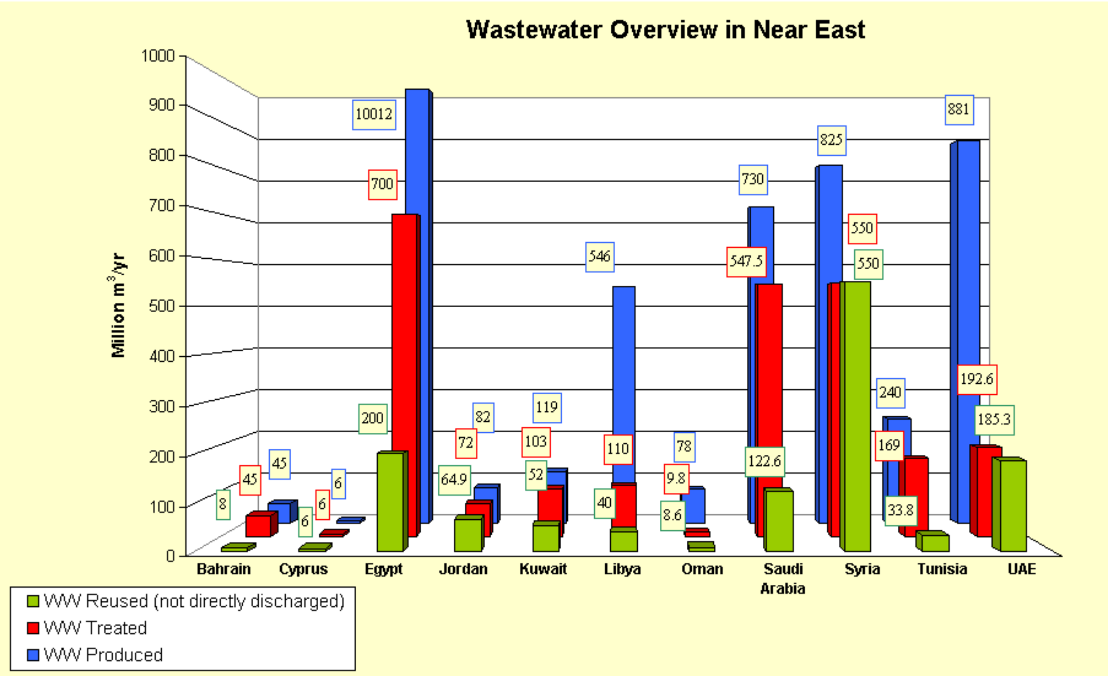

Fig 2.1 Wastewater Overview in Near East (FAO, 2006)

2.2 Benefits and Incentives of Reuse

Usually, establishing a wastewater reuse program is driven by a common reason which is identifying new water sources for increased water demand and finding economical ways to meet stringent discharge standards (McKenzie, 2004).

Several benefits of wastewater reuse can be identified, first: wastewater reuse is a guaranteed water supply even in droughts hence the demand on water resources can be reduced causing a reduction in infrastructure requirements and its positive effects economically and environmentally. Bounded to the effective allocation of this new resource for less costly applications -matching water quality- leads to a more sustainable use of resources, second: discharge of effluent in waterways is reduced which is environmentally sound, and third: treated wastewater could be viewed as a source for plant nutrients (UNEP, 2004; Fatta and Kythreotou, 2005; Kramer et al., 2007).

2.3 Risks and Constrains of Reuse

Kampa (2009) summarized the types of constrains to water reuse as follows:

1. Health and environmental risks
2. Financial constrains
3. Institutional constrains
4. Political constrains
5. Ignorance and public awareness
6. Standards and regulations

Lack of wastewater treatment in developing countries is due to financial reasons and also for the ignorance in low cost treatment methods and in the benefits of reuse (Mara, 2003).

2.4 Guidelines and Regulations for Wastewater Reuse

Standards of effluent quality differ from one country to another, some countries have taken the approach of minimizing any risk and have elaborated regulations close to the California's Title 22 effluent reuse criteria, whereas the approach of other countries is essentially a reasonable anticipation of adverse effects resulting in the adoption of a set of water quality criteria based on the world health organization WHO (1989) guidelines (Mogheir et al., 2007).

2.4.1 WHO Guidelines

The WHO in (1989) developed guidelines to assist policy makers to legislate permission for the safe use of wastewater since the previous health standards were not high and did not reflect conditions in developing countries. The recommended quality standards are combined with best practice guidelines for reuse management (Kramer et al., 2007). WHO has always revised their guidelines; the joint FAO, UNEP and WHO publication of Health Guidelines for the Safe Use of Wastewater, Excreta and Greywater has been updated in 2006, focusing on disease prevention and public health principles (WHO, 2006).

2.4.2 EPA Guidelines

The U.S. Environmental Protection Agency (USEPA) in 1992 developed guidelines for water reuse a comprehensive technical document, including a summary of state reuse requirements, guidelines for treating and reusing water, key issues in evaluating wastewater reuse opportunities, and case studies illustrating legal issues, such as water rights, that affect wastewater reuse. The 2004 guidelines updates the 1992 Guidelines document by incorporating information on water reuse that has been developed since the 1992 document was issued. It also expands coverage of water reuse issues and practices in other countries. It includes many new and updated case studies, expanded coverage of indirect potable reuse and industrial reuse issues, new information on treatment and disinfection technologies, emerging chemicals and pathogens of concern, economics, user rates and funding alternatives, public involvement and acceptance (both successes and failures), research activities and results (EPA, 2004).

2.4.3 Comparison between EPA and WHO Guidelines

The 2004 guidelines recommended much stricter standards than those of WHO (1989), the fecal coliforms /100 ml for crops eaten raw are no detectable while WHO guidelines (1989) ≤ 1000 FC/100 ml. Secondary treatment should be used followed by filtration (with prior coagulant and/or polymer addition) and disinfection. For irrigation of commercially processed crops, fodder crops etc., the EPA standard is ≤ 200 FC/100 ml, while no standards were recommended by WHO (1989). However, the EPA set no standards for intestinal nematode egg but WHO recommended ≤1 intestinal nematodes/liter (Kramer et al., 2007).

2.4.4 Palestinian Standards

Wastewater reuse complies with the aims and national visions of the Palestinian Policy especially the PWA which assures the vision of equitable and sustainable management and development of Palestine water resources (PWA, 2010[a]).

The Palestinian Standards Institution (PSI) and the PWA recommended Guidelines for the Environmental Limit Values (Standards and Guidelines) for effluent from domestic wastewater treatment plants as well as the industrial standards for wastewater to be discharged on the sewage systems however; these Limit Values have not been enforced so far. All treatment and/or reuse systems will be regulated through permits from PWA. The minimum acceptable treatment level set by the PWA is secondary treatment (e.g., removal of settleable and suspended solids and biodegradable organics plus disinfection) and is expanded to include tertiary treatment for regional utilities. Low cost technology is encouraged wherever it is possible. PWA emphasizes that treated wastewater is a valuable resource that must be utilized and agriculture is given priority for reuse. In order to encourage and promote the use of treated wastewater incentives need to be adopted (EMWATER, 2004).

In comparison with the WHO and international guidelines for treated wastewater reuse, the Palestinian draft of guidelines, which apply mainly to agricultural applications for unrestricted irrigation, considerably differs from the International and neighboring countries' standards, for example; BOD value for landscape lawns and parks irrigation in the Palestinian draft is 20 mg/l, while in Tunisia 30 mg/l and in Saudi Arabia 10 mg/l (MEDAWARE, 2004).

2.4.5 Jordanian Standards

The existing standards and laws that directly apply to wastewater reuse are the Water Authority of Jordan Law #18/1988, the Jordan Standard #202/1991 for Industrial Wastewater Discharges, Jordanian Standard 893/1995 for Discharge of Treated Domestic Wastewater, and Jordanian Standard # 1145/1996 regarding the use of sludge.

The standards adopted prior to 1995 in Jordan relied on WHO standards for wastewater treatment plant design and effluent control. In 1995 a comprehensive reuse standard for treated domestic wastewater was developed by the Water Authority of Jordan (Jordanian Standard 893/1995 for Discharge of Treated Domestic Wastewater) which was based upon categories of end use (type of crop and area to be irrigated) (Nazzal et al., 2000) and was reviewed in 2002.

2.5 Centralized V S. Decentralized Approach

Centralized approach of wastewater treatment and reuse systems in rural areas is not a convenient one, since these systems are costly to build and operate, especially in areas with low population densities and dispersed households (Massoud et al., 2008). Centralized systems require a network of collection pipes (sewers) leading from all homes to a central wastewater treatment facility. Therefore, centralized systems for wastewater collection and disposal require disproportionately large investments which are unaffordable to the majority of the rural and peri-urban poor (UN, 2001; Parkinson and Tayler, 2003 as cited by Abu Madi et al., 2010).

A decentralized system employs a combination of onsite and/or cluster systems and is used to treat and dispose of wastewater from dwellings and businesses close to the source. Decentralized wastewater systems allow for flexibility in wastewater management, and different parts of the

system may be combined into “treatment trains,” or a series of processes to meet treatment goals, overcome site conditions, and to address environmental protection requirements.
Managed decentralized wastewater systems are viable, long-term alternatives to centralized wastewater treatment facilities, particularly in small and rural communities where they are often most cost-effective. These systems already serve a quarter of the population in the U.S. and half the population in some states. They should be considered in any evaluation of wastewater management options for small and mid-sized communities (Pipeline, 2000).

Small and decentralized wastewater treatment presents unique opportunities for reuse. The important characteristic that distinguishes this type of wastewater management from larger systems is that there is a much greater potential for the treated wastewater to be generated closer to the potential reuse sites. With currently available technology, the capability exists to produce wastewater at the quality that is appropriate for the specific type of reuse, ranging from irrigation of low-value crops to toilet flushing. The most common type of reuse in the United States is landscape irrigation. Even if irrigation is not incorporated, it is worth recognizing that the common practice of disposing wastewater to the soil results in groundwater recharge; in some regions, such volumes may be an important part of the hydrological cycle. In-home reuse is also possible, and high quality effluent can be produced from either a part of or the entire wastewater stream.

Decentralized wastewater management, if viewed as an alternative to larger, centralized systems, presents perhaps the greatest opportunity for wastewater reclamation and reuse. If the production of reclaimed wastewater can be coordinated with the demand, facilities can be constructed close to the site of demand. This arrangement has the potential to achieve large savings in transport of both the untreated and treated wastewater. Furthermore, by treating the wastewater in smaller quantities, the necessary level of treatment can be coordinated with the reuse application. This type of arrangement is attractive to many users that face difficulty finding a new or secure water source.

In small communities, often located in agricultural regions, there is a large potential for reusing wastewater for agricultural irrigation. Ironically, much of the wastewater currently generated by small communities is currently disposed of on land (spray irrigation, infiltration basins, or overland flow), but no crop is harvested. As water becomes scarcer in many regions of the country, it is likely that land disposal will be converted to planned reuse (Nelson, 2005).

2.6 Case Studies

2.6.1 United States of America

26 million homes (23 percent of total households), businesses, and recreational facilities in the United States rely on onsite wastewater systems which serve approximately 60 million people Nelson, 2005).

2.6.1.1 Stinson Beach Water District

Instead of a centralized collection system, a summer community north of San Francisco utilizes an onsite management system for treatment and disposal of wastewater since 1978, and has managed 650 management systems that recharge the shallow aquifer enhancing the growth of trees and shrubs, instead of a centralized collection system that would have dewatered the slopes of the hills above the community. The effluent is also used to irrigate plants and as ground cover in individual yards (Asano, 1989).

2.6.1.2 Arcata Marsh and Wildlife Sanctuary

A constructed wetland treatment system is used in Arcata city in California which allows the reuse of 8,700 m^3/d in a 12.5 ha enhancement marsh. The marsh is a home or a rest stop for over 200 species of birds used as a recreational area, scientific studies or bird watching area for over 150,000 people per year (Asano, 1989).

2.6.2 Japan

Onsite systems in Japan range from outmoded designs that discharge grey water directly into the environment to advanced treatment units in high-density areas that produce reclaimed water onsite. Japan is a world leader in membrane technologies that have led to the development of onsite wastewater treatment units capable of water-reclamation quality effluent. Alternative ideas being pursued for onsite technologies also include separate waste stream collection, which would provide for more efficient treatment and reuse. Night soil treatment plants, where sludge from onsite systems is treated, are also distinctive to Japan, serving 37 million people. Japan has governmental regulations in place to ensure routine inspections of onsite units; furthermore, subsidies are available to reduce the cost of onsite systems for building owners. Lessons learned in onsite wastewater treatment in Japan have applications worldwide, from regions where water is scarce, to high-density areas in developing countries that currently lack sewer infrastructures (Gaulke, 2006).

2.6.3 Jordan, Jordan Valley

Rehabilitation and expanding Jordan's WWTPs is in the process and the exploring options for smaller communities are in process too. The use of recycled water from Amman-Alzarqa Basin for irrigating agriculture in the Jordan Valley has been established to be technically feasible, and sustainable although less productive. A wide variety of crops can be sustainably produced using the quality of recycled water available at King Talal Reservoir. The study concluded that improved irrigation water management of recycled water as with fresh water will result in better agricultural returns (Bdour and Hadadin, 2005).

2.6.4 Egypt, Mallawy Area

In a case study of wastewater reclamation and reuse potential In Rural areas of Egypt El Sayed and Abdel Gawad recommended that the construction of two WWTPs in Mallawy area of El Menya Governorate in Upper Egypt with secondary treatment is a must to reduce the pollution level from rural wastewater and increase the possibility for safe drainage water reuse for irrigation (El-Sayed and Abdel Gawad, 2001).

2.7 National Experience in Reuse Projects

The Palestinian experience in treated wastewater reuse is still young and poor, the existing treatment facilities of the main Palestinian cities are overloaded, except for Al-Bireh WWTP (MEDAWARE, 2005). However, several small scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied. The only organizations involved in the construction process are NGOs with international funds (EMWATER, 2004).

But since 1990, more than 600 onsite grey water treatment units are operating in Palestinian rural areas and the reuse of the effluent in agriculture is increasingly accepted and practiced incentivized by the financial revenues from the implementation such as decrease in water consumption, garden irrigation, and nutrients recirculation. However the difficulties for implementing these units are financial considerations and lack of funds, health concerns, lack of experience and vision in the system's performance and operational requirements (Mahmoud and Mimi, 2008).

2.7.1 Case Studies from Palestine

Pollution caused by direct discharges from rural communities can be significantly reduced by the promotion of onsite low cost treatment systems. Several small scale low technology wastewater treatment plants have been implemented in Palestine. They serve small rural communities partially or fully. The total population served by each plant range from 50 households to entire villages of around 5,000 people. The treatment plants are based on low-cost technology consisting of anaerobic treatment phase (up flow anaerobic sludge blanket) followed by constructed wetlands and effluent storage tank that can allow treated effluent flow to the downhill agricultural area (PHG, 2009).

One experience has demonstrated that simple treatment units can be built per household or school in order to help save more water that can be treated and reused easily for irrigating home gardens and school gardens. Moreover, the treated effluents from these systems are more socially acceptable to be treated and reused in the Islamic societies. The technology simply involves a Septic tank upflow gravel filter followed by aerobic filter system as shown in Figure 2.2 (PHG, 2009).

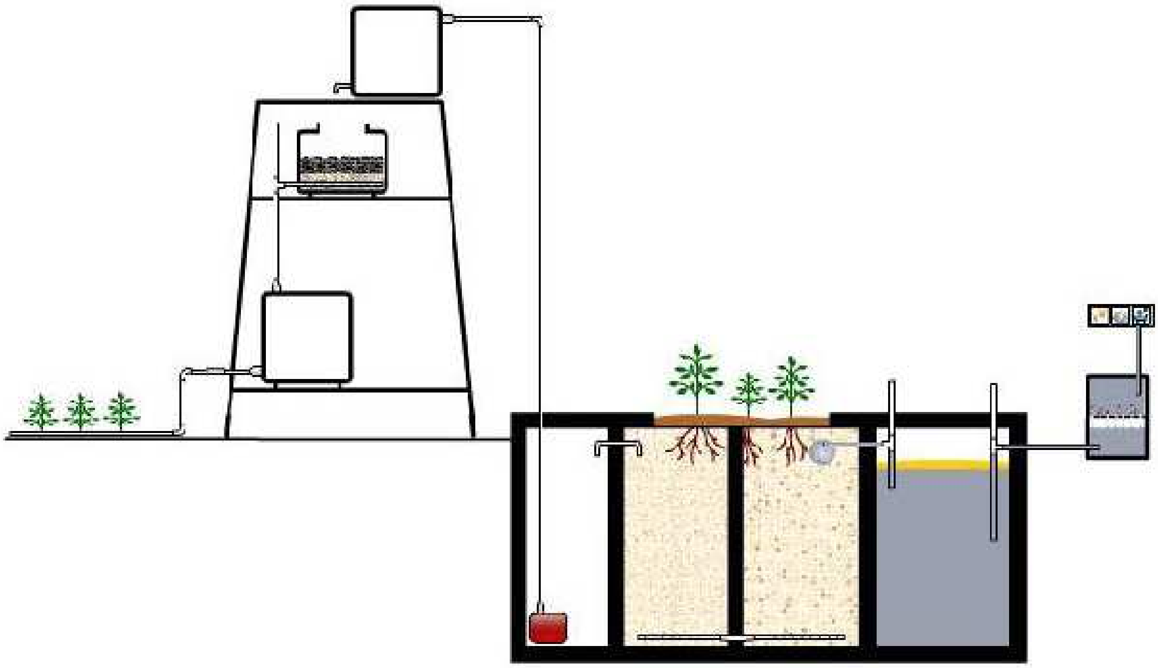

Fig. 2.2 Implemented grey water treatment units in schools and households in Palestine (PHG, 2009)

AISPO and UWAC have successfully implemented 20 (GWWTP) at 20 home gardens of 500 m^2 each at An Najadah and Az Zuweidin (Al-Ka`abneh Bedouins) in south east Yatta located in Hebron. The project provides 3,600 m^3 per year of unconventional water, that also enabled to produce at least 1,200 kg of vegetables and fruits per year, through this project larger amounts of water is well managed, treated and reused in irrigating home gardens. The environmental conditions are improved as stated by all the benefited households (AISPO and UWAC, 2009).

Chapter Three: Methodology

3.1 Conceptual Framework for Assessing Wastewater Generation, Collection, Treatment and Reuse in Palestinian Rural Areas

3.1.1 Household Water Sources for Domestic Use

Most of the examples and recent research papers are dealing with network distribution system as the only source of water supply when intending to assess generated wastewater quantities. Nevertheless it is worth to study the potential of cisterns and water vendors for domestic water supply.

In this study, the per capita water consumption took into consideration the contribution of three sources for water supply used by households; water network, cisterns and vendors. Percentages of households according to their use of each of the above three sources in each locality, and other useful data was obtained from PCBS for 2007. Annex A shows the Palestinian rural areas with some major statistics.

3.1.1.1 Water Quantity from Network

Average water consumption from network for each locality was obtained from PWA. These numbers where obtained from total supply rates based on estimates for unaccounted for water.

The amount of water consumed from network can be estimated using equation (1):

$$W_{NW} = 365 * \frac{\sum \ (POP_{NW} * LCD_{NW})}{1000} \text{............ Equation (1)}$$

Where,

W_{NW}: Quantity of Domestic water consumption from network (m^3/yr)

LCD_{NW}: Domestic consumption from network (l/C/D)

POP_{NW} : Population using network

$= (\sum number\ of\ HH * \%\ HH\ using\ NW * Avg.size\ of\ HH)$

The total annual quantity for consumption from water networks in the Palestinian rural areas is 9,044,826.6 m^3.

3.1.1.2 Water Quantity from Cisterns

Cisterns act as a major source of domestic water supply in the localities that do not have water supply networks. It is estimated that 6.6 million cubic meters is utilized from the cisterns. In localities where water networks exist, cisterns still act as another “good” source of domestic water supply (Abu Zahra, 2000).

The typical cistern can store from 70 –100 m^3 annually of rain water according to (Water for Future, 1999, Nazer et al., 2010 and Abu Zahra, 2000). The average value of 85 m^3/y was taken as the quantity of water from cistern for the households using cisterns.

The amount of water consumed from cisterns can be estimated using equation (2):

$$W_{cis} = HH_{cis} * CIS_s \quad \text{…………………. Equation (2)}$$

Where,

W_{cis}: Domestic water consumption from cisterns (m^3/yr)

HH_{cis}: Number of households using cisterns

$$= \sum \text{number of households} * \frac{\text{% of households using cisterns}}{100}$$

CIS_s : Average annual storage of typical cistern =85 m^3/y

The total annual quantity for consumption from water cisterns in Palestinian rural areas is 1,128,835.7m^3.

3.1.1.3 Water Quantity from Water Vendors

According to Sha`ar et al. (2003) the median liters per household per day from vendors in Nablus villages range from 96 in winter to 247 l/HH/d in summer time. So the average of the two medians is 172 l/HH/d and in Hebron villages it ranges from 134 to 178 so the average of the two medians is 156 l/HH/d.

Since there is lack of information about water consumption from vendors, these values were adopted. The value of 172 L/HH/d was used for the north areas (Jenin, Tubas, Tulkarem, Qalqiliya and Nablus) and the value of 156 L/HH/d was used for the south areas (Bethlehem and Hebron). For the central areas (Ramallah, Jerusalem and Jericho and Al Aghwar) the value was taken to be the average of the above two values (172 and 156) which is 163 L/HH/d.

The amount of water consumed from water vendors can be estimated using equation (3):

$$W_{ven} = \frac{365 * \sum HH_{ven} * Cven}{1000} \quad \text{……………. Equation (3)}$$

Where,

Wven: Domestic water consumption from water vendors (m^3/yr)

HH ven: Number of households using vendors

$$= \frac{\sum number\ of\ HH * \%\ of\ households\ using\ vendors}{100}$$

C_{ven}: Domestic consumption from vendors (L/HH/d)

=172 L/HH/d for the north areas (Jenin, Tubas, Tulkarem, Qalqiliya and Nablus)

=156 L/HH/d for the south areas (Bethlehem and Hebron)

=163 L/HH/d for the central areas (Ramallah, Jerusalem and Jericho and al Aghwar)

The total annual quantity for consumption from water vendors in the Palestinian rural areas is 1,094,826.0 m^3.

Other water sources (Springs, food water content, beverages…etc) did not constitute a significant source of wastewater.

W_C =Total quantity of domestic water consumption= $W_{NW} + W_{cis} + W_{ven}$

It is found that 80% of consumed water quantities in the rural areas are supplied by water networks. 10% of water quantities are supplied from cisterns, and 10% of water consumption quantities are from water vendors.

3.1.2 Wastewater Production and Collection

Not all consumed water is discharged as wastewater; part of it is used for garden irrigation, floor washing or car wash, so it is assumed that 80 % of the consumed water is released as wastewater. The wastewater produced enters either a sewerage system or an onsite disposal system mainly cesspits. Some of the wastewater produced is not collected at all. Sanitation coverage figures are obtained from PWA for year 2007.

The amount of wastewater collected in sewerage network, and collected in cesspits can be estimated using equations (4) and (5) respectively:

$$WW_{NW} = Wc * 0.8 * \%\ HH_{WW\ NW} \ldots\ldots \text{Equation (4)}$$

$$WW_{cess} = W_C * 0.8 * \%\ HH_{ww\ cess} \ldots\ldots \text{Equation (5)}$$

Where,

WW_{NW}: amount of wastewater collected in sewerage network

WW_{cess}: amount of wastewater collected in cesspits

% HH ww $_{NW}$: Percentage of households having sewerage network

% HH ww $_{cess}$: Percentage of households having cesspits

3.1.3 Wastewater Treatment and Reuse

The development of sanitation sector in rural areas was promoted by some non-governmental organizations (NGO's), among others are PARC, PHG, FAO, QWC, and ARIJ who have constructed onsite treatment systems in different small Palestinian rural areas. In order to investigate the extent of wastewater treatment and reuse in Palestinian villages field work was necessary. A group survey work was held through these NGOs with the cooperation of the Austrian project colleagues (Abdelhamid Shami, Ghadeer Arafeh, Hanadi Bader, Rehab Thaher and Ola Adilah). The survey included a simple form of a questionnaire which was distributed to the NGOs via email to gather information about the location, technology type, size and number of units for each implemented treatment plant as shown in Tables (3.1) and (3.2). Moreover, personal interviews and phone calls with persons in charge played an important role in obtaining the required information.

Table 3.1 Questionnaire Form Distributed to the NGO`s for Collective Systems

Implementing Agency	type of system	Village	Notes	no. of beneficiaries
PWEG		Al zaytouna		60 person
PHG	UFGF+ASF	Awarta	School	400
		AlBadhan	School	900
		Talluza	School	350
		Sabastiya	School	350
		Kafr Thulth	School	280
		Ijnisinia		336 person
PARC	A AN GF+PSF	Zeita		
		Sir		
	ST+CW	Bedya		
Total		10		

Table 3.2 Questionnaire Form Distributed to the NGO`s for Onsite Units

Implementing Agency	type of system	Village	no of beneficiaries	No. of units
FAO	UFGF+ASF	Hares	12.0	5
		Talfeet	12.0	6
PWEG	UFGF+ASF	Bet Inan	12.0	7
		Qatannah	12.0	12
		Jifna	12.0	5
		Dura Al Qar`	12.0	17
		Ein Seenya	12.0	5
		Kharbatha Almusbah	12.0	12
		Alqubeba	12.0	1
		Rafat	12.0	2
		Beit Hanina	12.0	1
QWC	UFGF+ASF	Qebia	12.0	48
ARIJ	UFGF+ASF	Dar Salah	30.0	4
		Al Reheya	18.0	4
	AS	Battir	30.0	15
		Al walaja	30.0	15
		Dar Salah	18.0	15
PHG	UFGF+ASF	Bel'in	12.0	2
		Ras Karkar	12.0	2
		Deir Ibzi'	12.0	3
		Kharbath AlMisbah	12.0	2
		Beit Sira	12.0	3
		Tayaseer	12.0	12
		Seir	12.0	12
		Meselyia	12.0	12
		Al-Jdayidah	12.0	12
		Rabah	12.0	12
		Sanour	12.0	57
PARC	UFGF+ASF	Qebia	12.0	18
		Beit Sira	12.0	12
		Al-Jdayidah	12.0	50
Total				383

3.1.3.1 Quantity of Treated Wastewater by Onsite Treatment Units

The quantity of wastewater that is treated by onsite treatment units is estimated using equation (6):

Treated quantity (m^3/y) =

$$\text{Wastewater Generation per capita } (m^3/c/y) * \text{No. of Beneficiaries} * \text{No. of units implemented} \quad \text{……….Equation (6)}$$

Where,

Wastewater generation rate per capita (m^3/c/year) =

$$= \frac{wastewater\ generation\ rate\ of\ the\ village}{Population}$$

For wastewater generation rate of the village see Annex A.
For No. of beneficiaries see Table (3.2)
For population see Annex A
For No. of units implemented see Table (3.2)

The 383 implemented onsite wastewater treatment units in Palestinian rural areas treat approximately about 633,263.2 m^3/y as shown by Table (3.3) which is a very small unmentionable part accounting for 7% of the collected wastewater.

According to the implementing agencies all of the generated effluent from the treatment plants is reused for irrigation since it is a prerequisite that each applicant (household) should have a piece of land with area not less than 400 m^2 to allow for the use of the effluent in irrigating trees and some crops, also the treatment unit installation is accompanied with the installation of irrigation network within the garden.

Table 3.3 On-site Treatment Units

Implementing Agency	type of system	Village	WW Generation (m³/Y)	Population	Quantity treated per capita m³/y	no of beneficiaries	No. of units	Total quantity m³/y
FAO	UFGF+ASF	Hares	42,342.3	3112	13.6	12.0	5	816.4
		Talfeet	3,530.8	238	14.8	12.0	6	1,068.1
PWEG	UFGF+ASF	Bet Inan	45,963.6	3980	11.5	12.0	7	970.1
		Qatannah	76,205.5	6458	11.8	12.0	12	1,699.2
		Jifna	13,062	1716	7.6	12.0	5	456.7
		Dura Al Qar`	37,587.12	2897	13.0	12.0	17	2,646.8
		Ein Seenya	21,538.4	711	30.3	12.0	5	1,817.6
		Kharbatha Almusbah	58,788.3	5211	11.3	12.0	12	1,624.5
		Alqubeba	55,251.6	3172	199.4	12.0	1	2,392.4
		Rafat	62,895.6	2374	299.0	12.0	2	7,176.3
		Beit Hanina	24,862.32	1071	273.7	12.0	1	3,284.4
QWC	UFGF+ASF	Qebia	49,271.0	4901.0	122.7	12.0	48	70,661.2
ARIJ	UFGF+ASF	Dar Salah	101,244	3373	324.1	30.0	4	38,886.7
		Al Reheya	394,9.0	28989.0	113.4	18.0	4	8,166.6
	AS	Battir	27,818.6	3967	74.2	30.0	15	33,406.6
		Al walaja	49,143.7	2041	252.2	30.0	15	113,474.4
		Dar Salah	101,244	3373	324.1	18.0	15	87,495.0
PHG	UFGF+ASF	Bel'in	15,726.5	1701	102.5	12.0	2	2,459.6
		Ras Karkar	20,563.4	1663	212.9	12.0	2	5,110.4
		Deir Ibzi'	45,712.6	2069	484.1	12.0	3	17,429.1
		Kharbath AlMisbah	58,788.3	5211	144.3	12.0	2	3,463.8
		Beit Sira	47,971.5	2749	194.7	12.0	3	7,007.9
		Tayaseer	22,748.3	2489	95.6	12.0	12	13,767.7
		Seir	7,205.5	744	105.2	12.0	12	15,145.9
		Meselyia	26,418.8	2388	120.1	12.0	12	17,298.3
		Al-Jdayidah	56,116.7	4738	121.6	12.0	12	17,513.9
		Rabah	27,219	3145	99.4	12.0	12	14,309.1
		Sanour	8,267.2	4067	23.7	12.0	57	16,210.3
PARC	UFGF+ASF	Qebia	49,271.0	4901.0	122.7	12.0	18	26,497.9
		Beit Sira	47,971.5	2749	194.7	12.0	12	28,031.6
		Al-Jdayidah	56,116.7	4738	121.6	12.0	50	72,974.9
Total							383	**633,263**

3.1.3.2 Quantity of Treated Wastewater by Collective Systems

For the collective wastewater treatment units, the influent of wastewater is calculated according to the information supplied by the NGOs, the consumption per student of water is obtained from PCBS.

The quantity of wastewater that is treated by collective treatment systems could be estimated using equations (7) and (8):

Treated quantity (m^3/y) =

$= \text{Wastewater Generation per capita } (m^3/c/y) * \text{No. of Beneficiaries}$ ……..Equation (7)

Where,

Wastewater Generation rate per capita (m^3/c/year) =

$$= \frac{wastewater\ generation\ rate\ of\ the\ village(\frac{m^3}{y})}{Population}$$

Treated quantity (m^3/y) for Schools =

$= \text{water consumption per student } * \text{No. of students} * 365 * 0.8/1000$ …..Equation (8)

The effluent from schools is used to water the plants within the school area, meanwhile the effluent from community systems was reused in irrigating trees and crops. Hence, it is assumed that all the effluent from the collective systems is reused. It is worth mentioning that several collective systems implemented were out of service either because of pumps and electricity problems or because of lack of maintenance. An example is Talita WWTP, Nuba, Izbet Shofeh and others.

The 10 implemented collective wastewater treatment systems in Palestinian rural areas and that are still working treat approximately about 25,195.4 m^3/y as shown in Table (3.4) which is also very small unmentionable part accounting for 0.3 % of the wastewater amount.

Table 3.4 Collective Systems for Treating Wastewater

Implementing Agency	type of system	Village	Notes	no. of benefeciariess	Student water consumption l/S/d	Quantity treated per unit m3/y
PWEG		Al zaytouna		60 person		775.5
PHG	UFGF+ASF	Awarta	School	400	4	467.2
		AlBadhan	School	900	4	1,051.2
		Talluza	School	350	4	408.8
		Sabastiya	School	350	4	408.8
		Kafr Thulth	School	280	4	327.0
		Ijnisinia		336 person		7,448.9
PARC	A AN GF+PSF	Zeita				5,110.0
		Sir				5,110.0
	ST+CW	Bedya				4,088.0
Total						**25,195.4**

3.2 Wastewater Generation Projections and Cost of Treatment

There is lack of reliable bench marks for wastewater generation rates in the rural areas of the West Bank. To estimate wastewater flow trends, the population projections in rural areas for each identified governorate were calculated based on the PCBS census results of the year 2007 as a baseline. Average population growth rates as indicated in Table (3.5) are applied for each period. Water consumption is assumed to stay constant.

Table (3.5) Population Growth Rates

Period	West Bank
2008-2010	2.8
2010-2015	2.4
2015-2020	2.0
2020-2030	1.4

Source: (Jayyousi and Srouji, 2009)

Table (3.6) shows the wastewater flow generations from year 2007 to year 2030

Population projection (P) is calculated according to the formula:

$$P = P_o\left(1 + (\frac{r}{100})\right)^n$$

Where

P_o: the present number of population, r: growth rate, n: period of projection.

Table (3.6) Wastewater flow Projections from year 2007 to year 2030

Governorate	Population	Wastewater Quantities (m^3/y)	Governorate	Population	Wastewater Quantities (m^3/y)
2007			**2007-2010**		
Jenin	99,194.0	963,559.4	Jenin	107,761.8	1,046,785.9
Tubas	11,052.0	147,396.9	Tubas	12,006.6	160,128.2
Tulkarem	34,683.0	723,191.3	Tulkarem	37,678.7	785,656.2
Nablus	112,904.0	1,539,067.5	Nablus	122,656.0	1,672,002.8
Qalqiliya	35,641.0	688,909.8	Qalqiliya	38,719.5	748,413.7
Salfit	37,956.0	512,002.1	Salfit	41,234.4	556,225.8
Ramallah&Bireh	118,365.0	1,927,097.4	Ramallah&Bireh	128,588.7	2,093,548.5
Jericho	9,518.0	265,258.9	Jericho	10,340.1	288,170.3
Jerusalem	40,700.0	740,164.1	Jerusalem	44,215.4	804,095.0
Bethlehem	39,804.0	966,568.7	Bethlehem	43,242.0	1,050,055.1
Hebron	66,518.0	502,297.2	Hebron	72,263.4	545,682.6
Total	606,335.0	**8,975,513.3**	**Total**	658,706.6	**9,750,763.8**
2010-2015			**2015-2020**		
Jenin	121,329.0	1,178,576.1	Jenin	133,957.0	1,301,243.2
Tubas	13,518.2	180,288.3	Tubas	14,925.2	199,052.9
Tulkarem	42,422.5	884,570.2	Tulkarem	46,837.8	976,637.0
Nablus	138,098.3	1,882,507.8	Nablus	152,471.7	2,078,440.7
Qalqiliya	43,594.2	842,638.9	Qalqiliya	48,131.6	930,341.4
Salfit	46,425.8	626,254.6	Salfit	51,257.9	691,435.6
Ramallah&Bireh	144,778.0	2,357,126.0	Ramallah&Bireh	159,846.6	2,602,457.6
Jericho	11,641.9	324,450.9	Jericho	12,853.6	358,220.0
Jerusalem	49,782.1	905,330.5	Jerusalem	54,963.5	999,558.0
Bethlehem	48,686.2	1,182,256.9	Bethlehem	53,753.5	1,305,307.2
Hebron	81,361.4	614,383.9	Hebron	89,829.5	678,329.5
Total	741,637.6	**10,978,384.1**	**Total**	818,827.9	**12,121,023.1**

Table (3.6) continue Wastewater Flow Projections from Year 2007 to year 2030

Governorate	Population	Wastewater Quantities (m^3/y)
	2020-2030	
Jenin	153,937.7	1,495,333.4
Tubas	17,151.4	228,743.1
Tulkarem	53,824.0	1,122,309.7
Nablus	175,214.0	2,388,455.7
Qalqiliya	55,310.7	1,069,108.8
Salfit	58,903.3	794,568.4
Ramallah&Bireh	183,688.9	2,990,633.6
Jericho	14,770.8	411,651.2
Jerusalem	63,161.7	1,148,649.6
Bethlehem	61,771.2	1,500,003.5
Hebron	103,228.3	779,507.5
Total	940,962.2	**13,928,964.5**

The cost of small scale grey wastewater treatment unit for household level ranges from \$2000 to \$4,000. The wastewater treatment unit has a capacity to treat 0.5 m^3 of grey wastewater /day/family (equivalent to 182.5 m^3/y/HH) (ARIJ, 2010).

For the amounts of wastewater calculated in Table (3.6) the treatment cost is estimated as below. It is assumed that wastewater is going to be collected as grey wastewater. According to (Burnat and shtayye, 2009) 80 % of wastewater is Grey wastewater. Table (3.7) shows the cost of treatment and reuse for wastewater quantities from year 2007 to 2030.

As an example: nuumber of units needed from year 2007 to year 2010 will equal the existing number of units already installed in 2007 plus the extra units needed to treat the extra amount generated from year 2007 to 2010 which is 39345 + (7800611.04-7180410.64) / 182.5.

The last column in Table (3.7) shows the increment in cost needed to upgrade the existing units and to install new units in order to cope with the increase in generation rate of wastewater for each period of time. The first year will have the highest cost.

Table (3.7) Investment Cost of Treatment and Reuse for Wastewater Quantities from Year 2007 to 2030

Period	Wastewater Quantities (m^3/y)	Grey Wastewater Quantities = 0.8*Wastewater Quantity (m^3/y)	Total No. of units needed = Grey Wastewater Quantity/ Capacity of Unit	no. of units needed as extra units from previous period	Cost of One Unit ($)	cost needed to upgrade units= No. of extra units * cost of one unit (million $)
2007	8,975,513.3	7,180,410.64	39345	0	2000-4000	78.7-157.4
2007-2010	9,750,763.8	7,800,611.04	42743	3398	2000-4000	6.8-13.6
2010-2015	10,978,384.1	8,782,707.28	48124	5381	2000-4000	10.8-21.5
2015-2020	12,121,023.1	9,696,818.48	53133	5009	2000-4000	10-20
2020-2030	13,928,964.5	11,143,171.60	61058	7925	2000-4000	15.9-31.7

For collective systems, the investment cost that is required to implement a collective system including the sewerage lines ranges from 145,000 – 175000$ for each unit, each unit treats 14 m^3/d (PARC, 2008) - which is equivalent to 5110 m^3/y. The number of units needed to treat the same amount of wastewater is 1405 unit as shown by Table (3.8), this will cost 203,725,000.0 – 245,875,000.0 $.

Table (3.8) Investment Cost of Treatment and Reuse for Wastewater Quantity for collective systems

year	Wastewater Quantity (m^3/y)	Grey Wastewater Quantities = 0.8*Wastewater Quantity (m^3/y)	No. of units needed = Grey Wastewater Quantity/ Capacity of Unit	Cost of One Unit	Total investment Cost (million$)== No. of units * cost of one unit (million $)
2007	8,975,513.3	7,180,410.64	1405	145,000 – 175,000	203.7 – 245.8

3.3 Percentages of Water Deficit Compensation

Under the assumption that the total amount of generated wastewater can be reused and knowing that reusing one cubic meter of wastewater saves one cubic meter of freshwater and avoids the negative effects of polluting the environment, calculations for water deficit compensation can be made.

Data concerning supply and demand quantities are obtained from PWA for year 2007. The generated amounts of wastewater and their role in bridging the gap between supply and demand are discussed more in chapter five. Table (3.9) shows percentage of water deficit compensation by reusing wastewater. These percentages were calculated using the formula:

$$\%\,Wdc = Qww * 100/AD$$

Where:

%Wdc: Percentages of water deficit compensation, Qww: Quantity of wastewater, AD: Actual deficit.

Existing water tariff along with the deficit compensation was used to suggest the most appropriate areas for implementing reuse projects.

Table 3.9 Percentage of Water Deficit Compensation by Reusing Wastewater

Governorate	**Actual Deficit (MCM)**	**Qww (m^3/y)**	**Percentage of water deficit compensation**
Jenin	10.220	963,559.4	9.4
Tubas	2.085	147,396.9	7.0
Tulkarm	3.043	723,191.3	23.7
Nablus	10.727	1,539,067.5	14.3
Qalqilya	1.317	688,909.8	52.3
Salfit	1.863	512,002.1	27.4
Jericho	0.000	265,258.9	-
Ramallah	5.652	1,927,097.4	34.0
Jerusalem	3.858	740,164.1	19.1
Bethlehem	4.068	966,568.7	23.7
Hebron	19.548	502,297.2	2.5
Totals	**62.380**	**8,975,513.3**	**14.3**

Actual Deficit (MCM) See table 4.4, Qww (m^3/y) See annex A

3.4 Effluent Quality and Potential for Different Reuse Applications

For considering the suitability of the different reuse options as having potential for reuse, data for treated wastewater was gathered from several NGO`s who implemented onsite units and collective systems, then quality analysis for reuse options was made. Projects quality results were compared with the Palestinian Standards of treated wastewater 742-2003 as shown in Tables (3.10) and (3.11).

Several reuse options under two scenarios of wastewater collection and treatment is set then critically reviewed and discussed in chapter five.

The first scenario is the collection and treatment of wastewater using onsite treatment units at household level. Under this scenario two options of reuse could be studied: reuse for garden irrigation with selected crops, and the reuse for toilet flushing. Although vegetables are important for Palestinian households' economy but it is prohibited to use effluent to irrigate them by the PSI, so it was excluded from the discussion, the second crop that could be irrigated within households' gardens is fruiting trees.

Since there are no standards concerning toilet flushing reuse option in the Palestinian standards draft, toilet flushing is taken to be in the same category with reuse for gardens, play grounds, and parks since there are possibilities of direct human exposure to the effluent as shown by Table (5.4).

The second scenario is the collection and treatment of wastewater using collective systems at community level: this scenario has several potential reuse options to be studied: reuse for forests and landscape irrigation, reuse for agricultural crops, reuse for groundwater recharge, reuse for industrial purposes and reuse for potable purposes.

Table 3.10 Projects' Results of Reclaimed Wastewater Quality by Basic Indicators/ Maximum Values Compared to PSI for onsite units

Indicator mg/l	Projects result	Toilet Flushing	Fruiting Trees
COD	27.2 -79.41[a] 58–266[b] 30.0-192.4[d] 80-284[e]	150	150
BOD	7.5-23.25[a] 21–121[b] 14.0-20.25[c] 27-129[d]	20	60 (3 barriers)
TSS	4–24 b 54-97[e]	30	90 (3 barriers)
DO	- 0.5-2[b]	>0.5	>0.5
TDS	258 – 506[a] 465–849[b] 1053-1470[e]	1200	1500
pH, (no mea. unit)	7.1 – 7.51[a] 6.70–7.79[b]	6-9	6-9
NO3	38.6 – 49.4[a] 13–36[b] 10-23[e]	50	50
NH4	5[a] 12–48[b]	50	-
OKN (Organic N)	0.67 – 1.57[a] -	50	50
Chloride	72 -172[a]	350	400
SO4	131.68 – 348.95[a]	500	500
Na	45.51 – 85.66[a]	200	200
Mg	1.3 – 13.3[a]	60	60
Ca	3.2 – 15.10[a]	400	400
Faecal coliforms/ 100ml	Zero [a] Zero-$1*10^{2}$ [b] Zero [e]	<200	<1000

a 17 samples from 5 treatment units Al Ka`abneh Bedouins, (AISPO and UWAC, 2009)

b Qibia Case study, 30 samples, (Burnat and shtayye, 2009)

c Hebron and Bethlehem sites at Nahhalen, Batter, Al Walajah, Al Khadr, Sa'ir, Ash Shuyukh, 28 samples, (ARIJ, 2010)

d different plants in rural areas in Ramallah and Bethlehem,(PHG, 2007)

e Four treatment plants in Belen village (PARC, 2008)

For collective systems there was not much available information about the quality analysis except for the WWTPs applied by PARC. The data analysis for Attil, Zeita, Bedia and Seir WWTPs is summarized in Table (3. 11), for more details see Annex (B).

Table 3.11 Projects' Results of Reclaimed Wastewater Quality by Basic Indicators/ Maximum Values Compared to PSI for Collective systems

Indicator mg/l	**Projects results**	**Groundwater recharge by infiltration**	**Dry fodders**	**Green fodders**	**Gardens, play grounds, parks**	**Industrial and cereal crops**	**Forests**	**Fruiting trees**
COD	160-960	150	200	150	150	200	200	150
BOD	70-410	40	60	40	20	60	60	60 (3 barriers)
TSS	20-520	50	90	50	30	90	90	90 (3 barriers)
TDS	258 – 506[a] 465–849[b] 1053-1470[e]	1500	1500	1500	1200	1500	1500	1500
Faecal coliforms/ 100ml	3*10^3 - 10*10^6	<1000	<1000	<1000	<200	<1000	<1000	<1000

Source: (PARC, 2009). Data analysis for Attil, Zeita, Bedia and Seir WWTPs

Each one of these reuse options is discussed in chapter five according to the water savings that could add to the water balance, quality required and the logic of implementing such option.

3.5 Water Consumption Categories and Water Savings

First Scenario

A) Garden Irrigation with Fruiting Trees:

Garden water use is assumed to be of an amount equal to the outdoor water use which in turn is estimated to be 20% of total water use at household level according to PWA (PWA, 2010[c]). The total yearly outdoor water consumption by Palestinian rural communities can be estimated using the formula:

$$Total\ Outdoor\ Water\ Consumption = Total\ water\ consumption * 20\%$$

Total water consumption from Annex A =11,268,488.4 m^3/y

Total Outdoor Water Consumption= 11,268,488.4 * 20% =2,253,698 cubic meter.

B) Toilet Flushing:

Toilet is considered as the largest indoor water consumer in the West Bank with 34 % of the indoor water use, the bath and shower water consumption follows with 22 %, the bathroom sink and kitchen covers 14% and 13% respectively of the indoor water use. Remaining consumption (17%; laundry, cooking and drinking and house cleaning was relatively small (Nazer et al 2010). Outdoor water use is estimated to be 20% of total water use at household level according to PWA (PWA, 2010[c]).

Toilet flushing amount could be estimated using the formula:

$$Toilet\ flushing\ amount = 34\% * \text{indoor water use}$$

Indoor water use = 80% * total water consumption

Indoor water use = 80% *11,268,488.4 = 9,014,791 m^3/y.

*Toilet flushing amount =34% *9,014,791 = 3,065,029 m^3/y.*

Second Scenario

C) Forests and Landscape Irrigation

This reuse option will not contribute to solving the problem of water stress since the majority of forests are rain-fed. No reallocating of water resources will take place; hence no water savings are achieved.

D) Reuse for Irrigation of Crops

The raw agricultural data to evaluate reuse potential in irrigation of crops was obtained from the Ministry of Agriculture. Data concerning crop water needs for the major cultivated fruits in Palestinian areas is tabulated below in Table (3.12). Fruiting trees were selected because although vegetables are important for Palestinian households' economy but they are prohibited to be irrigated with recycled water by the PSI. Serial, industrial and fodder crops are mainly rain fed, hence no water savings will be achieved.

Table 3.12 Major Cultivated Fruit Trees in Palestinian Areas with their Water Needs

Crop Type		Crop Water Needs m³/dunum
Tree/permanent crops	Almonds	350
	Guava	1,000
	Plum	350
	Peaches	350
	Grapes	400
	Olive	350
	Dates	1,800
	Citruses	1,200

Source: (MoA, 2010[a])

Data for land areas cultivated with irrigated fruit species in rural areas was extracted from the raw data supplied by the MoA. Table (3.13) shows villages with land areas cultivated with different fruit crops and their water requirements.

Total water requirement for each crop is estimated according to the formula:

$$Total\ Water\ requirement\ of\ crop = \sum Area\ of\ cultivated\ land\ for\ crop * Crop\ water\ need$$

Table 3.13 Land Areas Cultivated with Different Crops and their Water Requirements

Village	Land area in dunums cultivated with									Total water requirement m^3/y
	Citrus	Plum	Apricot	peach	Grape	Guava	Almond	Olive	Date	
Hebron										
Beit 'Einun	10	20	10	13	640					283,050
Qla'a Zeta	2	7	15	8	163					78,100
Jericho										
Az Zubeidat					38					15,,200
Al Jiftlik	54				41					16400
Fasayil					109					43,600
Ramallah										
Saffa							33			11,550
Beit 'Ur al Fauqa							20			7,000

Village	Land area in dunums cultivated with									Total water requirement m^3/y
	Citrus	Plum	Apricot	Peach	Grape	Guava	Almond	Olive	Date	
Salfit										
Deir Istiya	54									64,800
Kafr ad Dik	14									16,800
Yasuf	12									14,400
Qalqiliya										
Falamya	506					35				642,200
Jayyus	161			30		16				219,700
An Nabi Elyas	144									172,800
Ras 'Atiya	25									30,000
'Azzun 'Atma	70									84,000
Nablus										
Talluza	217									260,400
Zawata	49									58,800
Tulkarem										
An Nazla ash Sharqiya	58									69,600
Zeita	39									111,600
Kafa	80									96,000
Far'un	350									420,000
Shufa	170									204,000
Kafr Jammal	74									88,800
Tubas										
Bardala	84								132	338,400
'Ein el Beida	10				53				14	58,400
Al Farisiya									13	23,400
Kashda							55			19,250
Ras al Far'a	390									468,000
Wadi al Far'a								50		17,500
Jenin										
Deir Ghazal	20									24,000
Al Hafira	15									18,000

In order to estimate water savings the quantity of wastewater generated by each of the villages in Table (3.12) was compared to the total water requirement needed by crops.

Table 3.14 Wastewater Quantities Available Compared to Total Water Requirements of Cultivated Crops

	Total water crop Requirement m^3/y	**Wastewater quantity m^3/y**
Hebron		
Beit 'Einun	283,050	26,411
Qla'a Zeta	78,100	12,152
Jericho		
Az Zubeidat	15,200	60,944.5
Al Jiftlik	16,400	76,529.7
Fasayil	43,600	72,998.2
Ramallah		
Saffa	11,550	709,89.1
Beit 'Ur al Fauqa	7,000	18,832.4
Salfit		
Deir Istiya	64,800	32,387.3
Kafr ad Dik	16,800	50,313.2
Yasuf	14,400	24,186.7
Qalqiliya		
Falamya	642,200	13,828.7
Jayyus	219,700	57,642.1
An Nabi Elyas	172,800	28,432.7
Ras 'Atiya	30,000	34,186.9
'Azzun 'Atma	84,000	36,183.7
Nablus		
Talluza	260,400	52,357.2
An Nassariya		20,947.6
Zawata	58,800	41,191.6
Tulkarem		
Nazlat 'Isa		59,933.9
An Nazla ash Sharqiya	69,600	32,489.2
An Nazla al Gharbiya		10,402.7
Zeita	111,600	56,644.3
Kafa	96,000	137.8
Far'un	420,000	66,558.1
Shufa	204,000	56,187.9
Kafr Jammal	88,800	19,661.6

	Total water crop Requirement m^3/y	wastewater quantity m^3/y
Tubas		
Bardala	338,400	41,460.1
'Ein el Beida	58,400	29,272.2
Al Farisiya	23,400	1,404.5
Kashda	19,250	118.2
Ras al Far'a	468,000	12,731.4
Wadi al Far'a	17,500	17,576.2
Jenin		
Deir Ghazala	24,000	12,487.6
Al Hafira	18,000	652.9
Total	3,975,750	1,077,244

Total Water Crop Requirement from table (3.12)
Wastewater quantity from Annex A

This reuse option could save 1,077,244 m^3/y of the total water crop requirement.

Reuse for groundwater recharge, reuse for industrial purposes and reuse for potable purposes are considered to be of less importance for water savings for several reasons and implications of rural areas as discussed in chapter five.

Chapter Four: The Study Area

4.1 General

This chapter aims at describing the research area which is consisting of the 398 Palestinian communities classified as rural by the Palestinian Central Bureau of Statistics (PCBS, 2007). Full data about these communities are available in Annex (A). According to the Palestinian Central Bureau of Statistics the Palestinian communities are divided into three categories; urban, rural and camps.

- Urban community: a community with population number of more than or equal to 10,000 people, and all centers of governorates- despite its population- and each community with population number between 4,000-9,999 people conditioned by the availability of at least four of the following criteria: (electricity network, water network, post office, health care center with a full time (24/7) residence doctor and a high school).

- Rural community: each community with population number less than 4,000 people and each community with population between 4,000 and 9,999 people without achieving four of the above mentioned criteria.
- Camp: all communities referred to as camps and which is administrated by the UNRWA.

4.2 Geography

The West Bank is situated on the central highlands of Palestine. The area is bordered by the Jordan River and the Dead Sea in the east and the 1948 green line (cease-fire line) in the north, west and south. The total area of the West Bank is 5,800 km^2 including the area of the Dead Sea that falls within its boundaries. The West Bank is composed of 11 governorates (Jenin, Tubas, Tulkarm, Nablus, Qalqiliya, Salfit, Ramallah and al Bireh, Jericho and Al Aghwar, Jerusalem, Bethlehem and Hebron) as shown in Fig. 4.1.

The West Bank has a varied topography consisting of central highlands, where most of the population lives, and semi-arid rocky slopes, an arid rift valley and rich plains in the north and west (UNEP, 2003).

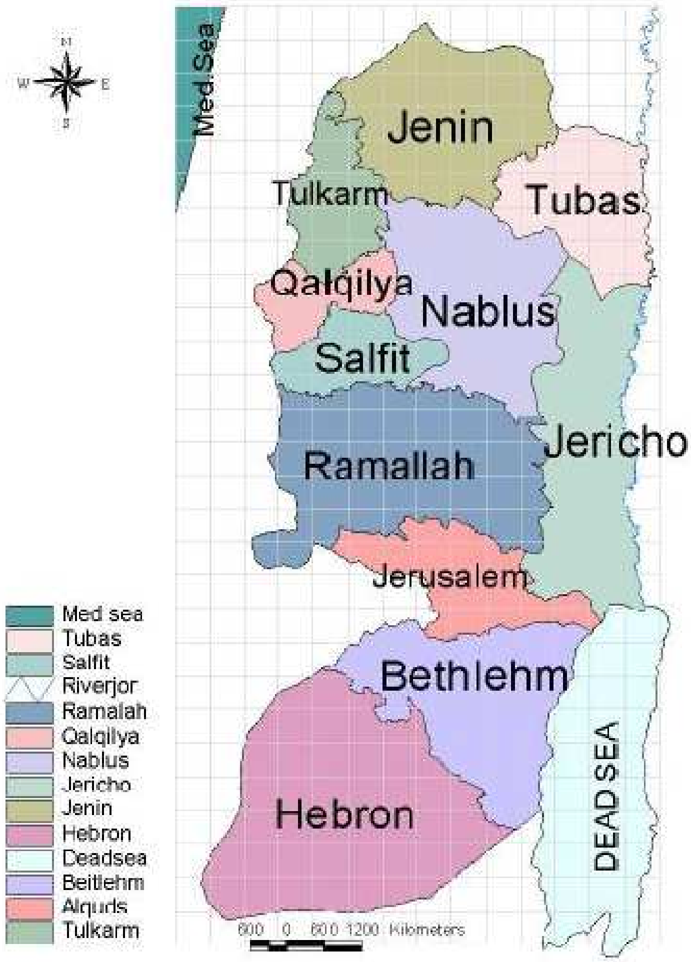

Fig 4.1 Districts composing WB (PWA, 2010[c])

The limestone hills of the West Bank that are 700-900m high act as a porous sponge which absorbs most of the rainwater falling on it, and much of this emerges as springs in valleys and along the margins of the highlands both east and west. Moving from east to west there are four main agro-ecological zones: the Jordan Valley, eastern slopes, central highlands, and semi-coastal region (FAO, 2001). Brown lithosols and loessial arid brown soils cover the eastern slopes and grassland, with pockets of cultivation spreading over the steep slopes. Fertile soils are found in the plains. Soil cover is generally thin and rainfall is erratic. In all, about 12 percent of the land is desert, eroded or saline. The dry southern West Bank, eastern slopes and central Jordan valley are composed of Mediterranean savanna grading into land dominated by steppe brush and spiny dwarf shrubs. The southern Jordan valley around Jericho and the Dead Sea is also influenced via the Wadi Araba by Sudanian vegetation (UNEP, 2003). The topographic variation directly reflects on climate as well as the distribution and diversification of agricultural patterns: from irrigated agriculture in the Jordan Valley, the lowest area in the world, to rainfed farming in the mountains. The population distribution and centres of urbanization are affected by the topography of the West Bank. The maximum concentration of built-up areas is found on the mountain ranges where climate is more suitable for human life than in the hot climate of the Jordan Valley. Furthermore, most of the West Bank rangelands are found on the arid Eastern Slopes. In addition to edaphic conditions, which are of great diversity. Among the obvious edaphic factors bearing on plant life, highest significance must be ascribed to soil properties. The country's soil is extremely variegated, ranging from deep, fine-grained, and very fertile, to dry stony desert. The dominant soil types of the West Bank are Terra Rossa, Rendzina, Alluvial, Gray Steppe, Hammada, and Saline soils (Ghattas et al., 2006).

4.3 Climate

The climate is hot and dry during the summer and cool and wet in winter. The central highlands have occasional frost, snow and hail. The Jordan Valley is warm and very dry in the south. The mean summer temperatures range from 30°C at Jericho to 22°C at Hebron, whereas the mean winter temperatures range from 13°C at Jericho to 7°C at Hebron. The average annual precipitation is 450-500 mm, decreasing from north to south and from high to low altitude. Rain tends to fall in intense storms.

Evaporation is high in summer when there is a water deficit. Winds prevail from the northwest but come from the southwest in winter. Land and sea breezes occur, and in late spring the hot dry khamsin blows from the desert in the south (UNEP, 2003). Global climate change may further aggravate the situation through increased temperatures and evaporation rates and lower and more erratic rainfall.

The following are the five major zones based on several factors including climate, topography, soil types and farming systems (FAO, 2001):

- The Jordan Valley Region lies 90-375 m above sea level with an annual rainfall of only 100-200 mm. Soil salinization is a major problem. Irrigation is essential for farming operations and winter vegetables and grapes are the main irrigated crops.
- The Eastern Slopes Region is a transitional zone between the Mediterranean and Desert climate with rainfall of 150-300 mm/year. The main economic activity is livestock. There

is also some spring-irrigated agriculture.

- The Central Highlands Region extends the length of the West Bank with mountains ranging from 400-1,000 m. Annual rainfall varies between 300 mm in the south to 600 mm in the north. Agriculture is primarily rainfed and includes olives, stone fruits, field crops, etc.
- The Semi-Coastal Region has an elevation of 100-300 m above sea level. Rainfall varies from 400-700 mm/year. It supports the same rainfed crops as the Central Highlands Region but it also has a limited irrigated area under vegetables.

The Semi Coast and the Central Highlands constitute most of the West Bank land and lie completely under the semi humid Mediterranean climate. It receives adequate rainfall and has a favorable environment. The prevailing Mediterranean climate is favorable for several plants and is highly diversified, demonstrating at least 2,483 plant species (Ghattas et al., 2006).

4.4 Population

In 2007 the total Palestinian population living in the West Bank was 2.4 million (PCBS, 2008).The total population in rural areas of Palestine is 606,335 people which comprise 26% of the total population in the West Bank. Population Density in the West Bank is 433 persons /Km^2. The growth rate is 3.13 according to 2005 estimates. Approximately 52% of the population of the West Bank lives in 12 urban areas, 42% in over 500 villages and around 6% in 19 refugee camps (MEDAWARE, 2005) Such rapid increase of both population and urbanization in the country has great impacts on natural resources and their development to meet market demand and to satisfy the rising human needs. In addition, Palestinians face lots of problems as they struggle to generate sufficient cash income to meet the most basic needs. Their difficulties escalate also because of the decreased area due to Israeli constraints, confiscations and continuous land degradation. At best, the overall results are static crop yields and widespread poverty especially in the years 2001 and 2002 and during the current Al Aqsa Intifada when the percentage of households reached 64.9% below poverty line (Ghattas et. al, 2006).

4.5 Water Resources

The Occupied Palestinian Territory hosts a considerable amount of fresh water resources in both West Bank and Gaza Strip, found in the form of surface water and groundwater, while additional sources include rainwater harvesting. The bulk of the surface water is found in the Jordan River, while the rest is distributed amongst numerous wadis and springs. Groundwater resources are supplied by two major aquifers: The coastal aquifer in Gaza and the mountain aquifer in the West Bank, the later consisting of three main groundwater basins (Western, Eastern and North-Eastern) (Water for Life, 2007) (See Figure 4.2). The underground water resources of the West Bank are mainly related to the following formation: Hebron, Jerusalem, Bethlehem, Upper and lower Beit Kahil, Jenin and Quaternary formations. Generally all these formations are part of the three main basins, namely western, north eastern and eastern basins, and the groundwater flow direction are to the west, north and to the east, respectively (EMWATER, 2004).

4.5.1 The Jordan River (Surface Water)

The only permanent river which can be used as a source of surface water in the West Bank is the Jordan River, which flows from north to south from an elevation of 2,200 m above mean sea level at Mount Hermon to about 395 m below mean sea level at the Dead Sea. The Jordan River flows along a straight distance of about 140 km with a river length of about 350 km due to its tortuous path. The slope of the land and accordingly that of the river bed is slight and directed toward the south. Much steeper gradients than the Jordan River itself were found in all of its tributaries. The catchment area of the Jordan River and Dead Sea basin comprises some 40,650 km^2 (Wallace and Wouters, 2006). The Palestinians lost all shares in the Jordan River with the occupation of WBGS even though the whole of the eastern aquifer falls within the borders of the WB. On the other hand, surface water in the West Bank could be found in a variety of other forms such as wadis, seasonal lakes, and natural springs. Seasonal lakes depend on annual rainfall and are known to especially occur in the Marj Sanour area of Jenin. Wadis also depend on seasonal rainfall especially in the winter and form in different areas of the WB. The four main wadis (Wadi Fara', Qilt, Maleh and Auja) are known to flow from the mountains towards the Jordan Valley in the east. Unfortunately, wadis have been subjected to extensive contamination caused by the unregulated wastewater dumping. Springs are naturally activated once groundwater levels rise to the surface of the earth. There are approximately 400 springs in the WB amongst which 114 are major ones with average annual yield around 60.8 MCM (Water for Life, 2007).

4.5.2 The Mountain Aquifer (Groundwater)

This aquifer is the main supplier of groundwater in the WB and is divided into three sub-basins that are classified according to their flow direction: western, north eastern and eastern basins. These aquifers share similar geological features; most of the formations are composed of carbonate rocks, mainly Karstic limestone, dolomite, chalk, marl and clay. The various formations occur in a series of aquifers and aquacultures, in which groundwater is found in shallow, intermediate and deep aquifers (beyond 200 m). These Rock formations outcrop (i.e., expose at the surface) throughout the West Bank constituting recharge areas for this hydrological system (Water for Life, 2007). Despite this fact Israel controls these aquifers granting Palestinians minimal allocation.

- *The Western Aquifer Basin* is the most important aquifer in the WB, 70% of the recharge area falls in the WB, annual replenishment capacity is estimated around 362 MCM. However the total quantity Palestinians are abstracting is 20 MCM, after 67 Palestinians were banned to drill any new well in this basin (Water for Life, 2007).
- *The North-Eastern Aquifer* replenishment capacity is estimated at 145 MCM of which Palestinians consumes less than 37 MCM (World Bank, 2009[c]).
- *The Eastern Aquifer* is an active donor to surface water and accounts for 90 % of the total annual discharge of springs in the WB. Unlike the western aquifer, it is almost completely situated within the borders of the WB; still Israel abstracts two thirds of its water supply. Palestinians utilizes approximately 60 MCM a year (Water for Life, 2007).

4.5.3 Rainwater Harvesting (Additional water Sources)

Cisterns act as a major source of domestic water supply in the localities that do not have water supply networks. It is estimated that 6.6 MCM is utilized from the cisterns. In localities where water networks exist, cisterns still act as another “good” source of domestic water supply (Abu Zahra, 2000).

4.6 Water Tariff

There is not one tariff system existing in West Bank. There are many systems. Each municipality or utility has its own tariff system. Each one applies different structure than the other. These structures are not designed in the proper way, which depends on the scientific financial analysis. They used old account systems. The blocks they used are chosen in random way and prices are determined as the municipality council decides. Each one put minimum limit as it wants without taking the consideration of the consumer's conditions (Issa, 2003).

Fig 4.2 Mountain and coastal aquifers (UNEP, 2003)

4.7 Water Consumption

According to the WHO, 100 liters per day constitutes the minimum water amount needed for a balanced and healthy person. The average consumption of Palestinians from water networks in rural areas is approximately 41 l/c/d. The average water consumption is also an indicator for the availability of water supply, for example the communities that are short of water networks or those that undergo water cuts by Mekorot have both reflected low consumption rates. Table (4.1) shows water consumption in Palestinian districts.

Table 4.1 Water Consumption in the West Bank in 2007, by Districts

District	**Annual quantity of water supplied to the district (in million cubic meters)**	**Loss (resulting from defective pipes or theft)**	**Per capita daily consumption (in liters)**
Jenin	6.43	34%	44
Tubas	0.92	27%	37
al-Quds	7.55	32%	86
Hebron	16.69	30%	56
Salfit	2.12	29%	67
Tulkarm	9.74	39%	99
Nablus	11.76	37%	62
Qalqiliya	5.20	26%	112
Bethlehem	9.74	39%	89
Ramallah	14.79	32%	96
Jericho	3.60	20%	183
Total	**88.57**	**33%**	**84**

Source: The Palestinian Water Authority's statistics for the end of 2008, (PWA, 2008)

4.8 Water Services

Recently, surveys and studies revealed that water network coverage is around 65-90% of communities in the oPt. However, the system lacks an equitable distribution among the different communities and governorates with a distinct split among rural and urban communities (Water for Life, 2007). Table (4.2) shows population of the WB not connected to a running-water network, by district. The table below shows dissimilarities among governorates. Coverage among the central region of the WB is higher than both northern and southern regions. Reasons for this are demographical aspects since this area contains larger number of rural communities within its borders, also the communities are much more spread out amongst each other making it harder to expand piped networks and other political reasons such as interruption by settlements, military zones, and area C, besides the destruction of infrastructure by occupation.

Table 4.2 Population of the West Bank Not Connected to a Running-Water Network, by District

District	**Number of residents**	**Communities not Connected to Running-water Network**	**Residents in Unconnected Communities**	**Residents not Connected to Running-water Network** (by percentage)
Tubas	50,380	12	14,796	29%
Nablus	332,102	26	67,772	20%
Jenin	264,667	31	49,284	19%
Qalqiliya	94,051	7	5,373	5.7%
Salfit	61,426	2	8,032	13%
Tulkarm	163,434	5	2,707	12%
Hebron	569,317	47	38,712	7%
Bethlehem	182,340	0	0	5%
al-Quds	164,247	3	2,113	0.9%
Ramallah	287,193	0	0	0.06%
Jericho	43,101	0	0	0
Total	**2,212,262**	**134**	**191,238**	**10.4%**

Source: (Betselem, 2008)

4.9 Deficit in Supply and Demand

The latest study on supply and demand in the West Bank has indicated that there is a gap of around 70 MCM between demand and supply for all sectors. This gap is expected to grow significantly if no other sources are developed and no further demand management is implemented.

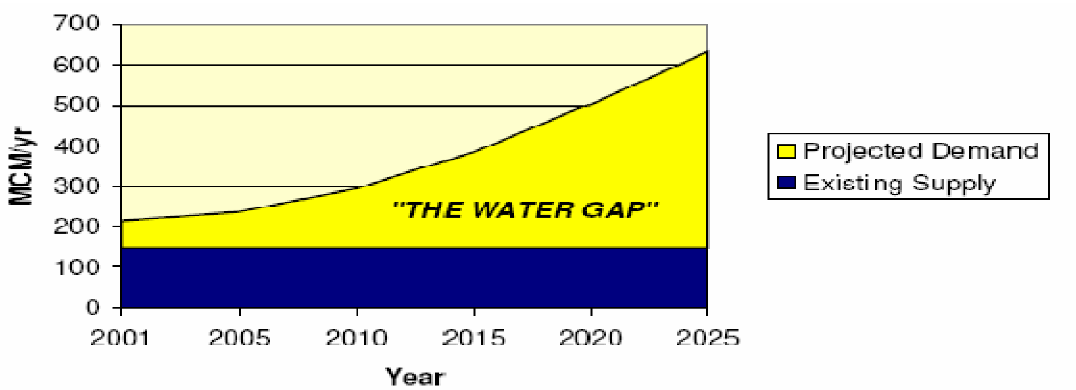

Fig 4.3 Gap between existing supply and projected demands (Froukh, 2007)

Table 4.3 Supply and Demand Quantities for 2008

Governorate	Population (1000)	Needed Quantities (MCM)	Available Quantities (MCM)	Deficit (MCM)	Actual Consumption (MCM)	Actual Deficit (MCM)
Jenin	264.667	14.491	6.432	8.059	4.271	10.220
Tubas	50.380	2.758	0.924	1.834	0.673	2.085
Tulkarm	163.434	8.948	9.745	0.000	5.905	3.043
Nablus	332.102	18.183	11.761	6.422	7.456	10.727
Qalqilya	94.051	5.149	5.207	0.000	3.832	1.317
Salfit	61.426	3.363	2.122	1.241	1.500	1.863
Jericho	43.101	2.360	3.609	0.000	2.873	0.000
Ramallah	287.193	15.724	14.79	0.934	10.072	5.652
Jerusalem	164.247	8.993	7.552	1.441	5.135	3.858
Bethlehem	182.340	9.983	9.744	0.239	5.915	4.068
Hebron	569.317	31.170	16.698	14.472	11.622	19.548
Totals	**2,212,262**	**121.121**	**88.579**	**34.641**	**59.255**	**62.380**

Source: (PWA ,2008)

4.10 Water Use Patterns

The total Palestinian use from the groundwater resources in the West Bank is approximated to 118 MCM annually which has declined to 94 MCM in 2009. 50 MCM is used annually to irrigate 90,000 Dunums of land while 44 MCM is used for the domestic use including industry (PWA, 2010[a])

4.10.1 Domestic and Municipal Sectors

The total water use by the domestic and municipal sectors in the WBGS during 2006 was estimated to be 130 MCM/year. An amount of approximately 75 MCM/year was used in the WB, whereas a total of approximately 55 MCM was used in GS. No accurate records of domestic water consumption rates are currently available, as quantities allocated to the various sectors (i.e., domestic, public, industrial, touristic, and commercial) cannot be separated. Hence, assumption was made that water consumption rates for public, industrial, and commercial uses are about 12 percent of the total consumption quantities based on data available on selected area in the WB (Jayyousi and Srouji, 2009).

4.10.2 Industrial Sector

The existing situation of the industrial sector in Palestine, which consists mainly of light and small industries, does not represent the actual stable industry that should be achieved in Palestine. This implies that the current industrial water demand cannot be utilized for the projection of the future water needs. The Present industrial Water consumption is included in the total present domestic consumption and is very difficult to estimate. According to PWA estimates, the present industrial water demand in Palestine represents 8% of the total municipal water demand.

However the national vision regarding this sector in reference to different studies carried out by MOPIC and MOIn is the establishment of 9-13 Palestinian industrial estates of which eight are distributed between the different Governorates of the WB.

The total area of the industrial zones that are in operation in the WB is around 7 Km^2 with some 14,105 industrial firms distributed inside the municipal areas (Jayyousi and Srouji, 2009).

4.10.3 Agricultural Sector

The agricultural sector has been traditionally important to the economy of Palestinians in terms of its contribution to GDP and employment but is on the decline (Mogheir, 2005). The current supply of water in West Bank through irrigation is about 89 MCM. This water comes from springs and wells (Jayyousi and Srouji, 2009) and this amount is likely to decrease proportionally with the rising demands in the domestic and industrial water. Moreover, most of the wells and springs that were used for agriculture have been drying up, with no availability of digging and licensing new wells (IDRC, 2009).

4.11 Wastewater Status

Appropriate management of wastewater has been neglected throughout the Occupied Palestinian Territories, both prior to and during the present conflict, and little investment has been made in the wastewater sector since the Oslo Accords. The situation is worsened by the discharge of untreated wastewater from Israeli settlements (UNEP, 2003). In the OPT it is estimated that over 60-75 MCM is generated annually. Although there has been expansion in water networks, this has not been met with analogous development of the wastewater network (Water for Life, 2007). About 1.43 million in 446 community mainly in rural areas of WB lack any Wastewater network (PWA, 2010[b]), instead, cesspits are used. The high cesspit and septic tank coverage has not necessarily secured the basic needs of Palestinians sanitation conditions. Cesspits are particularly problematic because they are not serviced regularly causing pits to fill up spilling wastewater (Water for Life, 2007). Most of the cesspits enable sewage to infiltrate into the earth layers polluting the groundwater, and causing severe environmental problems and health hazards (Sbeih, 2008). Moreover when they are full they are emptied by sewage tankers and the contents are disposed of in a nearby sewage dump or simply into wades surrounding the area. A cesspit with an average volume of 25 m^3 is usually emptied once every 5 to 6 months. Obviously, no treatment prior to disposal occurs in most of the areas. Four Wades in the West Bank carry wastewater all over the year during the summer and winter seasons, and considered as pollutant carrier that mixed with rain water, are Wade Al-Nar (Eastern aquifer), Wade Al-Fara' (North Eastern Aquifer), Wade Al-Zumar (western aquifer), and Wade Qana (western aquifer). The groundwater contamination from disposal of wastewater will result in the direct contamination of springs. Moreover, the flow of raw wastewater into open areas will negatively affect the soil cover and plants. Additional problems connected to existing discharges also include odor and aesthetic problems (Ghanem, 2004). Wastewater may also contaminate nearby cisterns and crops in addition to direct health hazard. It is not easy to identify the occurrence of waterborne diseases except for large scale infection incidents such as Burin (Nablus), where 450 people were diagnosed with Hepatitis A due to the free flow of untreated wastewater (Water for Life, 2007).

Sanitation coverage figures are given for each community at appendix (A). A 2002 UN Environmental Program report showed that raw sewage polluted West Bank Palestinian water sources. A 1998 Al-Quds University study of the Jordan Valley, Nablus, Jenin and Tulkarm found one-third of samples with higher than WHO recommended nitrate levels. A 1999 Bethlehem University investigation showed over 99% of 400 spring water samples with high concentrations of coliform bacteria requiring removal before use (Lendman, 2009).

Palestinians have been prohibited from developing wastewater treatment plants that could potentially contain the environmental catastrophe currently occurring in the WB (Water for Life, 2007). The Palestinian experience in treated wastewater reuse is still young and poor, the existing treatment facilities of the main Palestinian cities are overloaded, except for Al-Bireh WWTP (MEDAWARE, 2005). However, several small scale wastewater treatment plants have been constructed in the unsewerd rural areas of the West Bank. In addition, some applied research studies of biological treatment systems for small rural communities were recently installed and studied. The only organizations involved in the construction process are NGOs with international funds (EMWATER, 2004).

But since 1990, More than 600 onsite grey water treatment units are operating in Palestinian rural areas and the reuse of the effluent in agriculture is increasingly accepted and practiced incentivized by the financial revenues from the implementation such as decrease in water consumption, garden irrigation, and nutrients recirculation. However the difficulties for implementing these units are financial considerations and lack of funds, health concerns, lack of experience and vision in the system's performance and operational requirements (Mahmoud and Mimi, 2008).

Wastewater quantity as well as their characteristic is currently not well defined due to the lack of data. The quality of wastewater is usually judged by its BOD5 or COD which in turn is governed to a very large degree by its water consumption. The higher the concentration of the organic matter in a wastewater the stronger it is said to be (Mara, 2003). The West Bank per capita water consumption is low, so the generated wastewater is concentrated and its strength is high. Considering the limited industrial activities in the West Bank; light industries are prevailing, which means that heavy metal contamination is not probable (EMWATER, 2004).

Chapter 5: Results and Discussion

5.1 Factors Affecting Reuse Potential

An in-depth analysis is required to come up with a sound assessment of wastewater reuse potential. The reuse potential in rural areas is affected by a range of factors such as:

- Local water demand and existing water tariff
- Collection method and cost of treatment
- Effluent quality
- Degree of community acceptance
- Environmental impacts

This chapter discusses local water demand, collection method and cost of treatment and effluent quality in details. Social, environmental and economic considerations for some reuse options are discussed briefly for selected reuse options.

5. 1.1 Local Water Demand and Existing Water Tariff

From Chapter three it is found that 80% of consumed water quantities in Palestinian rural areas are supplied by water networks, 10% are supplied from cisterns, and 10% are from water vendors.

The 383 implemented onsite wastewater treatment units treat a very small unmentionable part accounting for 7% of the collected wastewater. Besides, the 10 implemented collective wastewater treatment systems in Palestinian rural areas treat also very small unmentionable part accounting for 0.3 % of the wastewater amount. This assures the fact that the wastewater treatment and reuse sector is still very poor and tremendous efforts are needed to improve the sanitation sector.

The total wastewater generation rate for 2007 in Palestinian rural areas as shown in Annex (A) is 8,975,513.3 cubic meter per year, and it is estimated that the average wastewater generation rate will increase to 13,928,964.5 million cubic meter by year 2030 as Table (3.6) and Fig.(5.1) show. Reusing one cubic meter of wastewater saves one cubic meter of freshwater and avoids the negative effects of polluting the environment. Achievements in water savings can be done through reuse of treated wastewater in other uses that does not require the best quality of water.

This reallocation of water must be studied. Table (5.1) shows water tariff for year 2008.

Table 5.1 Water Price NIS/m^3 According To the Supplying Agency 2008

Governorate	Supplying agency	0-10	11-20	21-30	31-40	41-50	Above50
Jenin	Jenin	4.5	4	4	4	4	6
Jenin	Qabatya	4	4	5.5	5.5	5.5	5.5
Tubas	Tubas	3	3	4	5.5	6	6
Tulkarem	Tulkarem	3	2.5	2.5	3	3.5	3.5
Nablus	Nablus	3.7	6.5	7.6	7.8	9	10
Qalqiliya	Qalqiliya	3	0.5	0.5	0.7	0.8	0.8
Salfit	Salfit	3.5	3.5	4	4	4	4.5
Ramallah	Water undertaking	4.1	4.6	4.9	4.9	5.5	6.3
Jerusalem	Water undertaking	4.1	4.6	4.9	4.9	5.5	6.3
Jericho	Jericho	1	1	1	1	1	1
Bethlehem	Water undertaking	4	4	4	4	4	4
Hebron	Hebron	4	4	5	5	5	5

Source: The Palestinian Water Authority's statistics for the end of 2008 (PWA, 2008)

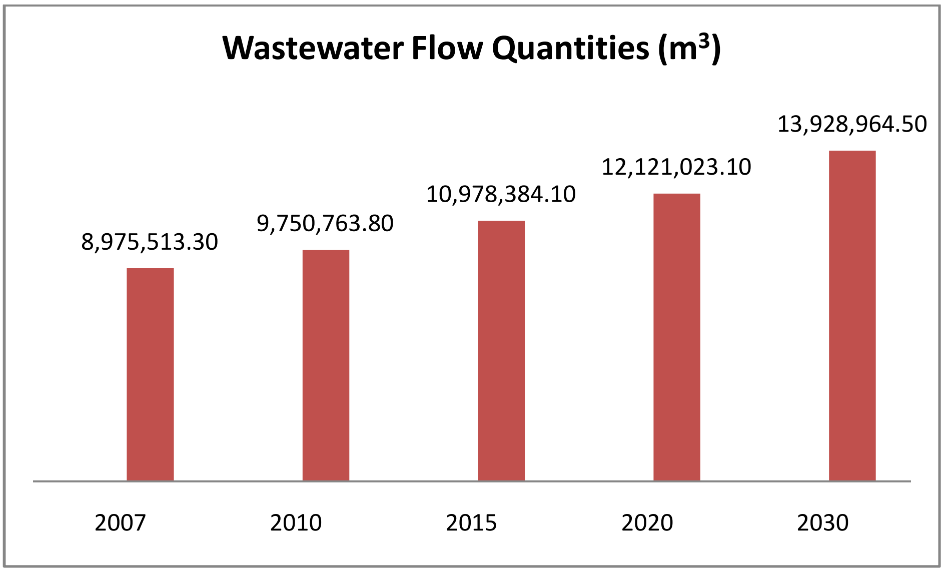

Fig. 5.1 Projections of Wastewater Flow Quantities

If all of the wastewater generated by Palestinian rural areas were to be reused, it would be possible to save some7% of the 114 MCM of groundwater resources in the WB. Indeed, 12% of the 75 MCM used annually by the domestic sector in the WB could be saved. 14% of the supply and demand gap shown in Table (3.9) could be bridged by this unconventional water resource development. The figure of 14% shows that wastewater reuse in rural areas by itself is not sufficient to achieve the savings needed, although the figure is large enough to generate relevant effects and scopes of action.

At Jericho, water is abundant and there is no water deficit between supply and demand as shown by Table (3.9), in addition to that, the water tariff used in Jericho is one of the lowest in WB districts as shown in Table (5.1). These factors may hamper the implementation of reuse projects.

For Qalqiliya district the generated wastewater quantities can compensate for 52% of the gap between supply and demand. This later is one of the lowest with respect to other districts. However, the very low water tariff makes the reuse option unattractive. In the contrary, Ramallah has a higher water tariff, besides the generated wastewater quantities in Ramallah can make up for 34% of water deficit. This makes Ramallah a good candidate for the implementation of water reuse.

The water tariff in Jerusalem and Bethlehem is very close to Ramallah water tariff, however their supply and demand gaps could benefit from wastewater reuse only by percentages of 19%, 23% respectively.

In the case of Hebron, although the actual deficit in water is the largest amongst WB districts, but reusing wastewater will just compensate for 2.5% of water deficit.
In Nablus district the water tariff is one of the highest amongst other districts, this could be an incentive for reusing wastewater, however the deficit between supply and demand could be bridged by a percentage of only 14%.

In the case of Tubas, Salfit and Tulkarem the water deficit gap is low with respect to other districts and each have a moderate water Tariff. The generated quantities of wastewater in these districts could potentially compensate for 7%, 27.5% and 24% respectively from water deficit.

Jenin is one of the districts that suffer badly from water shortage having a deficit between supply and demand of 10 million cubic meter, the water tariff is also not low, these are incentives for wastewater reuse, however the water consumption of water is low imposing a low rate of wastewater generation, the amount of water that could be recovered from wastewater reuse can only cover 9.4% from the supply and demand gap.

5.1.2 Collection Method and Cost of Treatment

The fact that most of the generated wastewater in Palestinian rural areas remains not collected in sewered systems brings up the question of how to collect these amounts to be available for treatment and utilization. Centralized approach of wastewater treatment and reuse systems in rural areas is not a convenient one, since these systems are costly to build and operate, especially in areas with low population densities and dispersed households (Massoud et al., 2008). On the Other hand, Political obstacles also stand in the way of centralized reuse progress. The construction of these systems are prevented by the Israeli Authorities and conditioned by connecting the Israeli Colonies to the same system (Rabi, 2009), in addition to this, the stringent standards enforced by the Israeli side on the effluent of the centralized treatment plants will be very hard to be achieved by the Palestinians. Decentralized systems will have less political complications with the Israeli side. The important characteristic that distinguishes this type of wastewater management from larger systems is that there is a much greater potential for the treated wastewater to be generated closer to the potential reuse sites.

In order to compare the investment costs for onsite and collective systems. Table (3.7) and Table (3.8) show these costs. For year 2007 the number of onsite treatment units needed to treat the generated 7,180,410.64 m^3 of rural grey wastewater is 39,345 units. This will require an investment cost that ranges between 78.7 – 157.4 million $ as shown in Table (3.7). However this cost is much higher for collective systems. The investment cost that is required to implement collective systems (including the sewerage lines) to treat the whole amount of rural wastewater will range from 203,725,000.0 – 245,875,000.0 $ as shown in Table (3.8).

5.1.3 Effluent Quality and Potential for Different Reuse Applications

Results of the analysis of raw municipal, grey and black wastewater for different parameters from different sites in Palestinian areas are reported in Table (5.3).

Table 5.2 Characteristics of Raw Municipal and Rural Domestic Wastewater in the West Bank

	Municipal Urban Wastewater				Rural Domestic Wastewater	
Parameter mg/l	**Ramallah**	**Nablus**	**Hebron**	**Al-Bireh**	**Grey**	**Black**
BOD_5	525	11850	1008	522	286 941 – 997[a]	282
COD	1390	2115	2886	1044	630 1391 – 2405[a] 462.1-933.1[b]	560
Kj-N	79	120	278	73	17	360
NH_4 –N	51	104	113	27	10 25 - 45[a]	370
NO_3 –N	0.6	1.7	0.3	-	1 0 – 1.3[a]	-
SO_4	132	137	267	-	53	36
PO_4	13.1	7.5	20	44	16	34
Cl-	350	-	1155	1099	200	-
TSS	1290	-	1188	554	- 36 – 396[a]	-
Fecal Coliforms CFU/100ml					$1*10^4$-$37*10^4$ [a]	
Total Coliforms CFU/100ml					$1*10^9$-$5*10^9$ [a]	

Source: EMWATER (2004)

a Qebia Case study Burnat and shtayye, 2009)

b Different plants in rural areas in Ramallah and Bethlehem. PHG (2007)

Table (5.2) shows that the generated wastewater is concentrated. Its strength is high due to the fact that the West Bank per capita water consumption is low. Considering the limited industrial activities in the West Bank; light industries are prevailing, which means that heavy metal contamination is not probable. Table (5.2) shows also that the municipal urban wastewater is stronger than the grey wastewater in terms of COD, BOD_5. Higher values occurred in houses with small children who are bathed in sinks. The ammonium concentration in the black wastewater is much greater than the grey wastewater due to the presence of urine. The results show that raw wastewater cannot be reused without treatment since most of the parameters exceed the Palestinian Standards. Fecal coliforms exceeds WHO guidelines (200-1000 /100 ml) for irrigation of crops likely to be eaten uncooked, sport fields and public parks.

The collected wastewater must be treated to adjust its quality to any of the following end-uses: (i) irrigation, (ii) artificial recharge, (iii) potable water supply, (iv) toilet flushing, and (v) industrial water supply (Abu Madi and Al Sa`ed, 2010). Shelef (1991) as cited by Kretschmer et al, (2004) describes the potential types of the various consumptive uses of reclaimed wastewater together with their respective water quality considerations in a more or less scending order of quality requirements in Table (5.3).

Table 5.3 Consumptive Uses of Reclaimed Wastewater Together With Their Respective Water Quality Considerations

Consumptive use	**Removal of Pathogens**	**Chlorine residual or other disinfection**	**Removal of Susp. Solids & Turbidity**	**Presence of dissolved oxygen**	**Removal of BOD & COD**	**Removal of Nutrients**	**Removal of Taste, odor and color**	**Removal of Trace Organics and Metals**	**Removal of excess Salinity**
Forest and landscape irrigation	X	-	X	X	X	-	X	X	0
Irrigation of restricted crops	X	-	X	X	X	-	X	X	0
Unrestricted irrigation of crops	Xxx	Xxx	Xxx	Xx	Xxx	-	Xx	Xxx	X
Groundwater Recharge	Xxx	Xx	Xxx	Xx	Xxx	xxx	Xxx	Xxxx	-
Industrial reuse	Xx	Xx	Xxx	Xxx	Xxx	xxx	Xxx	Xx	Xx
Dual urban systems (toilet flushing; gardens)	Xxxx	Xxxx	Xxxx	Xxxx	Xxxx	xxx	Xxxx	Xxxx	Xx
Potable reuse	Xxxxx	Xxxxx	Xxxxx	Xxxx	xxxxx	xxxx	Xxxxx	Xxxxx	Xxx

Source: (Kretschmer et al., 2004)

(-) no need; (0) usually not essential; (x) slight need; (xx) moderate need; (xxx) strong need; (xxxx) stringent requirements; (xxxxx) very stringent requirements.

The two bottom rows of consumptive uses of treated wastewater in table (5.4) require the highest effluent considerations since these two are associated with direct human exposure.

Wastewater reuse options are studied using the scenarios of collection suitable for rural areas; Onsite Treatment Units at household level and Collective Treatment Systems at community level. Projects quality results for onsite treatment units and collective systems were compared with the Palestinian Standards of treated wastewater 742-2003 as shown in Tables (3.10) and (3.11). For onsite treatment units fruiting trees could be irrigated with the effluent from treatment plants generating effluent with COD, BOD and TSS values less than 150, 60 and 90 mg/l respectively but with 3 barriers. Unfortunately, the treated effluent from the collective systems is not suitable for even unrestricted irrigation. The effluent quality in terms of BOD and FC is not complying with the worst effluent quality, type D, imposed by the Palestinian Standards.

5.2 Water Savings under Two Scenarios of collection and Treatment

5.2.1 First Scenario: Water Savings with Onsite Treatment Units at Household Level

5.2.1.1 Reuse for Garden Irrigation

Garden water use which is assumed to equal outdoor water use in *section 3.5 part A* is estimated to be 2,253,698 cubic meter. This amount could be reallocated for other water stressed needs such as water for drinking if wastewater reuse was implemented. Moreover, if treated wastewater reuse is implemented surplus amounts of water will be available for outside use, in Canada for example, the outdoor water consumption reaches more than 50% of water use. If this amount was to be used nationally 5.5 million cubic meters annually could be utilized for greening backyards and home gardens. Households can improve the productivity of their gardens, reduce food costs, grow fruits nearby for their own consumption, and improve their nutritional status.

5.2.1.2 Reuse in Non Potable Domestic Applications (Toilet Flushing)

The total indoor water consumption by Palestinian rural communities equals 3,065,029 cubic meters annually as shown in *section 3.5 part B.* If this amount was to be considered as water savings with this reuse option, effluent with stringent quality requirements- as shown by table (5.4) - should be available from treatment plants which is not the case herein especially if mixed wastewater is used. Even if grey wastewater is the source for toilet flushing, the system will require a duel system hence, the level of complexity of treatment and operation of grey water systems designed to produce water for toilet flushing is considerably more complicated than for garden irrigation, and leads to increased operation and maintenance costs.

5.2.2 Second Scenario: Water Savings with Collective Treatment at Community Level

The reuse potential for application using this approach will be reuse for forests and landscape irrigation, reuse for irrigation of crops, reuse for groundwater recharge and reuse for industrial purposes. This section discusses each reuse option.

5.2.2.1 Reuse for Forests and Landscape Irrigation

The irrigation of forests has the lowest requirements concerning quality considerations as shown in Table (5.2) and Table (3.11). However, for Palestinian rural areas this option is not expected to be a common practice. The forest and landscaping will need a dual network system which means increase cost. Besides, forests are usually not situated near villages, which makes it unfavorable choice for reuse, in addition to that, there are much urgent needs for wastewater reuse in Palestinian villages such as agricultural crops which will contribute to water savings. However, from the ecological assessment point of view the environment can benefit from this water resource if they are used, to conserve forests, benefiting from the nutrient content. This reuse option will not contribute to solving the problem of water stress since the majority of forests are rain-fed. No reallocating of water resources will take place; hence no water savings are achieved.

5.2.2.2 Reuse for Irrigation of Crops

The quality analysis for collective systems as shown above does not allow wastewater reuse for any of the reuse options. If assumed that the quality generated by collective treatment systems is improved, dry fodders, industrial and cereal crops have a very high potential to be irrigated with treated wastewater in terms of effluent quality requirements according to WHO and Palestinian standards. However, it will not contribute to solving the problem of water stress since the majority of these crops are rain-fed. No reallocating of water resources will take place, even though this reuse option will enhance the yield of crops and gain economical benefits.

Hence, and under the same assumption that the quality of generated effluent is improved, fruiting trees will have high potential in terms of quality and water savings to be the option for reuse. Collective systems at community level will be the most convenient option to some villages but not for all. The amount of water saving by this reuse option as section 3.5 Part D indicates is

1,077,244 m^3/y which could add to the water balance.

Table 5.4 Wastewater Quantities Available as a Percentage of the Total Water Crop Requirements

	Total Water Crop Requirements m^3/y	wastewater quantity m^3/y	%
Hebron			
Beit 'Einun	283,050	26,411	9.3
Qla'a Zeta	78,100	12,152	15.5
Jericho			
Az Zubeidat	15,200	60,944.5	400.9
Al Jiftlik	16,400	76,529.7	466.6
Fasayil	43,600	72,998.2	167.4
Ramallah			
Saffa	11,550	709,89.1	614.6
Beit 'Ur al Fauqa	7,000	18,832.4	269.0
Salfit			
Deir Istiya	64,800	32,387.3	50.0
Kafr ad Dik	16,800	50,313.2	299.5
Yasuf	14,400	24,186.7	168.0
Qalqiliya			
Falamya	642,200	13,828.7	2.1
Jayyus	219,700	57,642.1	26.2
An Nabi Elyas	172,800	28,432.7	16.4
Ras 'Atiya	30,000	34,186.9	114.0
'Azzun 'Atma	84,000	36,183.7	43.1
Nablus			
Talluza	260,400	52,357.2	20.1
An Nassariya		20,947.6	
Zawata	58,800	41,191.6	70.0
Tulkarem			
Nazlat 'Isa		59,933.9	
An Nazla ash Sharqiya	69,600	32,489.2	46.6
An Nazla al Gharbiya		10,402.7	
Zeita	111,600	56,644.3	50.7
Kafa	96,000	137.8	0.1
Far'un	420,000	66,558.1	15.8
Shufa	204,000	56,187.9	27.5
Kafr Jammal	88,800	19,661.6	22.1

	Total Water Crop Requirements m^3/y	wastewater quantity m^3/y	%
Tubas			
Bardala	338,400	41,460.1	12.2
'Ein el Beida	58,400	29,272.2	50.1
Al Farisiya	23,400	1,404.5	6.0
Kashda	19,250	118.2	0.6
Ras al Far'a	468,000	12,731.4	2.7
Wadi al Far'a	17,500	17,576.2	100.4
Jenin			
Deir Ghazala	24,000	12,487.6	52.0
Al Hafira	18,000	652.9	3.6

% = wastewater quantity (m^3/y) *100/water crop need m^3/y

The above table does not specify the irrigation quantities needed by the cultivated land, because each crop water requirements differ according to the type of crop, effective rainfall, slope of area, etc. but still at least it gives an indication of the wastewater quantities available as a percentage of the total water requirements of the cultivated land.

The quantity of treated wastewater as a percentage from the total crops water need indicates that rural villages with agricultural lands lie in one of three categories:

1. *Wastewater quantities are greater than crops water needs;*

In this case mixed approach between cluster and onsite sanitation and treatment system will be the optimal solution. The cluster system will deal with the quantity of wastewater to supply the demanded quantity for agricultural irrigation. Treatment unit site must be chosen as near as possible to the irrigation site. Quantities of wastewater not collected and treated by the cluster system must be treated by onsite treatment plants. Therefore, each village gains water savings from both approaches. Examples of these villages are Az Zubeidat and Al Jiftlik in Jericho and Saffa in Ramallah.

2. *Wastewater quantities is very much close to the crops water needs quantities;*

In this case cluster system and treatment will be best for villages in this category, all or most of the generated wastewater will be treated and reused in the same village. Savings in water quantities will be achieves by the reallocation of agricultural water to other urgent water needs such as drinking water. An example of these villages are Ras Atiya in Qalqilya and Wadi el Far`a in Tubas.

3. *Wastewater quantities are much less than agricultural water quantity requirement;*

In this case there are two possibilities:

a. Wastewater quantities are very limited thus; onsite treatment and reuse for garden irrigation will be the best choice to water savings. Kafa in Tulkarem, Kashda in Tubas and Alhafira in Jenin are examples of those villages.

b. Wastewater quantities are available but not in amounts that will be enough to irrigate all cultivated land, in this case cluster approach to collect and treat and reuse the available amounts will supply part of the water needed by agriculture, and will save equal amount of fresh water for other uses.

   An alternative approach to achieve more savings in water will imply the integration of treated urban wastewater to supply the deficit amounts that rural areas alone cannot afford for agriculture. Urban wastewater treatment and reuse is out of the scope of this study. Half of the villages in Table (5.11) lie in this category. Jayyus in Qalqiliya, Zeita in Tulkarem, Talluza in Nablus are some of these villages.

One of the most important criteria that one has to pay attention at is the salinity especially in the arid and semi-arid zones; the salinity in the root zone is directly related to the water quality, irrigation methods and practices, soil conditions and rainfall. Crops and soil can be protected by already available information on crops and soil sensitive to wastewater irrigation. Groundwater and surface water can be protected by mapping sensitive areas, such as shallow aquifers used for drinking, and banning wastewater irrigation in those areas. Table (5.12) summarizes the needed information for using treated effluent in irrigation.

Table 5.5 Agricultural Needs Requirements for Using Treated Effluent in Irrigation

Information needed	Decision
Available effluent Quantity during growing season	Total area irrigated of special crop
Available effluent quantity during the whole year	The need for storage facility
The rate of delivery of effluent and type of delivery	Irrigation scheduling
TDS or EC of effluent	Crop selection & leaching requirement
SAR of effluent	Assess sodicity hazard
Concentration of toxic ions (heavy metals, B, Cl…)	Assess toxicity hazard
Concentration of nutrients	Set fertilization programme
TSS	Choose irrigation system and filtration method

Source: MoA (2010[b])

5.2.2.3 Reuse for Groundwater Recharge

Since the quality of the water of a recharged aquifer is a function of the quality of the recharge water, the recharge method used, the physical characteristics of the vadose zone and the aquifer layers, the water residence time, the amount of blending with other sources and the history of the recharge regulations for water, quality should be made to avoid any significant and sustained degradation of either the quality or quantity of aquifer water (Brissaud, 2006). The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, by retention and oxidation processes. However, forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is hardly feasible. Therefore, when transfer through the vadose zone is part of the treatment intended to bring injected water up to potable water quality, a case-by-case approach is highly recommended. For each project, pollutant removal tests should be performed, at the laboratory and onsite. Every category of pollutants of concern should be considered.

Recharging potable water aquifer with secondary effluents through such treatment would not be recommended; further treatment, including microbial decontamination, would be needed to reliably obtain potable quality in the aquifer. Furthermore, relying on water transfer in the unsaturated zone to meet potable water quality would not be recommended in heterogeneous soils. Recharge for non-potable reuse, health related standards might be less stringent. For irrigation, limits can be set for other parameters such as organic matter and heavy metals. As with potable aquifer recharge, relying on the saturated zone of aquifers to improve the recharged water quality is not recommended; even if there is no doubt that filtration effects exist. The saturated zone should only be considered as an additional barrier. The saturated zone When highly permeable or heterogeneous onsite soils are not able to provide the required treatment, infiltration percolation through calibrated sand beds filling pits excavated at the soil surface can be used as a treatment before infiltration through onsite soil layers (Brissaud, 2006).

Groundwater recharge by treated wastewaters is especially controversial in the Middle East, due primarily to concerns over the long-term accumulation of trace contaminants in aquifers. Direct recharge for aquifers is prohibited by the Palestinian specifications, but recharge by filtration is possible with effluent not less than quality C, BOD-TSS (40-50) mg/l FC<1000/100 ml.

The contamination of aquifers is already a significant issue for Palestine. The Mountain Aquifer system underlying and largely recharged from the West Bank is by far the most important source of water in this area. The aquifer system is highly permeable due to its geological nature. The limited soil cover over the water recharge zones makes the aquifers highly susceptible to pollution since there is no natural barrier to contaminants that travel down rapidly to the water. Further, salinization can occur from subterranean saline water bodies, if and when the aquifer is over-pumped (UNEP, 2003). Groundwater recharge for aquifers that are not used as drinking water supply is one of the explicit uses of wastewater in Jordan (Scott et. al, 2004).

Based upon the above discussion, it is a good decision to ban recharging aquifers with direct injection, but still, there should be more stringent standards in the Palestinian specifications associated with recharging aquifers by filtration. In general, distinction should be made between aquifers that are used as a source for drinking water supply and those used for agricultural purposes, a case-by-case approach is highly recommended.

5.2.2.4 Reuse for Industrial Purposes

Reclaimed wastewater is ideal for many industries where processes do not require water of potable quality, and when industries are located near populated areas where centralized WWTPs already generate an available source of reclaimed wastewater (Abu Madi, 2004). Considering the limited industrial activities in the West Bank; light industries are prevailing, the reuse of domestic treated effluent in industry will not be of much significance. The industrial zones - according to the national vision mentioned before - will be located inside governorates and far away from rural areas. In addition to this, the treatment requirements will vary according to the type of industry (textile, food industry, cooling… etc). Moreover, it is common for industries in western countries to reuse their own wastewaters before discharge, this also is the case for some industrial locations in the West Bank; i.e Al Robeh Treatment Plant in Hebron which treats the wastewater from 8 cutting stones and is expected to treat for a larger number (field visit with PWA, 2010).

5.2.2.5 Reuse for Potable Purposes

A way of wastewater reuse involves providing water by highly treated wastewater; high-quality potable water can be produced if advanced technologies are applied to secondary/tertiary urban wastewater effluent. "Such implementation would yield many advantages , namely: satisfying the increasing agricultural, industrial and domestic demands for good quality water that is free from viruses and bacteria and other microbial present preserving the natural strategic water resources; reducing the environmental pollution resulting from the direct discharge of secondary/tertiary municipal effluents to the sea; and meeting unexpected emergency cases of shortages in freshwater produced from the desalination of seawater for certain domestic applications" (Abdel-Jawad et al., 2002). However, the use of recycled water for direct potable reuse raises a number of issues and requires a careful examination of regulatory requirements, health concerns, project management and operation, and public perception. According to Table (5.5) potable reuse imposes very stringent requirements. Direct potable reuse currently is not practiced anywhere in the U.S. It was implemented on an emergency basis in Chanute, Kansas, for a five-month period in 1956 during an extreme drought circumstance and was evaluated in Denver, Colorado, during a demonstration project from 1985 to 1992. The only known existing direct potable reuse facility in the world is located in Windhoek, Namibia (Crook, 2010). Despite the viability of technology to produce drinkable water quality it is unlikely that it will be widely adapted because of the high cost and low public acceptance (Abu- Madi, 2004). In Palestinian Rural areas all of the above mentioned reasons will be barriers for this option of reuse.

Chapter Six: Framework for a National Palestinian Strategy for Management of Rural Wastewater

Managing Wastewater in Palestinian rural areas should be based on an integrated approach. Collection, treatment and reuse should be taken into account when considering any scenario of the process. Alike many developing countries, Palestine lacks a national wastewater management strategy that can effectively protect public health and environmental quality. This has led the local communities and NGOs to plan and implement their own arrangements for wastewater treatment systems. However, most local communities still lack the human and financial resources, management capabilities, and environmental awareness necessary to implement wastewater management in an environmentally sound manner.

Water stress is an issue for rural areas, 123 communities out of the 395 rural communities does not have water network as the blue color in Annex A indicates. Hence, there should be an expansion of the water services. Expected growth is projected to increase the base wastewater flow from 8,975,513.3 cubic meters for year 2007 to 13,928,964.5 cubic meters by year 2030. hence, accelerated extension of adequate wastewater management services to rural communities is essential.

Decentralized wastewater management will be the proposed strategy to manage wastewater in rural Palestinian areas. Existing cesspits can be replaced by low cost treatment alternatives. The total construction cost just to deal with current needs may reach for onsite systems between 78.7 – 157.4 million $ which is much lower than the investment cost required for collective systems which ranges from 203,725,000.0 – 245,875,000.0 $ in addition to annual operation and maintenance. This cost could increase by 20 % for onsite units, in order to accommodate future growth.

The first scenario of reuse - using onsite treatment units at household level - is the most practical scenario. The proposed reuse option is the home garden irrigation of fruit trees and flowers planted around houses for the 357communities out of the 395 rural villages.

From the results and discussion in chapter five, it is found that 357 communities in the West Bank generating almost 7,827,280.1 cubic meter of wastewater annually can benefit from onsite treatment units. The reuse of the treated wastewater in the irrigation of gardens around homes will approximately save an amount of fresh water that is equal to the outdoor water consumption by these households. Two million cubic meters could be saved annually if onsite reuse is implemented. For these rural areas, the implementation of onsite treatment plants should be planned through governmental bodies to achieve the expected results.

The other 34 communities annually generating 1,148,233 cubic meter of wastewater are mainly agricultural villages. The collective systems with the treated effluent are not enough to cover the water needs for irrigated agriculture within the villages for most of these villages. It is recommended to also apply onsite treatment units for households and use the effluent in irrigating fruit trees and flowers around homes. The savings in water will be of much significance if urban treated wastewater is used to cover the deficit of water needed for irrigation. For the few villages that the treated quantity of wastewater can by itself cover the water needs for agriculture, it is proposed to use collective systems in irrigating the fruit trees that those villages are cultivated with.

The limited available data on the quality of the effluent showed that onsite units at household level could be used in watering fruit trees, but collective systems do not comply with WHO or the Palestinian standards. Hence, quality analysis for the effluent should be done periodically to insure the safety on health and environment. Technical guidelines for site evaluation, design, construction, and operation/maintenance must be included in the management of onsite wastewater treatment and should be conducted through experts in order to overcome the malfunctioning of some units resulting from lack of maintenance issues. Some of the implemented onsite treatment plants as reported by the NGO`s stopped for reasons such as lack of maintenance. As such, the effectiveness of these systems, particularly with regard to the quality of the treated effluent, warrants evaluation. Accordingly, performance evaluation of the treatment/disposal systems must be carried out.

For any reuse project to be implemented, the goal must be first set through the master plan. Priority for the most stressing issue of the country that should benefit from the reuse has to be clarified. For example this thesis is dealing with the water stress issue as the most stressful problem for rural areas besides environmental problems resulting from the untreated sewage, however many other issues do exist such as food security and economic deterioration. All stakeholders should be involved in the process of identifying the goal of treatment and reuse, for example from the point of view of the MoA (2010[a]), "the agricultural sector would benefit most from reuse projects if large scale agricultural projects is implemented, and if new lands suitable for irrigation of specific crops such as almonds and dates are cultivated". This implies plentiful quantities of treated wastewater to be available, hence pushes towards benefiting from centralized treatment plants which can be installed in urban areas.

Chapter Seven: Conclusions and Recommendations

7.1 Conclusions

1. If all generated wastewater by Palestinian rural areas were to be reused as an unconventional water resource, it would be possible to bridge the supply and demand gap by 14%. The figure of 14% shows that wastewater reuse in rural areas by itself is not sufficient to achieve the savings needed, although the figure is large enough to generate relevant effects and scopes of action.

2. Ramallah has a higher water tariff from other districts, besides the generated wastewater quantities in Ramallah can make up for 34% of water deficit. This makes Ramallah a good candidate for the implementation of water reuse.

3. The investment costs for onsite systems which ranges between 78.7 – 157.4 million $ is much lower than the investment cost required for collective systems which ranges from 203,725,000.0 – 245,875,000.0 $.

4. Projects quality results for onsite treatment units and collective systems compared to Palestinian standards shows that: For onsite treatment units fruiting trees could be irrigated with the effluent from treatment plants generating effluent with COD, BOD and TSS values less than 150, 60 and 90 mg/l respectively but with 3 barriers. However, unfortunately, the treated effluent from the collective systems is not suitable for even unrestricted irrigation. The effluent quality in terms of BOD and FC is not complying with the worst effluent quality, type D, imposed by the Palestinian Standards.

5. From points 4 and 5 above the proposed systems to be applied in most of the rural Palestinian areas is the onsite systems at household level.

6. Within the first scenario, although reusing effluent in toilet flushing could save 3,065,029 cubic meters annually, but this will require a duel system hence, the level of complexity of treatment and operation of grey water systems designed to produce water for toilet

flushing is considerably more complicated than for garden irrigation, and leads to increased operation and maintenance costs. Home garden irrigation will save 2,253,698 cubic meters annually but will be easier to implement. Within the second scenario reuse with crop irrigation will save 1,077,244 cubic meters annually.

7. The reuse option that has the most potential to be adopted is the home garden irrigation around houses, with the type of crops to be planted and irrigated by the effluent is the fruit trees and flowers.

7.2 Recommendations

1. Given the blooming water resource crisis, wastewater must be recognized as part of the total water cycle and therefore managed within the integrated water resources management process.

2. The framework suggested in Chapter Six concludes that onsite treatment units must be maintained and monitored to control pollution and to recover water for non-potable water uses. Periodical supervision and monitoring and quality analysis concerning the onsite treatment units should take place in order for these units to achieve the expected results.

3. For any reuse project to be implemented, the goal of the project must be first set. Priority for the most stressing issue of the country that should benefit from the reuse has to be identified through stakeholders' participation.

4. More studies must be done to ensure that health and environmental risks are minimized.

5. Geographic Information System (GIS) could be used as a tool to identify threats to the aquifer, to illustrate suitability of areas for agriculture and agricultural value.

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Annexes

Annex (A)

List of all Palestinian rural areas with some major statistics

Annex (B)

Tables of results of wastewater samples collected from the wastewater treatment units at Attil, Zeita, Bidya and Seir during October 2008-September 2009, Water and Environmental Studies Institute (WESI) An-Najah

Annex A

Pop	Population
HHs	Households
Wc NW	Water consumption from network
% HHs using W NW	Percentage of households using water network
% HHs using Cis	Percentage of households using cisterns
Wc Tanks	Water consumption from tanks (vendors)
Qw Nw	Quantity of water consumed from water network
Qw Cis	Quantity of water consumed from cisterns
Qw tanks	Quantity of water consumed from water tanks (vendors)
% HH WW NW	Percentage of households having wastewater network
% HH Cess	Percentage of households having Cesspits
Qww NW	Quantity of wastewater collected in network
Qww cess	Quantity of wastewater collected in Cesspits

Summary of Palestinian Rural Areas Major figures

Governorate	Pop	Qw Nw	Qw cist	Qw Tanks	Qw total	Qww NW	Qww cess	Total Q (m3/y)
Jenin	99,194.0	574,667.1	303,121.4	326,660.7	1,204,449.3	47.9	963,511.5	963,559.4
Tubas	11,052.0	126,526.5	3,722.8	53,996.9	184,246.2	0.0	147,396.9	147,396.9
Tulkarem	34,683.0	879,138.4	58,504.6	9,358.9	947,001.9	117,386.9	605,804.4	723,191.3
Nablus	112,904.0	1,250,355.6	342,827.8	330,651.0	1,923,834.3	155,532.1	1,383,535.3	1,539,067.5
Qalqiliya	35,641.0	775,578.9	66,276.4	19,479.3	861,334.6	19,385.7	669,524.1	688,909.8
Salfit	37,956.0	522,207.6	85,627.4	32,167.6	640,002.7	0.0	512,002.1	512,002.1
Ramallah&Bireh	118,365.0	2,352,211.9	43,497.6	13,183.5	2,408,893.0	26,505.2	1,900,592.3	1,927,097.4
Jericho	9,518.0	325,556.0	355.5	5,662.1	331,573.6	0.0	265,258.9	265,258.9
Jerusalem	40,700.0	868,878.1	30,535.5	31,657.0	931,070.5	188,254.3	551,909.8	740,164.1
Bethlehem	39,804.0	1,200,108.4	3,791.3	4,311.2	1,208,210.9	0.0	966,568.7	966,568.7
Hebron	66,518.0	169,598.1	190,575.5	267,697.9	627,871.5	41.2	502,256.0	502,297.2
Total	**606,335.0**	**9,044,826.6**	**1,128,835.7**	**1,094,826.0**	**11,268,488.4**	**507,153.3**	**8,468,360.0**	**8,975,513.3**

Jenin Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using W NW	Pop using NW	% HHs using cis	no. of HHs using cis	Wc tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw cis (m3/y)	Qw Tanks (m3/y)	Qw from 3 sources (m3/y)	% HH WWNW	% HH having Cess	Qww NW (m3/y)	Qww cess (m3/y)
1	Zububa	1,934.0	359.0	5.4	23	88.4	1,708.7	2.3	8.2	172.0	8.5	30.6	14,381.0	693.5	1,920.9	16,995.4	0.0	100.0	0.0	13,596.3
2	Rummana	3,140.0	596.0	5.3	28	86.7	2,722.4	1.9	11.2	172.0	9.9	59.1	27,959.3	952.6	3,709.7	32,621.6	0.0	100.0	0.0	26,097.3
3	Ti'innik	1,000.0	178.0	5.6	16	40.0	400.0	40.0	71.2	172.0	16.6	29.5	2,274.3	6,052.0	1,851.8	10,178.2	0.0	100.0	0.0	8,142.5
4	At Tayba	2,155.0	416.0	5.2	43	92.9	2,002.0	4.2	17.3	172.0	0.7	3.1	31,754.2	1,473.3	192.0	33,419.6	0.0	100.0	0.0	26,735.6
5	Arabbuna	810.0	160.0	5.1		5.1	41.3	10.2	16.3	172.0	84.1	134.5	0.0	1,387.2	8,445.3	9,832.5	0.0	100.0	0.0	7,866.0
6	Al Jalama	2,060.0	413.0	5.0	81	99.3	2,045.6	0.0	0.0	172.0	0.2	1.0	60,799.1	0.0	64.0	60,863.2	0.0	100.0	0.0	48,690.5
7	As Sa'aida	70.0	13.0	5.4		0.0	0.0	0.0	0.0	172.0	100.0	13.0	0.0	0.0	816.1	816.1	0.0	100.0	0.0	652.9
8	'Anin	3,691.0	658.0	5.6	25	89.8	3,314.5	2.5	16.3	172.0	4.5	29.6	30,754.9	1,387.4	1,857.3	33,999.6	0.0	100.0	0.0	27,199.7
9	'Arrana	1,996.0	367.0	5.4		1.7	33.3	0.0	0.0	172.0	98.1	359.9	0.0	0.0	22,592.3	22,592.3	0.0	100.0	0.0	18,073.8
10	Deir Ghazala	895.0	177.0	5.1	53	89.9	804.6	0.0	0.0	172.0	0.6	1.0	15,545.6	0.0	63.9	15,609.5	0.0	100.0	0.0	12,487.6
11	Faqqu'a	3,467.0	689.0	5.0		3.4	118.0	26.2	180.4	172.0	70.1	483.1	0.0	15,334.3	30,330.0	45,664.3	0.0	100.0	0.0	36,531.4
12	Khirbet Suruj	56.0	9.0	6.2		0.0	0.0	0.0	0.0	172.0	88.9	8.0	0.0	0.0	502.2	502.2	0.0	100.0	0.0	401.8
14	Umm ar Rihan	370.0	65.0	5.7	45	100.0	370.0	0.0	0.0	172.0	0.0	0.0	6,037.3	0.0	0.0	6,037.3	0.0	100.0	0.0	4,829.8
15	Khirbet 'Abdallah al Yunis	138.0	33.0	4.2	54	100.0	138.0	0.0	0.0	172.0	0.0	0.0	2,720.0	0.0	0.0	2,720.0	0.0	100.0	0.0	2,176.0
16	Dhaher al Malih	198.0	40.0	5.0	45	97.4	192.9	0.0	0.0	172.0	0.0	0.0	3,147.9	0.0	0.0	3,147.9	0.0	100.0	0.0	2,518.3
17	Barta'a ash Sharqiya	4,176.0	817.0	5.1	54	88.8	3,708.3	0.1	1.0	172.0	0.0	0.0	73,005.8	86.6	0.0	73,092.4	0.0	100.0	0.0	58,473.9
18	Al 'Araqa	2,161.0	367.0	5.9		37.8	816.4	47.2	173.3	172.0	14.4	53.0	0.0	14,731.0	3,328.0	18,059.0	0.0	100.0	0.0	14,447.2
20	Al Jameelat	32.0	5.0	6.4		0.0	0.0	0.0	0.0	172.0	100.0	5.0	0.0	0.0	313.9	313.9	0.0	100.0	0.0	251.1
21	Beit Qad	1,447.0	265.0	5.5		2.7	39.0	0.4	1.0	172.0	95.8	253.8	0.0	86.6	15,932.8	16,019.5	0.0	100.0	0.0	12,815.6
22	Tura al Gharbiya	918.0	197.0	4.7	41	100.0	918.0	0.0	0.0	172.0	0.0	0.0	13,807.7	0.0	0.0	13,807.7	0.0	100.0	0.0	11,046.1
23	Tura ash Sharqiya	174.0	35.0	5.0	41	100.0	174.0	0.0	0.0	172.0	0.0	0.0	2,617.1	0.0	0.0	2,617.1	0.0	100.0	0.0	2,093.7
24	Al Hashimiya	1,051.0	186.0	5.7	28	55.2	580.1	18.6	34.6	172.0	26.2	48.8	5,930.1	2,937.4	3,062.8	11,930.3	0.0	100.0	0.0	9,544.3
25	Nazlat ash Sheikh Zeid	704.0	119.0	5.9	43	97.5	686.4	0.9	1.0	172.0	0.0	0.0	10,713.6	86.5	0.0	10,800.1	0.0	100.0	0.0	8,640.1
26	At Tarem	369.0	70.0	5.3	43	100.0	369.0	0.0	0.0	172.0	0.0	0.0	5,759.5	0.0	0.0	5,759.5	0.0	100.0	0.0	4,607.6
27	Khirbet al Muntar al Gharbiya	22.0	6.0	3.7		0.0	0.0	0.0	0.0	172.0	66.7	4.0	0.0	0.0	251.2	251.2	0.0	100.0	0.0	201.0
28	Jalbun	2,390.0	463.0	5.2		0.2	5.3	15.2	70.4	172.0	83.9	388.6	0.0	5,981.3	24,393.3	30,374.6	0.0	100.0	0.0	24,299.7
29	'Aba	204.0	36.0	5.7		0.0	0.0	0.0	0.0	172.0	100.0	36.0	0.0	0.0	2,260.1	2,260.1	0.0	100.0	0.0	1,808.1
30	Khirbet Mas'ud	47.0	11.0	4.3		0.0	0.0	100.0	11.0	172.0	0.0	0.0	0.0	935.0	0.0	935.0	0.0	100.0	0.0	748.0
32	Kafr Qud	1,143.0	215.0	5.3	42	92.4	1,056.3	0.5	1.1	172.0	6.2	13.2	16,052.2	91.4	831.6	16,975.2	0.0	100.0	0.0	13,580.2
33	Deir Abu Da'if	5,572.0	935.0	6.0		8.1	449.6	53.1	496.6	172.0	37.9	354.8	0.0	42,207.6	22,276.3	64,483.8	0.0	100.0	0.0	51,587.1
34	Umm Dar	557.0	108.0	5.2		0.9	5.0	10.4	11.2	172.0	88.7	95.8	0.0	952.6	6,012.7	6,965.3	0.0	100.0	0.0	5,572.2
35	Al Khuljan	509.0	88.0	5.8		1.2	5.9	16.3	14.3	172.0	82.6	72.7	0.0	1,217.7	4,561.0	5,778.7	0.0	100.0	0.0	4,623.0
36	Wad ad Dabi'	411.0	69.0	6.0		0.0	0.0	1.5	1.0	172.0	92.6	63.9	0.0	86.3	4,013.3	4,099.6	0.0	100.0	0.0	3,279.6
37	Dhaher al 'Abed	363.0	65.0	5.6		3.1	11.3	90.6	58.9	172.0	4.7	3.0	0.0	5,007.0	191.3	5,198.3	0.0	100.0	0.0	4,158.7
38	Zabda	944.0	184.0	5.1		0.0	0.0	16.6	30.5	172.0	81.8	150.5	0.0	2,592.3	9,445.4	12,037.7	0.0	100.0	0.0	9,630.2
39	Kufeirit	2,406.0	433.0	5.6	27	53.9	1,296.4	3.8	16.3	172.0	41.9	181.4	12,789.2	1,385.6	11,385.2	25,560.0	0.0	100.0	0.0	20,448.0
40	Imreiha	423.0	85.0	5.0		0.0	0.0	0.0	0.0	172.0	78.3	66.6	0.0	0.0	4,179.0	4,179.0	0.0	100.0	0.0	3,343.2
41	Umm at Tut	989.0	169.0	5.9	19	95.0	939.6	1.2	2.0	172.0	97.6	164.9	6,441.6	173.1	10,354.2	16,968.9	0.0	100.0	0.0	13,575.1
42	Ash Shuhada	1,748.0	319.0	5.5	0	97.4	1,702.6	1.3	4.1	172.0	0.6	2.0	0.0	346.5	128.0	474.5	0.0	100.0	0.0	379.6
43	Jalqamus	1,992.0	343.0	5.8	16	38.3	762.5	8.3	28.5	172.0	53.4	183.2	4,441.9	2,422.4	11,501.6	18,365.8	0.0	100.0	0.0	14,692.7
44	Al Mughayyir	2,420.0	404.0	6.0	14	8.4	203.3	16.9	68.4	172.0	72.2	291.8	1,011.5	5,810.1	18,317.8	25,139.3	0.0	100.0	0.0	20,111.5
45	Al Mutilla	295.0	57.0	5.2		3.6	10.5	96.4	55.0	172.0	0.0	0.0	0.0	4,672.0	0.0	4,672.0	0.0	100.0	0.0	3,737.6
46	Bir al Basha	1,307.0	217.0	6.0		2.4	31.4	20.7	44.8	172.0	76.1	165.0	0.0	3,810.2	10,361.4	14,171.6	0.0	100.0	0.0	11,337.3

Jenin Governorate - continue

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using W NW	Pop using NW	% HHs using cis	no. of HHs using cis	Wc tanks(l/HH/d)	% HHs tanks	no. of HH using tanks	Qw NW (m3/y)	Qw cis (m3/y)	Qw Tanks (m3/y)	Qw from 3 sources (m3/y)	% HH WWNW	% HH having Cess	Qww NW (m3/y)	Qww cess (m3/y)
47	Al Hafira	58.0	13.0	4.5		0.0	0.0	0.0	0.0	172.0	100.0	13.0	0.0	0.0	816.1	816.1	0.0	100.0	0.0	652.9
48	Telfit	238.0	58.0	4.1	57	80.4	191.3	3.6	2.1	172.0	7.1	4.1	3,979.0	176.1	258.5	4,413.6	0.0	100.0	0.0	3,530.8
49	Mirka	1,611.0	284.0	5.7	33	98.2	1,582.1	1.4	4.1	172.0	0.0	0.0	19,286.4	346.1	0.0	19,632.4	0.0	100.0	0.0	15,706.0
50	Wadi Du'oq	123.0	17.0	7.2	75	100.0	123.0	0.0	0.0	172.0	0.0	0.0	3,367.1	0.0	0.0	3,367.1	0.0	100.0	0.0	2,693.7
51	Fahma al Jadida	369.0	65.0	5.7		96.9	357.5	0.0	0.0	172.0	1.6	1.0	0.0	0.0	63.8	63.8	94.0	6.0	47.9	3.1
52	Raba	3,145.0	548.0	5.7		1.1	35.1	0.6	3.1	172.0	98.1	537.8	0.0	259.7	33,764.0	34,023.7	0.0	100.0	0.0	27,219.0
53	Al Mansura	173.0	29.0	6.0	39	100.0	173.0	0.0	0.0	172.0	0.0	0.0	2,485.5	0.0	0.0	2,485.5	0.0	100.0	0.0	1,988.4
54	Misliya	2,388.0	440.0	5.4		3.0	71.6	65.0	286.2	172.0	31.5	138.5	0.0	24,327.3	8,696.2	33,023.5	0.0	100.0	0.0	26,418.8
55	Al Jarba	63.0	13.0	4.8		0.0	0.0	100.0	13.0	172.0	0.0	0.0	0.0	1,105.0	0.0	1,105.0	0.0	100.0	0.0	884.0
56	Az Zababida	3,665.0	826.0	4.4	42	76.9	2,818.9	4.8	39.8	172.0	16.2	133.6	43,244.0	3,380.5	8,386.6	55,011.1	0.0	100.0	0.0	44,008.9
57	Fahma	2,486.0	432.0	5.8	27	53.0	1,317.6	38.4	166.1	172.0	8.3	35.7	13,113.2	14,116.4	2,238.8	29,468.4	0.0	100.0	0.0	23,574.7
58	Az Zawiya	770.0	111.0	6.9	66	73.4	565.1	7.3	8.1	172.0	18.3	20.4	13,693.2	692.5	1,278.6	15,664.3	0.0	100.0	0.0	12,531.5
60	Sir	744.0	137.0	5.4		1.5	11.1	23.9	32.7	172.0	72.4	99.2	0.0	2,780.9	6,226.0	9,006.9	0.0	100.0	0.0	7,205.5
61	'Ajja	5,055.0	897.0	5.6	35	93.9	4,744.8	5.0	44.9	172.0	0.8	7.1	60,325.1	3,812.3	447.9	64,585.3	0.0	100.0	0.0	51,668.2
62	'Anza	1,873.0	395.0	4.7	59	80.9	1,515.8	17.3	68.2	172.0	1.5	6.1	32,915.3	5,797.7	383.5	39,096.5	0.0	100.0	0.0	31,277.2
63	Sanur	4,067.0	698.0	5.8	5	94.0	3,823.0	3.8	26.5	172.0	1.9	13.2	7,250.5	2,251.9	831.6	10,334.0	0.0	100.0	0.0	8,267.2
64	Ar Rama	964.0	172.0	5.6	57	98.2	946.9	1.8	3.1	172.0	0.0	0.0	19,642.0	259.5	0.0	19,901.6	0.0	100.0	0.0	15,921.2
65	Al Judeida	4,738.0	923.0	5.1		2.7	127.9	70.1	646.9	172.0	26.2	241.4	0.0	54,987.8	15,158.0	70,145.8	0.0	100.0	0.0	56,116.7
66	al 'Asa'asa	464.0	64.0	7.3	45	98.4	456.6	0.0	0.0	172.0	1.6	1.0	7,422.0	0.0	63.8	7,485.7	0.0	100.0	0.0	5,988.6
67	Al 'Attara	1,159.0	199.0	5.8		5.6	64.9	92.8	184.7	172.0	1.0	2.0	0.0	15,700.6	128.1	15,828.7	0.0	100.0	0.0	12,663.0
68	Siris	4,886.0	812.0	6.0		2.5	122.2	72.8	590.9	172.0	24.1	195.6	0.0	50,227.9	12,280.6	62,508.5	0.0	100.0	0.0	50,006.8
69	Al Fandaqumiya	3,401.0	596.0	5.7	37	97.9		0.0	0.0	172.0	0.5	3.1	0.0	0.0	191.9	191.9	0.0	100.0	0.0	153.5
	Total	**99,194.0**	**18,170.0**	**5.5**	**38.8**	**48.3**		**17.2**	**3,566.1**		**33.8**		**574,667.1**	**303,121.4**	**326,660.7**	**1,204,449.3**			**47.9**	**963,511.5**

served with water network
served with water network but cosumption rate is missing
not served with water network

Tubas Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw cis (m3/y)	Qw tanks (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q wwNW (m3/y)	Q ww cess (m3/y)
1	Bardala	1,637.0	271.0	6.0	89	96.9	1586	2.3	6.3	172.0	0.0	0.0	51291.5	533.6	0.0	51825.1	0.0	100.0	0.0	41460.1
2	'Ein el Beida	1,163.0	197.0	5.9	89	97.3	1132	0.0	0.0	172.0	0.0	0.0	36590.3	0.0	0.0	36590.3	0.0	100.0	0.0	29272.2
3	Kardala	307.0	49.0	6.3	89	44.7	137	0.0	0.0	172.0	55.3	27.1	4437.3	0.0	1701.7	6139.0	0.0	100.0	0.0	4911.2
4	Ibziq	211.0	32.0	6.6	0.0	0.0	0	3.2	1.0	172.0	96.8	31.0	0.0	87.7	1944.2	2031.9	0.0	100.0	0.0	1625.5
5	Salhab	45.0	5.0	9.0	0.0	0.0	0	0.0	0.0	172.0	100.0	5.0	0.0	0.0	313.9	313.9	0.0	100.0	0.0	251.1
6	Tayasir	2,489.0	467.0	5.3		2.0	50	2.2	10.4	172.0	94.0	438.8	0.0	888.0	27547.4	28435.4	0.0	100.0	0.0	22748.3
7	Al Farisiya	151.0	29.0	5.2	0.0	0.0	0	0.0	0.0	172.0	96.4	28.0	0.0	0.0	1755.6	1755.6	0.0	100.0	0.0	1404.5
8	Al 'Aqaba	104.0	23.0	4.5	0.0	0.0	0	27.3	6.3	172.0	72.7	16.7	0.0	533.2	1050.1	1583.3	0.0	100.0	0.0	1266.7
9	Ath Thaghra	546.0	100.0	5.5	51.0	80.2	438	11.5	11.5	172.0	8.3	8.3	8152.2	974.0	523.2	9649.3	0.0	100.0	0.0	7719.5
10	Al Malih	370.0	58.0	6.4	0.0	0.0	0	0.0	0.0	172.0	74.5	43.2	0.0	0.0	2714.4	2714.4	0.0	100.0	0.0	2171.5
11	Kashda	71.0	8.0	8.9		12.5	9	12.5	1.0	172.0	12.5	1.0	0.0	85.0	62.8	147.8	0.0	100.0	0.0	118.2
12	Khirbet Yarza	39.0	8.0	4.9	0.0	0.0	0	0.0	0.0	172.0	100.0	8.0	0.0	0.0	502.2	502.2	0.0	100.0	0.0	401.8
13	Ras al Far'a	706.0	125.0	5.6	70	87.5	618	0.0	0.0	172.0	1.7	2.1	15783.5	0.0	130.8	15914.3	0.0	100.0	0.0	12731.4
14	Khirbet ar Ras al Ahmar	179.0	35.0	5.1		0.0	0	0.0	0.0	172.0	75.8	26.5	0.0	0.0	1664.6	1664.6	0.0	100.0	0.0	1331.7
15	Wadi al Far'a	2,730.0	474.0	5.8	40	25.8	704	1.5	7.3	172.0	37.2	176.4	10271.8	621.2	11077.2	21970.2	0.0	100.0	0.0	17576.2
16	Khirbet 'Atuf	171.0	28.0	6.1	0.0	0.0	0	0.0	0.0	172.0	92.6	25.9	0.0	0.0	1627.6	1627.6	0.0	100.0	0.0	1302.1
17	Khirbet Humsa	133.0	22.0	6.0	0.0	0.0	0	0.0	0.0	172.0	100.0	22.0	0.0	0.0	1381.2	1381.2	0.0	100.0	0.0	1104.9
	Total	**11,052.0**	**1931.0**	**6.1**	**30.5**	**26.3**		**3.6**			**59.9**		**126526.5**	**3722.8**	**53996.9**	**184246.2**	**0.0**	**100.0**	**0.0**	**147396.9**

Tulkarm Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q wwNW (m3/y)	Q ww cess (m3/y)
1	Akkaba	254.0	41.0	6.2		0.0	0.0	100.0	41.0	172.0	0.0	0.0	0.0	0.0	3,485.0	3,485.0	0.0	100.0	0.0	2,788.0
2	Nazlat 'Isa	2,334.0	440.0	5.3	90	97.7	2,280.6	0.0	0.0	172.0	0.0	0.0	74,917.4	0.0	0.0	74,917.4	0.0	100.0	0.0	59,933.9
3	An Nazla ash Sharqiya	1,514.0	277.0	5.5	104	51.7	782.7	41.5	114.8	172.0	6.5	18.1	29,712.7	1,138.3	9,760.5	40,611.5	0.0	100.0	0.0	32,489.2
4	An Nazla al Wusta	340.0	74.0	4.6	104	20.5	69.7	20.5	15.2	172.0	0.0	0.0	2,645.8	0.0	1,292.5	3,938.3	0.0	100.0	0.0	3,150.6
5	An Nazla al Gharbiya	937.0	156.0	6.0		1.3	12.2	98.1	153.0	172.0	0.0	0.0	0.0	0.0	13,003.4	13,003.4	0.0	100.0	0.0	10,402.7
6	Zeita	2,852.0	560.0	5.1	191.0	98.9	2,821.2	0.0	0.0	172.0	0.0	0.0	196,681.6	0.0	0.0	196,681.6	64.0	36.0	100,746.2	56,644.3
7	Seida	2,929.0	568.0	5.2	90	70.8	2,073.7	29.3	166.2	172.0	0.0	0.0	68,122.1	0.0	14,124.5	82,246.6	0.0	100.0	0.0	65,797.3
8	Al Jarushiya	932.0	183.0	5.1		64.3	599.1	10.4	19.1	172.0	0.0	0.0	0.0	0.0	1,623.9	1,623.9	0.0	100.0	0.0	1,299.1
9	Al Masqufa	260.0	47.0	5.5		100.0	260.0	0.0	0.0	172.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
10	Iktaba	2,665.0	463.0	5.8	92.0	99.1	2,641.8	0.0	0.0	172.0	0.4	2.0	88,710.8	126.7	0.0	88,837.5	21.4	79.0	15,174.0	56,145.3
11	Kafr al Labad	4,074.0	693.0	5.9	43.0	91.3	3,718.7	8.4	58.4	172.0	0.1	1.0	58,365.1	63.2	4,965.8	63,394.2	0.0	100.0	0.0	50,715.4
12	Kafa	404.0	75.0	5.4	0.0	0.0	0.0	2.7	2.0	172.0	0.0	0.0	0.0	0.0	172.3	172.3	0.0	100.0	0.0	137.8
14	Ramin	1,806.0	353.0	5.1	74.0	100.0	1,806.0	0.0	0.0	172.0	0.0	0.0	48,780.1	0.0	0.0	48,780.1	0.0	100.0	0.0	39,024.0
15	Far'un	3,100.0	633.0	4.9	74.0	99.4	3,080.3	0.0	0.0	172.0	0.0	0.0	83,197.7	0.0	0.0	83,197.7	0.0	100.0	0.0	66,558.1
16	Shufa	2,194.0	400.0	5.5	88.0	99.3	2,178.6	0.8	3.0	172.0	0.0	0.0	69,978.0	0.0	256.9	70,234.9	0.0	100.0	0.0	56,187.9
17	Khirbet Jubara	293.0	63.0	4.7	90	100.0	293.0	0.0	0.0	172.0	0.0	0.0	9,625.1	0.0	0.0	9,625.1	19.0	81.0	1,466.7	6,233.4
18	Saffarin	760.0	136.0	5.6		3.0	22.5	3.7	5.0	172.0	91.9	124.9	0.0	7,842.4	428.1	8,270.5	0.0	100.0	0.0	6,616.4
19	Ar Ras	540.0	96.0	5.6	78.0	100.0	540.0	0.0	0.0	172.0	0.0	0.0	15,373.8	0.0	0.0	15,373.8	0.0	54.7	0.0	6,732.1
20	Kafr Sur	1,117.0	222.0	5.0	78.0	99.6	1,112.5	0.5	1.0	172.0	0.0	0.0	31,673.8	0.0	85.8	31,759.6	0.0	92.3	0.0	23,444.3
21	Kur	262.0	54.0	4.9		1.9	4.9	79.6	43.0	172.0	5.6	3.0	0.0	188.3	3,655.0	3,843.3	0.0	94.4	0.0	2,903.9
22	Kafr Zibad	1,078.0	208.0	5.2	66.0	98.1	1,057.1	1.9	4.0	172.0	0.0	0.0	25,464.8	0.0	343.3	25,808.1	0.0	94.2	0.0	19,443.7
23	Kafr Jammal	2,424.0	455.0	5.3	55.0	99.3	2,407.9	0.4	2.0	172.0	0.0	0.0	48,338.8	0.0	171.1	48,510.0	0.0	50.7	0.0	19,661.6
24	Kafr 'Abbush	1,457.0	281.0	5.2	66.0	78.5	1,143.7	21.5	60.4	172.0	0.0	0.0	27,550.9	0.0	5,136.6	32,687.5	0.0	74.6	0.0	19,495.3
	Total	**34,526.0**	**6,478.0**	**5.3**	**81.4**	**68.5**		**18.2**			**4.5**		**879,138.4**	**9,358.9**	**58,504.6**	**947001.9**	**4.5**	**89.4**	**117,386.9**	**605,804.4**

Nablus Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q wwNW (m3/y)	Q ww cess (m3/y)
1	Bizzariya	2,252.0	380.0	5.9	47	94.1	2120	3.2	12.2	172.0	1.1	4.1	36,593.7	255.1	1,036.4	37,885.2	0.0	100.0	0.0	30,308.2
2	Burqa	3,670.0	733.0	5.0	60	98.1	3600	1.0	7.1	172.0	0.3	2.0	78,687.8	127.5	604.1	79,419.3	0.0	100.0	0.0	63,535.5
3	Yasid	2,084.0	349.0	6.0		1.5	30	77.6	270.9	172.0	20.3	71.0	0.0	4,458.5	23,024.9	27,483.3	0.0	100.0	0.0	21,986.7
4	Beit Imrin	2,821.0	528.0	5.3	60	97.7	2756	1.5	8.1	172.0	0.6	3.0	60,373.9	191.2	690.5	61,255.6	0.0	100.0	0.0	49,004.5
5	Nisf Jubeil	394.0	83.0	4.7	68	100.0	394	0.0	0.0	172.0	0.0	0.0	9,733.2	0.0	0.0	9,733.2	0.0	100.0	0.0	7,786.6
6	Sabastiya	2,614.0	515.0	5.1	43	99.2	2593	0.0	0.0	172.0	0.4	2.0	40,727.9	127.5	0.0	40,855.4	0.0	100.0	0.0	32,684.3
7	Ijnisinya	505.0	106.0	4.8	76	100.0	505	0.0	0.0	172.0	0.0	0.0	13,994.3	0.0	0.0	13,994.3	0.0	100.0	0.0	11,195.5
8	Talluza	2,375.0	429.0	5.5	76	99.1	2352	0.0	0.0	172.0	0.9	4.1	65,191.2	255.3	0.0	65,446.4	0.0	100.0	0.0	52,357.2
9	An Naqura	1,545.0	290.0	5.3	49	99.7	1540	0.0	0.0	172.0	0.3	1.0	27,309.6	63.7	0.0	27,373.3	0.0	100.0	0.0	21,898.6
10	Al Badhan	2,485.0	447.0	5.6	76	92.5	2299	0.0	0.0	172.0	0.7	3.0	63,698.5	191.3	0.0	63,889.9	0.0	100.0	0.0	51,111.9
11	Deir Sharaf	2,460.0	464.0	5.3	76	98.9	2433	0.0	0.0	172.0	0.9	4.1	67,424.6	255.0	0.0	67,679.6	78.0	22.0	42,232.1	11,911.6
12	An Nassariya	1,585.0	259.0	6.1	47	95.7	1517	0.0	0.0	172.0	1.6	4.1	25,929.4	255.1	0.0	26,184.5	0.0	100.0	0.0	20,947.6
13	Zawata	1,875.0	360.0	5.2	76	98.3	1843	1.1	4.1	172.0	0.3	1.0	51,081.0	63.7	344.8	51,489.5	0.0	100.0	0.0	41,191.6
14	Al 'Aqrabaniya	1,001.0	157.0	6.4		80.6	807	5.8	9.1	172.0	12.9	20.3	0.0	1,271.8	774.9	2,046.7	0.0	100.0	0.0	1,637.3
15	Qusin	1,709.0	300.0	5.7	168	100.0	1709	0.0	0.0	172.0	0.0	0.0	104,915.2	0.0	0.0	104,915.2	0.0	100.0	0.0	83,932.2
16	Beit Iba	3,150.0	628.0	5.0	119	100.0	3150	0.0	0.0	172.0	0.0	0.0	136,450.4	0.0	0.0	136,450.4	87.0	13.0	94,969.5	14,190.8
17	Beit Hasan	1,121.0	190.0	5.9	57	95.7	1073	0.5	1.0	172.0	2.1	4.1	22,505.1	255.1	86.4	22,846.6	0.0	100.0	0.0	18,277.3
18	Beit Wazan	1,057.0	207.0	5.1	51	100.0	1057	0.5	1.0	172.0	0.0	0.0	19,684.7	0.0	86.3	19,771.0	0.0	100.0	0.0	15,816.8
20	'Ein Shibli	335.0	57.0	5.9	83	69.6	233	0.0	0.0	172.0	28.6	16.3	7,069.8	1,022.4	0.0	8,092.2	0.0	100.0	0.0	6,473.8
21	'Azmut	2,650.0	449.0	5.9	54.2	99.7	2,642.1	0.2	1.0	172.0	0.0	0.0	52,258.4	0.0	86.3	52,344.8	0.0	100.0	0.0	41,875.8
22	Deir al Hatab	2,213.0	368.0	6.0	43.0	100.0	2,213.0	0.0	0.0	172.0	0.0	0.0	34,733.0	0.0	0.0	34,733.0	0.0	100.0	0.0	27,786.4
23	Sarra	2,562.0	463.0	5.5		6.1	156.3	64.0	296.5	172.0	29.8	138.1	0.0	8,669.1	25,201.0	33,870.2	60.0	40.0	16,257.7	10,838.4
24	'Iraq Burin	768.0	147.0	5.2		2.8	21.2	70.3	103.4	172.0	25.5	37.5	0.0	2,354.9	8,789.6	11,144.5	0.0	100.0	0.0	8,915.6
25	Tell	4,344.0	778.0	5.6		1.6	68.1	47.9	372.7	172.0	50.0	389.0	0.0	24,421.4	31,683.7	56,105.1	0.0	100.0	0.0	44,884.1
26	Beit Dajan	3,485.0	640.0	5.4		0.8	27.7	21.3	136.1	172.0	77.0	492.7	0.0	30,931.6	11,570.8	42,502.4	0.0	100.0	0.0	34,001.9
27	Rujeib	4,202.0	770.0	5.5	77.0	99.8	4,193.6	0.1	1.0	172.0	0.1	1.0	117,861.0	63.8	86.3	118,011.1	0.0	100.0	0.0	94,408.9
28	Kafr Qallil	2,451.0	423.0	5.8		89.4	2,191.2	9.8	41.6	172.0	0.2	1.0	0.0	63.7	3,535.1	3,598.8	72.0	28.0	2,072.9	806.1
29	Furush Beit Dajan	769.0	121.0	6.4		49.6	381.4	0.0	0.0	172.0	47.1	56.9	0.0	3,574.8	0.0	3,574.8	0.0	100.0	0.0	2,859.8
30	Madama	1,754.0	325.0	5.4		0.6	10.5	41.3	134.1	172.0	57.8	187.9	0.0	11,795.8	11,395.3	23,191.1	0.0	100.0	0.0	18,552.9
31	Burin	2,309.0	429.0	5.4		5.7	131.6	34.8	149.4	172.0	57.3	246.0	0.0	15,444.8	12,702.3	28,147.0	0.0	100.0	0.0	22,517.6
32	'Asira al Qibliya	2,366.0	392.0	6.0		1.2	28.4	66.3	260.0	172.0	32.4	126.9	0.0	7,969.5	22,098.2	30,067.7	0.0	100.0	0.0	24,054.2
33	'Awarta	5,623.0	992.0	5.7		2.0	115.1	41.0	407.2	172.0	54.6	541.2	0.0	33,975.5	34,608.3	68,583.8	0.0	100.0	0.0	54,867.0
34	'Urif	2,921.0	493.0	5.9		2.9	84.1	86.0	424.0	172.0	10.9	53.8	0.0	3,375.3	36,041.7	39,417.0	0.0	100.0	0.0	31,533.6
35	Odala	1,135.0	173.0	6.6	42.0	100.0	1,135.0	0.0	0.0	172.0	0.0	0.0	17,399.6	0.0	0.0	17,399.6	0.0	100.0	0.0	13,919.6
36	'Einabus	2,340.0	421.0	5.6	49.0	86.3	2,019.4	10.8	45.7	172.0	2.4	10.1	36,117.3	636.9	3,880.3	40,634.5	0.0	100.0	0.0	32,507.6
37	Yanun	102.0	19.0	5.4		0.0	0.0	100.0	19.0	172.0	0.0	0.0	0.0	0.0	1,615.0	1,615.0	0.0	100.0	0.0	1,292.0
39	Zeita Jamma'in	2,115.0	309.0	6.8	34.5	96.1	2,031.5	3.0	9.1	172.0	0.3	1.0	25,597.6	63.8	777.6	26,439.0	0.0	100.0	0.0	21,151.2
40	Osarin	1,612.0	288.0	5.6		2.1	34.1	2.8	8.1	172.0	95.1	273.8	0.0	17,189.3	689.6	17,878.9	0.0	100.0	0.0	14,303.1
41	Aqraba	8,180.0	1,389.0	5.9		1.8	143.5	52.6	730.0	172.0	44.7	620.4	0.0	38,947.4	62,053.2	101,000.6	0.0	100.0	0.0	80,800.5
44	Yatma	2,853.0	517.0	5.5	48.4	99.4	2,836.2	0.2	1.0	172.0	0.0	0.0	50,107.0	0.0	86.3	50,193.3	0.0	100.0	0.0	40,154.6
45	Jurish	1,400.0	222.0	6.3		2.3	32.0	18.3	40.5	172.0	78.5	174.4	0.0	10,946.1	3,446.6	14,392.7	0.0	100.0	0.0	11,514.1
46	Qusra	4,377.0	674.0	6.5		2.0	85.7	7.1	47.7	172.0	90.5	610.1	0.0	38,299.0	4,055.2	42,354.2	0.0	100.0	0.0	33,883.3

Nablus Governorate, Continue																				
47	Talfit	2,824.0	420.0	6.7		1.2	34.1	3.4	14.2	172.0	93.5	392.6	0.0	24,648.0	1,207.2	25,855.2	0.0	100.0	0.0	20,684.2
48	As Sawiya	2,393.0	383.0	6.2	43.5	99.2	2,374.0	0.8	3.0	172.0	0.0	0.0	37,735.6	0.0	259.1	37,994.6	0.0	100.0	0.0	30,395.7
49	Majdal Bani Fadil	2,382.0	404.0	5.9		1.8	41.9	28.1	113.7	172.0	70.1	283.2	0.0	17,779.7	9,663.5	27,443.2	0.0	100.0	0.0	21,954.6
50	Al Lubban ash Sharqiya	2,465.0	410.0	6.0	52.4	100.0	2,465.0	0.0	0.0	172.0	0.0	0.0	47,175.6	0.0	0.0	47,175.6	0.0	100.0	0.0	37,740.5
51	Qaryut	2,321.0	396.0	5.9		1.8	41.7	77.7	307.7	172.0	19.7	78.2	0.0	4,908.4	26,151.2	31,059.7	0.0	100.0	0.0	24,847.7
52	Jalud	464.0	85.0	5.5		4.8	22.1	7.1	6.1	172.0	86.9	73.9	0.0	4,637.5	516.1	5,153.6	0.0	100.0	0.0	4,122.9
53	'Ammuriya	302.0	48.0	6.3		0.0	0.0	46.8	22.5	172.0	44.7	21.4	0.0	1,346.4	1,909.8	3,256.2	0.0	100.0	0.0	2,605.0
54	Duma	2,099.0	341.0	6.2		0.3	6.2	7.1	24.4	172.0	92.6	315.6	0.0	19,815.1	2,070.4	21,885.5	0.0	100.0	0.0	17,508.4
	Total	**112,819.0**	**19,771.0**	**5.7**	**64.4**	**55.6**		**18.8**			**24.7**		**1,250,355.6**	**330,651.0**	**342,827.8**	**1,923,834.3**	**5.9**	**94.1**	**155,532.1**	**1,383,535.3**

Qalqiliya Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q wwNW (m3/y)	Q ww cess (m3/y)
1	Falamya	633.0	114.0	5.6	77.6	96.4	610.2	0.0	0.0	172.0	0.0	0.0	17,285.8	0.0	0.0	17,285.8	0.0	100.0	0.0	13,828.7
2	Kafr Qaddum	2,908.0	490.0	5.9	112.1	99.6	2,895.8	0.4	2.1	172.0	0.0	0.0	118,521.2	0.0	175.0	118,696.2	0.0	100.0	0.0	94,956.9
3	Jit	2,197.0	375.0	5.9	41.3	100.0	2,197.0	0.0	0.0	172.0	0.0	0.0	33,153.6	0.0	0.0	33,153.6	0.0	100.0	0.0	26,522.9
4	Baqat al Hatab	1,644.0	297.0	5.5		2.4	40.0	20.5	60.8	172.0	77.1	228.9	0.0	14,372.7	5,171.7	19,544.4	0.0	100.0	0.0	15,635.5
5	Hajja	2,148.0	389.0	5.5		82.8	1,778.6	15.9	61.7	172.0	1.3	5.1	0.0	323.0	5,248.4	5,571.4	19.0	81.0	846.9	3,610.3
6	Jayyus	2,894.0	538.0	5.4	68.6	99.2	2,871.8	0.4	2.1	172.0	0.0	0.0	71,877.0	0.0	175.5	72,052.6	0.0	100.0	0.0	57,642.1
7	Khirbet Sir	447.0	92.0	4.9	123.6	100.0	447.0	0.0	0.0	172.0	0.0	0.0	20,163.2	0.0	0.0	20,163.2	53.0	47.0	8,549.2	7,581.4
8	'Arab ar Ramadin ash Shamali	81.0	16.0	5.1		18.8	15.2	0.0	0.0	172.0	81.3	13.0	0.0	816.1	0.0	816.1	0.0	100.0	0.0	652.9
9	Far'ata	642.0	101.0	6.4		2.0	13.1	98.0	98.9	172.0	0.0	0.0	0.0	0.0	8,409.8	8,409.8	0.0	100.0	0.0	6,727.8
10	Immatin	2,388.0	433.0	5.5		1.2	28.4	94.3	408.3	172.0	2.9	12.4	0.0	776.7	34,701.9	35,478.5	0.0	100.0	0.0	28,382.8
11	Al Funduq	756.0	149.0	5.1	207.8	99.3	750.8	0.0	0.0	172.0	0.0	0.0	56,949.4	0.0	0.0	56,949.4	0.0	100.0	0.0	45,559.5
12	An Nabi Elyas	1,171.0	216.0	5.4	83.3	99.5	1,165.4	0.5	1.0	172.0	0.0	0.0	35,453.5	0.0	87.4	35,540.9	0.0	100.0	0.0	28,432.7
13	Kafr Laqif	856.0	157.0	5.5	57.7	99.3	850.4	0.7	1.0	172.0	0.0	0.0	17,900.6	0.0	87.8	17,988.4	0.0	100.0	0.0	14,390.7
14	'Arab Abu Farda	116.0	24.0	4.8		4.3	5.0	0.0	0.0	172.0	91.3	21.9	0.0	1,375.7	0.0	1,375.7	0.0	100.0	0.0	1,100.6
15	'Izbat at Tabib	231.0	40.0	5.8	148.1	100.0	231.0	0.0	0.0	172.0	0.0	0.0	12,487.0	0.0	0.0	12,487.0	100.0	0.0	9,989.6	0.0
16	Jinsafut	2,119.0	351.0	6.0	107.2	99.1	2,100.4	0.3	1.0	172.0	0.0	0.0	82,189.0	0.0	87.5	82,276.4	0.0	100.0	0.0	65,821.2
18	'Isla	855.0	137.0	6.2	128.3	98.5	842.1	0.0	0.0	172.0	0.0	0.0	39,436.0	0.0	0.0	39,436.0	0.0	100.0	0.0	31,548.8
22	Ras 'Atiya	1,522.0	269.0	5.7	77.1	99.6	1,516.2	0.0	0.0	172.0	0.4	1.0	42,668.9	64.7	0.0	42,733.6	0.0	100.0	0.0	34,186.9
23	Ad Dab'a	335.0	57.0	5.9		100.0	335.0	0.0	0.0	172.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
24	Kafr Thulth	3,921.0	696.0	5.6	90.0	91.7	3,596.2	8.0	55.6	172.0	0.0	0.0	118,134.6	0.0	4,725.8	122,860.4	0.0	100.0	0.0	98,288.3
26	Al Mudawwar	271.0	43.0	6.3		92.9	251.6	0.0	0.0	172.0	7.1	3.1	0.0	192.8	0.0	192.8	0.0	100.0	0.0	154.3
27	'Izbat Salman	722.0	130.0	5.6		65.1	469.9	17.5	22.7	172.0	16.7	21.7	0.0	1,360.2	1,929.4	3,289.6	0.0	100.0	0.0	2,631.7
28	'Izbat al Ashqar	315.0	50.0	6.3		0.0	0.0	100.0	50.0	172.0	0.0	0.0	0.0	0.0	4,250.0	4,250.0	0.0	100.0	0.0	3,400.0
29	Beit Amin	1,010.0	168.0	6.0		95.1	960.4	3.1	5.2	172.0	0.0	0.0	0.0	0.0	438.0	438.0	0.0	100.0	0.0	350.4
30	Sanniriya	2,780.0	476.0	5.8	64.3	98.5	2,737.9	1.5	7.2	172.0	0.0	0.0	64,304.5	0.0	613.0	64,917.5	0.0	100.0	0.0	51,934.0
31	'Azzun 'Atma	1,771.0	310.0	5.7	75.5	92.4	1,635.7	0.7	2.1	172.0	0.0	0.0	45,054.5	0.0	175.1	45,229.6	0.0	100.0	0.0	36,183.7
	Total	**34,733.0**	6,118.0	5.7	**97.5**	**74.5**		**13.9**			**10.7**		**775,578.9**	**19,282.0**	**66,276.4**	**861,137.3**	**6.6**	**93.4**	**19,385.7**	**669,524.1**

Salfit Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Deir Istiya	3,146.0	592.0	5.3	35.0	97.6	3,070.6	2.4	14.2	172.0	0.0	0.0	39,277.8	0.0	1,206.3	40,484.1	0.0	100.0	0.0	32,387.3
2	Qarawat Bani Hassan	3,801.0	669.0	5.7	45.0	99.8	3,795.2	0.2	1.0	172.0	0.0	0.0	62,296.3	0.0	86.2	62,382.5	0.0	100.0	0.0	49,906.0
3	Qira	1,143.0	176.0	6.5	39.8	87.4	998.5	12.1	21.2	172.0	0.0	0.0	14,522.8	0.0	1,805.5	16,328.3	0.0	100.0	0.0	13,062.7
4	Kifl Haris	3,248.0	599.0	5.4	48.4	99.7	3,237.0	0.2	1.0	172.0	0.0	0.0	57,195.0	0.0	86.2	57,281.2	0.0	100.0	0.0	45,824.9
5	Marda	1,992.0	348.0	5.7	39.0	97.4	1,939.7	2.3	8.1	172.0	0.0	0.0	27,635.1	0.0	689.9	28,325.0	0.0	100.0	0.0	22,660.0
6	Haris	3,112.0	534.0	5.8	46.6	100.0	3,112.0	0.0	0.0	172.0	0.0	0.0	52,927.8	0.0	0.0	52,927.8	0.0	100.0	0.0	42,342.3
7	Yasuf	1,621.0	312.0	5.2	51	99.4	1,610.5	0.6	2.0	172.0	0.0	0.0	30,061.2	0.0	172.2	30,233.4	0.0	100.0	0.0	24,186.7
8	Mas-ha	2,003.0	384.0	5.2	69	99.7	1,997.7	0.3	1.0	172.0	0.0	0.0	50,412.0	0.0	86.1	50,498.1	0.0	100.0	0.0	40,398.5
9	Iskaka	912.0	155.0	5.9	30.3	94.1	858.4	5.9	9.1	172.0	0.0	0.0	9,502.2	0.0	775.0	10,277.2	0.0	100.0	0.0	8,221.7
10	Sarta	2,530.0	466.0	5.4	45	100.0	2,530.0	0.0	0.0	172.0	0.0	0.0	41,883.9	0.0	0.0	41,883.9	0.0	100.0	0.0	33,507.1
12	Rafat	1,861.0	344.0	5.4	69	99.4	1,850.1	0.3	1.0	172.0	0.0	0.0	46,593.6	0.0	86.0	46,679.6	0.0	100.0	0.0	37,343.7
13	Bruqin	3,236.0	564.0	5.7		3.9	127.8	94.1	530.6	172.0	1.3	7.1	0.0	445.0	45,099.7	45,544.7	0.0	100.0	0.0	36,435.8
14	Farkha	1,366.0	222.0	6.2	79	82.2	1,122.7	14.2	31.4	172.0	2.3	5.1	32,394.6	318.2	2,671.1	35,383.9	0.0	100.0	0.0	28,307.1
15	Kafr ad Dik	4,553.0	884.0	5.2		0.9	41.7	42.5	375.7	172.0	55.8	493.1	0.0	30,959.1	31,932.3	62,891.4	0.0	100.0	0.0	50,313.2
16	Deir Ballut	3,195.0	609.0	5.2	45.4	96.7	3,088.7	1.7	10.1	172.0	1.2	7.1	51,132.7	445.3	861.3	52,439.3	0.0	100.0	0.0	41,951.5
17	Khirbet Qeis	226.0	45.0	5.0	79	97.7	220.9	2.3	1.0	172.0	0.0	0.0	6,372.7	0.0	69.5	6,442.3	0.0	100.0	0.0	5,153.8
	Total	**37,945.0**	**6,903.0**	**5.6**	**51.6**	**84.7**		**11.2**			**3.8**		**522,207.6**	**32,167.6**	**85,627.4**	**640,002.7**	**0.0**	**100.0**	**0.0**	**512,002.1**

Ramallah and Al Bireh Governorates

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Qarawat Bani Zeid	2,915.0	504.0	5.8	70	98.9	2,884.3	0.0	0.0	163.0	1.1	5.3	73,692.6	316.3	0.0	74,008.9	0.0	100.0	0.0	59,207.1
2	Kafr 'Ein	1,743.0	341.0	5.1	70	99.7	1,737.6	0.3	1.1	163.0	0.0	0.0	44,321.4	0.0	90.6	44,412.0	0.0	100.0	0.0	35,529.6
3	'Abwein	3,119.0	572.0	5.5	40	84.2	2,626.2	11.2	63.8	163.0	0.0	0.0	38,286.6	0.0	5,422.3	43,708.9	0.0	100.0	0.0	34,967.1
4	Turmus'ayya	3,736.0	625.0	6.0	73	94.7	3,538.7	2.9	18.1	163.0	0.2	1.1	93,762.8	63.3	1,538.5	95,364.7	0.0	100.0	0.0	76,291.7
5	Al Lubban al Gharbi	1,476.0	248.0	6.0	79	97.9	1,444.3	0.0	0.0	163.0	2.1	5.3	41,692.8	316.6	0.0	42,009.4	0.0	100.0	0.0	33,607.5
6	Deir as Sudan	1,991.0	326.0	6.1	36	85.6	1,704.7	13.7	44.7	163.0	0.3	1.1	22,673.9	63.4	3,803.3	26,540.6	0.0	100.0	0.0	21,232.5
7	Rantis	2,534.0	421.0	6.0	41	99.2	2,514.8	0.3	1.1	163.0	0.5	2.1	37,261.9	126.5	90.4	37,478.7	0.0	100.0	0.0	29,983.0
8	Jilijliya	741.0	154.0	4.8	76	95.9	710.3	3.4	5.3	163.0	0.7	1.1	19,611.4	63.2	451.4	20,126.0	0.0	100.0	0.0	16,100.8
9	'Ajjul	1,237.0	220.0	5.6	33	83.6	1,033.8	15.9	35.1	163.0	0.0	0.0	12,385.2	0.0	2,981.2	15,366.3	0.0	100.0	0.0	12,293.1
10	Al Mughayyir	2,368.0	376.0	6.3	46	94.6	2,240.5	5.1	19.2	163.0	0.0	0.0	37,796.4	0.0	1,629.7	39,426.1	0.0	100.0	0.0	31,540.9
11	'Abud	2,084.0	419.0	5.0	60	98.5	2,052.3	0.3	1.1	163.0	1.0	4.3	44,944.6	253.1	90.4	45,288.1	0.0	100.0	0.0	36,230.4
12	An Nabi Salih	534.0	91.0	5.9	70	98.8	527.8	0.0	0.0	163.0	0.0	0.0	13,462.9	0.0	0.0	13,462.9	0.0	100.0	0.0	10,770.3
13	Khirbet Abu Falah	3,996.0	620.0	6.4	45	77.7	3,105.0	22.0	136.1	163.0	0.0	0.0	51,160.2	0.0	11,570.5	62,730.7	0.0	100.0	0.0	50,184.5
14	Umm Safa	612.0	114.0	5.4	4	94.4	577.7	3.7	4.3	163.0	0.0	0.0	941.4	0.0	362.2	1,303.7	0.0	100.0	0.0	1,042.9
15	Deir Nidham	879.0	139.0	6.3	30	93.1	818.6	0.0	0.0	163.0	6.1	8.5	9,055.9	505.0	0.0	9,560.9	0.0	100.0	0.0	7,648.7
16	'Atara	2,270.0	413.0	5.5	50	96.6	2,193.9	2.8	11.7	163.0	0.0	0.0	40,372.7	0.0	995.2	41,367.9	0.0	100.0	0.0	33,094.3
17	Deir Abu Mash'al	3,522.0	672.0	5.2	55	99.8	3,516.4	0.0	0.0	163.0	0.0	0.0	70,300.1	0.0	0.0	70,300.1	0.0	100.0	0.0	56,240.0
18	Jibiya	148.0	26.0	5.7	47	91.7	135.7	0.0	0.0	163.0	0.0	0.0	2,340.3	0.0	0.0	2,340.3	0.0	100.0	0.0	1,872.2
19	Burham	616.0	120.0	5.1	70	100.0	616.0	0.0	0.0	163.0	0.0	0.0	15,695.5	0.0	0.0	15,695.5	0.0	100.0	0.0	12,556.4
20	Kafr Malik	2,787.0	561.0	5.0	74	92.6	2,580.8	0.4	2.1	163.0	6.3	35.1	69,416.6	2,090.0	181.0	71,687.6	0.0	100.0	0.0	57,350.1
21	Shuqba	4,497.0	793.0	5.7	51	99.6	4,478.9	0.0	0.0	163.0	0.1	1.1	82,677.6	63.3	0.0	82,740.9	0.0	100.0	0.0	66,192.7
22	Kobar	3,677.0	668.0	5.5	57	95.5	3,513.1	3.5	23.4	163.0	0.5	3.2	72,754.1	189.9	1,989.1	74,933.0	0.0	100.0	0.0	59,946.4
23	Qibya	4,901.0	803.0	6.1	35	98.4	4,823.1	0.4	3.2	163.0	0.0	0.0	61,317.5	0.0	271.2	61,588.7	0.0	100.0	0.0	49,271.0
24	Yabrud	644.0	111.0	5.8	55	87.5	563.5	1.0	1.1	163.0	0.0	0.0	11,265.9	0.0	90.7	11,356.6	0.0	100.0	0.0	9,085.3
25	Shabtin	844.0	149.0	5.7	28	100.0	844.0	0.0	0.0	163.0	0.0	0.0	8,548.9	0.0	0.0	8,548.9	98.0	2.0	6,702.3	136.8
26	AL-Doha	50.0	10.0	5.0		100.0	50.0	0.0	0.0	163.0	0.0	0.0	0.0	0.0	0.0	0.0	67.0	33.0	0.0	0.0
27	'Ein Siniya	711.0	136.0	5.2	105	98.4	699.9	0.0	0.0	163.0	0.0	0.0	26,923.0	0.0	0.0	26,923.0	10.0	90.0	2,153.8	19,384.6
28	Deir Jarir	3,986.0	750.0	5.3	49	99.0	3,946.4	0.4	3.2	163.0	0.3	2.1	70,328.5	126.6	271.3	70,726.4	0.0	100.0	0.0	56,581.1
29	Budrus	1,399.0	236.0	5.9	31	100.0	1,399.0	0.0	0.0	163.0	0.0	0.0	15,912.3	0.0	0.0	15,912.3	0.0	100.0	0.0	12,729.9
30	AL-Zaytouneh	6,190.0	1,027.0	6.0	45	96.1	5,946.2	2.2	22.3	163.0	0.7	7.4	97,667.1	443.2	1,899.7	100,010.0	0.0	100.0	0.0	80,008.0
31	Jifna	1,716.0	378.0	4.5	143	98.6	1,691.7	0.3	1.1	163.0	0.8	3.2	88,389.1	191.1	91.0	88,671.3	0.0	100.0	0.0	70,937.0
32	Dura al Qar'	2,897.0	541.0	5.4	45	99.4	2,879.9	0.4	2.1	163.0	0.0	0.0	46,803.3	0.0	180.7	46,983.9	47.0	53.0	17,649.0	19,921.2
33	At Tayba	1,452.0	333.0	4.4	109	98.7	1,433.3	0.0	0.0	163.0	1.0	3.2	57,072.8	191.1	0.0	57,263.9	0.0	100.0	0.0	45,811.1
34	Abu Qash	1,404.0	273.0	5.1	81	98.1	1,376.7	0.0	0.0	163.0	0.8	2.1	40,787.9	126.4	0.0	40,914.3	0.0	100.0	0.0	32,731.5
35	Deir Qaddis	1,942.0	345.0	5.6	55	100.0	1,942.0	0.0	0.0	163.0	0.0	0.0	39,039.9	0.0	0.0	39,039.9	0.0	100.0	0.0	31,231.9
36	'Ein Yabrud	2,999.0	577.0	5.2	98	98.9	2,965.8	0.6	3.2	163.0	0.4	2.1	106,339.3	126.7	271.5	106,737.4	0.0	100.0	0.0	85,390.0
37	Kharbatha Bani Harith	2,846.0	487.0	5.8	57	98.9	2,814.9	0.0	0.0	163.0	0.2	1.1	58,121.2	63.3	0.0	58,184.5	0.0	100.0	0.0	46,547.6
38	Ras Karkar	1,663.0	288.0	5.8	42	100.0	1,663.0	0.0	0.0	163.0	0.0	0.0	25,704.2	0.0	0.0	25,704.2	0.0	100.0	0.0	20,563.4
39	Surda	1,031.0	214.0	4.8	98	99.5	1,025.9	0.0	0.0	163.0	0.0	0.0	36,540.3	0.0	0.0	36,540.3	0.0	100.0	0.0	29,232.3
40	Al Janiya	1,163.0	180.0	6.5	45	100.0	1,163.0	0.0	0.0	163.0	0.0	0.0	19,101.2	0.0	0.0	19,101.2	0.0	100.0	0.0	15,280.9
41	Al Midya	1,301.0	216.0	6.0	48	100.0	1,301.0	0.0	0.0	163.0	0.0	0.0	23,001.8	0.0	0.0	23,001.8	0.0	100.0	0.0	18,401.5
42	Rammun	2,626.0	468.0	5.6	80	98.0	2,572.3	0.9	4.3	163.0	1.1	5.3	74,945.7	316.4	361.6	75,623.7	0.0	100.0	0.0	60,499.0

Ramallah and Al Bireh Governorates, Continue

43	Kafr Ni'ma	3,750.0	709.0	5.3	56	91.9	3,445.9	7.8	55.4	163.0	0.0	0.0	70,491.1	0.0	4,705.4	75,196.5	0.0	100.0	0.0	60,157.2
44	Bil'in	1,701.0	307.0	5.5	31	92.4	1,571.5	6.2	19.1	163.0	0.0	0.0	18,032.8	0.0	1,625.3	19,658.1	0.0	100.0	0.0	15,726.5
45	Beitin	2,143.0	440.0	4.9	74	98.8	2,117.1	0.2	1.1	163.0	0.0	0.0	57,431.3	0.0	90.3	57,521.7	0.0	100.0	0.0	46,017.3
46	'Ein Qiniya	812.0	130.0	6.2	50	95.1	772.1	0.0	0.0	163.0	0.0	0.0	14,090.2	0.0	0.0	14,090.2	0.0	100.0	0.0	11,272.2
47	Badiw al Mu'arrajat	753.0	112.0	6.7		2.9	21.5	5.7	6.4	163.0	90.5	101.3	0.0	6,028.8	544.0	6,572.8	0.0	100.0	0.0	5,258.3
48	Deir Ibzi'	2,069.0	354.0	5.8	77	97.6	2,019.3	2.1	7.4	163.0	0.0	0.0	56,508.2	0.0	632.5	57,140.7	0.0	100.0	0.0	45,712.6
49	'Ein 'Arik	1,567.0	287.0	5.5	53	98.9	1,549.5	0.0	0.0	163.0	0.0	0.0	30,024.1	0.0	0.0	30,024.1	0.0	100.0	0.0	24,019.2
50	Saffa	3,802.0	651.0	5.8	64	99.8	3,795.8	0.2	1.1	163.0	0.0	0.0	88,645.9	0.0	90.4	88,736.4	0.0	100.0	0.0	70,989.1
51	Burqa	2,090.0	314.0	6.7	45	96.3	2,012.1	2.4	7.5	163.0	0.7	2.1	33,241.2	126.7	633.3	34,001.2	0.0	100.0	0.0	27,201.0
52	Beit Sira	2,749.0	493.0	5.6	60	99.4	2,731.2	0.0	0.0	163.0	0.0	0.0	59,964.4	0.0	0.0	59,964.4	0.0	100.0	0.0	47,971.5
53	Kharbatha al Misbah	5,211.0	815.0	6.4	39	96.5	5,027.3	0.5	4.3	163.0	2.9	23.4	71,731.0	1,392.6	361.7	73,485.3	0.0	100.0	0.0	58,788.3
54	Beit 'Ur al Fauqa	864.0	178.0	4.9	75	100.0	864.0	0.0	0.0	163.0	0.0	0.0	23,540.4	0.0	0.0	23,540.4	0.0	100.0	0.0	18,832.4
55	At Tira	1,358.0	246.0	5.5	45	99.1	1,346.2	0.9	2.1	163.0	0.0	0.0	22,004.8	0.0	181.0	22,185.8	0.0	100.0	0.0	17,748.7
56	Beit Nuba	249.0	32.0	7.8	45	100.0	249.0	0.0	0.0	163.0	0.0	0.0	4,089.8	0.0	0.0	4,089.8	0.0	100.0	0.0	3,271.9
	Total	**118,365.0**	21,013.0	5.6	**58**	**94.8**		**2.1**			**2.1**		**2,352,211.9**	**13,183.5**	**43,497.6**	**2,408,893.0**	**4.0**	**96.0**	**26,505.2**	**1,900,592.3**

Jerusalem Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Rafat	2,374.0	420.0	5.7	112	80.9	1,920.9	0.0	0.0	163.0	0.0	0.0	78,619.5	0.0	0.0	78,619.5	0.0	100.0	0.0	62,895.6
2	Mikhmas	1,447.0	312.0	4.6	88	98.4	1,423.8	0.0	0.0	163.0	0.0	0.0	45,786.9	0.0	0.0	45,786.9	0.0	100.0	0.0	36,629.5
3	Jaba' (Tajammu' Badawi)	72.0	16.0	4.5	44	96.6	69.6	0.3	0.1	163.0	0.8	0.1	1,117.1	7.7	4.4	1,129.2	0.0	100.0	0.0	903.4
4	Qalandiya	1,179.0	214.0	5.5	44	0.0	0.0	0.0	0.0	163.0	95.2	203.8	0.0	12,125.6	0.0	12,125.6	50.0	50.0	4,850.3	4,850.3
5	Beit Duqqu	1,621.0	308.0	5.3	12	62.6	1,014.6	35.3	108.6	163.0	2.2	6.6	4,584.1	395.5	9,228.9	14,208.5	0.0	100.0	0.0	11,366.8
6	Jaba'	3,183.0	462.0	6.9	43	95.4	3,038.0	1.7	7.8	163.0	1.7	7.8	47,240.0	461.4	659.2	48,360.6	0.0	100.0	0.0	38,688.5
7	Al Judeira	2,276.0	410.0	5.6	80	98.9	2,251.4	0.0	0.0	163.0	0.3	1.1	65,925.2	65.9	0.0	65,991.1	97.0	3.0	51,209.1	1,583.8
8	Beit 'Anan	3,980.0	764.0	5.2	40	87.8	3,494.8	8.7	66.5	163.0	2.3	17.7	50,743.8	1,055.5	5,655.2	57,454.5	0.0	100.0	0.0	45,963.6
9	Beit Ijza	698.0	120.0	5.8	19	82.4	575.2	15.7	18.9	163.0	0.0	0.0	3,926.9	0.0	1,605.6	5,532.5	0.0	100.0	0.0	4,426.0
10	Al Qubeiba	3,172.0	555.0	5.7	61	95.6	3,031.6	2.2	12.3	163.0	0.0	0.0	68,020.4	0.0	1,044.1	69,064.5	0.0	100.0	0.0	55,251.6
11	Kharayib Umm al Lahim	363.0	53.0	6.8		2.1	7.6	56.3	29.8	163.0	31.3	16.6	0.0	985.4	2,534.1	3,519.4	0.0	100.0	0.0	2,815.6
12	An Nabi Samwil	258.0	43.0	6.0	142	94.9	244.8	0.0	0.0	163.0	0.0	0.0	12,708.3	0.0	0.0	12,708.3	0.0	53.8	0.0	5,474.4
13	Beit Hanina al Balad	1,071.0	181.0	5.9	87	90.2	965.9	1.8	3.3	163.0	1.2	2.2	30,662.6	132.1	283.2	31,077.9	75.0	25.0	18,646.7	6,215.6
14	Qatanna	6,458.0	1,069.0	6.0	46	71.1	4,588.9	8.9	95.4	163.0	16.6	177.4	76,594.6	10,556.0	8,106.2	95,256.8	0.0	100.0	0.0	76,205.5
15	Beit Surik	3,887.0	629.0	6.2	56	95.2	3,701.9	1.9	12.2	163.0	2.5	15.5	75,291.6	924.0	1,037.2	77,252.8	0.0	100.0	0.0	61,802.3
16	Beit Iksa	1,895.0	362.0	5.2	70	98.5	1,865.9	0.9	3.3	163.0	0.3	1.1	47,407.8	66.1	283.2	47,757.0	44.0	56.0	16,810.5	21,395.1
17	Al Ka'abina (Tajammu' Badawi)	694.0	122.0	5.7	44	54.5	378.5	0.9	1.1	163.0	36.4	44.4	6,079.4	2,639.4	94.3	8,813.1	0.0	100.0	0.0	7,050.5
18	Az Za'ayyem	3,402.0	695.0	4.9	165	86.9	2,957.1	0.0	0.0	163.0	5.4	37.7	178,238.6	2,242.2	0.0	180,480.8	67.0	33.0	96,737.7	47,646.9
19	'Arab al Jahalin	721.0	101.0	7.1	44	98.9	713.1	0.0	0.0	163.0	0.0	0.0	11,452.0	0.0	0.0	11,452.0	0.0	100.0	0.0	9,161.6
20	Ash Sheikh Sa'd	1,949.0	385.0	5.1	92	98.6	1,920.9	0.0	0.0	163.0	0.0	0.0	64,479.3	0.0	0.0	64,479.3	0.0	100.0	0.0	51,583.4
	Total	**40,700.0**	**7,221.0**	**5.7**	**67.8**	**79.5**		**6.7**			**9.8**		**868,878.1**	**31,657.0**	**30,535.5**	**931,070.5**	**16.7**	**81.0**	**188,254.3**	**551,909.8**

Jericho and Al Aghwar Governorates

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Marj Na'ja	715.0	116.0	6.2	71	72.1	515.3	2.7	3.1	163.0	21.6	25.1	13,437.2	1,492.2	266.5	15,195.9	0.0	100.0	0.0	12,156.7
2	Az Zubeidat	1,421.0	199.0	7.1	150	97.9	1,391.1	0.0	0.0	163.0	1.6	3.1	75,993.7	186.9	0.0	76,180.6	0.0	100.0	0.0	60,944.5
3	Marj al Ghazal	203.0	43.0	4.7	71	100.0	203.0	0.0	0.0	163.0	0.0	0.0	5,272.7	0.0	0.0	5,272.7	0.0	100.0	0.0	4,218.2
4	Al Jiftlik	3,714.0	578.0	6.4	76	90.8	3,370.9	0.2	1.0	163.0	7.2	41.9	93,081.2	2,491.9	89.0	95,662.1	0.0	100.0	0.0	76,529.7
5	Fasayil	1,078.0	190.0	5.7	248	92.9	1,001.0	0.0	0.0	163.0	7.1	13.6	90,440.4	807.4	0.0	91,247.8	0.0	100.0	0.0	72,998.2
6	An Nuwei'ma	1,245.0	213.0	5.8	51	97.9	1,218.8	0.0	0.0	163.0	1.6	3.4	22,687.8	200.1	0.0	22,887.9	0.0	100.0	0.0	18,310.3
7	'Ein ad Duyuk al Fauqa	821.0	137.0	6.0	77	100.0	821.0	0.0	0.0	163.0	0.0	0.0	23,048.5	0.0	0.0	23,048.5	0.0	100.0	0.0	18,438.8
8	Deir al Qilt	4.0	1.0	4.0		0.0	0.0	0.0	0.0	163.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
9	Deir Hajla	8.0	1.0	8.0		0.0	0.0	0.0	0.0	163.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
10	An Nabi Musa	309.0	66.0	4.7	70.0	20.2	62.4	0.0	0.0	163.0	12.3	8.1	1,594.5	483.6	0.0	2,078.1	0.0	100.0	0.0	1,662.5
	Total	**9,518.0**	**1,544.0**	**5.9**	**101.7**	**67.2**		**0.3**			**5.1**		**325,556.0**	**5,662.1**	**355.5**	**331,573.6**	**0.0**	**100.0**	**0.0**	**265,258.9**

Bethlehem Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Al Walaja	2,041.0	390.0	5.2	83	99.7	2,035.6	0.0	0.0	156.0	0.0	0.0	61,429.6	0.0	0.0	61,429.6	0.0	100.0	0.0	49,143.7
2	Battir	3,967.0	798.0	5.0	23	96.8	3,838.2	2.9	22.8	156.0	0.0	0.0	32,835.3	0.0	1,938.0	34,773.3	0.0	100.0	0.0	27,818.6
8	Dar Salah	3,373.0	625.0	5.4	103	99.2	3,345.0	0.7	4.1	156.0	0.0	0.0	126,202.6	0.0	352.4	126,555.0	0.0	100.0	0.0	101,244.0
9	Wadi Fukin	1,168.0	217.0	5.4	50	98.6	1,151.2	0.0	0.0	156.0	0.0	0.0	20,989.8	0.0	0.0	20,989.8	0.0	100.0	0.0	16,791.8
10	Hindaza	4,799.0	794.0	6.0	140	99.7	4,786.5	0.0	0.0	156.0	0.0	0.0	244,588.6	0.0	0.0	244,588.6	0.0	100.0	0.0	195,670.9
11	Ash Shawawra	3,737.0	694.0	5.4	73	98.7	3,686.7	0.9	6.2	156.0	0.3	2.1	98,082.2	118.1	529.1	98,729.4	0.0	100.0	0.0	78,983.5
12	Artas	3,663.0	603.0	6.1	83	99.3	3,637.8	0.0	0.0	156.0	0.0	0.0	109,781.2	0.0	0.0	109,781.2	0.0	100.0	0.0	87,825.0
13	Beit Ta'mir	1,229.0	200.0	6.1	83	95.9	1,178.1	0.5	1.0	156.0	0.0	0.0	35,551.5	0.0	88.1	35,639.6	0.0	100.0	0.0	28,511.6
15	Al Jab'a	896.0	140.0	6.4	56	96.3	862.8	0.0	0.0	156.0	0.0	0.0	17,635.9	0.0	0.0	17,635.9	0.0	100.0	0.0	14,108.7
16	Wadi Rahhal	1,419.0	278.0	5.1	221	99.3	1,408.4	0.0	0.0	156.0	0.0	0.0	113,463.5	0.0	0.0	113,463.5	0.0	100.0	0.0	90,770.8
19	Khallet al Haddad	407.0	73.0	5.6	42	100.0	407.0	0.0	0.0	156.0	0.0	0.0	6,263.2	0.0	0.0	6,263.2	0.0	100.0	0.0	5,010.5
20	Al Ma'sara	803.0	129.0	6.2	13	99.2	796.5	0.8	1.0	156.0	0.0	0.0	3,671.6	0.0	88.4	3,760.1	0.0	100.0	0.0	3,008.0
21	Wadi an Nis	772.0	119.0	6.5	26	98.3	758.6	0.0	0.0	156.0	0.0	0.0	7,126.1	0.0	0.0	7,126.1	0.0	100.0	0.0	5,700.9
22	Jurat ash Sham'a	1,491.0	250.0	6.0	25	100.0	1,491.0	0.0	0.0	156.0	0.0	0.0	13,630.1	0.0	0.0	13,630.1	0.0	100.0	0.0	10,904.1
24	Marah Ma'alla	685.0	99.0	6.9	73	98.9	677.8	0.0	0.0	156.0	0.0	0.0	18,037.8	0.0	0.0	18,037.8	0.0	100.0	0.0	14,430.3
25	Umm Salamuna	945.0	139.0	6.8	0	100.0	945.0	0.0	0.0	156.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
26	Ash Shawawra	3,737.0	694.0	5.4	119	98.7	3,688.4	0.9	6.2	156.0	0.3	2.1	160,206.5	118.5	530.9	160,855.9	0.0	100.0	0.0	128,684.8
27	Al Manshiya	433.0	57.0	7.6	126	100.0	433.0	0.0	0.0	156.0	0.0	0.0	19,882.0	0.0	0.0	19,882.0	0.0	100.0	0.0	15,905.6
28	Marah Rabah	1,320.0	169.0	7.8	71	98.2	1,295.7	0.6	1.0	156.0	0.0	0.0	33,684.0	0.0	88.1	33,772.1	0.0	100.0	0.0	27,017.7
29	Al Maniya	1,012.0	157.0	6.4	130	98.7	998.6	0.0	0.0	156.0	0.7	1.0	47,522.4	59.2	0.0	47,581.6	0.0	100.0	0.0	38,065.3
30	Kisan	454.0	76.0	6.0	27	98.6	447.8	0.0	0.0	156.0	0.0	0.0	4,431.1	0.0	0.0	4,431.1	0.0	100.0	0.0	3,544.9
31	'Arab ar Rashayida	1,453.0	224.0	6.5	70	67.6	982.1	0.9	2.1	156.0	31.5	70.5	25,093.4	4,015.3	176.3	29,285.0	0.0	100.0	0.0	23,428.0
	Total	**39,804.0**	**6,925.0**	**6.1**	**74.4**	**97.3**		**0.4**			**1.5**		**1,200,108.4**	**4,311.2**	**3,791.3**	**1,208,210.9**	**0.0**	**100.0**	**0.0**	**966,568.7**

Hebron Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
1	Khirbet ad Deir	264.0	47.0	5.6	190	100.0	264.0	0.0	0.0	156.0	0.0	0.0	18,289.2	0.0	0.0	18,289.2	0.0	100.0	0.0	14,631.3
2	Jala	249.0	40.0	6.2	90	100.0	249.0	0.0	0.0	156.0	0.0	0.0	8,179.7	0.0	0.0	8,179.7	0.0	100.0	0.0	6,543.7
3	Hitta	891.0	114.0	7.8	58	100.0	891.0	0.0	0.0	156.0	0.0	0.0	18,887.6	0.0	0.0	18,887.6	0.0	100.0	0.0	15,110.1
4	Shuyukh al 'Arrub	1,550.0	257.0	6.0		99.6	1,543.8	0.0	0.0	156.0	0.4	1.0	0.0	58.5	0.0	58.5	88.0	12.0	41.2	5.6
5	Umm al Butm	71.0	11.0	6.5		9.1	6.5	90.9	10.0	156.0	0.0	0.0	0.0	0.0	850.0	850.0	0.0	100.0	0.0	680.0
6	Hamrush	53.0	7.0	7.6		0.0	0.0	100.0	7.0	156.0	0.0	0.0	0.0	0.0	595.0	595.0	0.0	100.0	0.0	476.0
7	Beit 'Einun	1,809.0	282.0	6.4	50.0	100.0	1,809.0	0.0	0.0	156.0	0.0	0.0	33,014.3	0.0	0.0	33,014.3	0.0	100.0	0.0	26,411.4
8	Qla'a Zeta	903.0	158.0	5.7	55.0	45.5	410.5	46.1	72.8	156.0	8.4	13.3	8,239.9	759.4	6,191.8	15,191.1	0.0	100.0	0.0	12,152.9
9	Beit Maqdum	2,568.0	432.0	5.9		95.2	2,446.0	2.1	9.2	156.0	2.6	11.3	0.0	642.7	785.0	1,427.7	0.0	100.0	0.0	1,142.2
10	Al Baqa	1,218.0	193.0	6.3		25.5	311.0	54.3	104.7	156.0	11.7	22.6	0.0	1,286.0	8,900.6	10,186.6	0.0	100.0	0.0	8,149.3
11	Al Bowereh (Aqabat Injeleh)	694.0	106.0	6.5		1.0	6.7	57.3	60.7	156.0	39.8	42.2	0.0	2,402.5	5,161.1	7,563.6	0.0	100.0	0.0	6,050.9
12	Khallet Edar	2,186.0	316.0	6.9		84.1	1,838.2	14.0	44.1	156.0	0.6	2.1	0.0	116.8	3,749.9	3,866.8	0.0	100.0	0.0	3,093.4
13	Khallet Al Masafer	217.0	39.0	5.6		0.0	0.0	0.0	0.0	156.0	100.0	39.0	0.0	2,220.7	0.0	2,220.7	0.0	100.0	0.0	1,776.5
14	Qalqas	1,149.0	159.0	7.2	66	38.1	437.4	27.1	43.1	156.0	32.3	51.3	10,464.8	2,920.5	3,662.1	17,047.4	0.0	100.0	0.0	13,637.9
15	Sikka	855.0	149.0	5.7	46	6.2	53.1	83.4	124.3	156.0	9.0	13.4	900.6	760.6	10,568.7	12,230.0	0.0	100.0	0.0	9,784.0
16	Khirbet Salama	371.0	64.0	5.8		0.0	0.0	25.8	16.5	156.0	74.2	47.5	0.0	2,703.7	1,403.9	4,107.6	0.0	100.0	0.0	3,286.1
17	Wadi 'Ubeid	130.0	21.0	6.2		0.0	0.0	30.0	6.3	156.0	70.0	14.7	0.0	837.0	535.5	1,372.5	0.0	100.0	0.0	1,098.0
18	Fuqeiqis	271.0	42.0	6.5		0.0	0.0	36.6	15.4	156.0	61.0	25.6	0.0	1,458.2	1,306.1	2,764.3	0.0	100.0	0.0	2,211.5
19	Khursa	3,440.0	554.0	6.2		0.2	6.4	11.9	65.7	156.0	87.0	482.2	0.0	27,455.6	5,581.0	33,036.7	0.0	100.0	0.0	26,429.3
20	Tarrama	631.0	106.0	6.0	59	12.6	79.6	1.9	2.1	156.0	85.4	90.6	1,724.6	5,156.7	175.0	7,056.2	0.0	100.0	0.0	5,645.0
21	Al Majd	1,925.0	315.0	6.1		6.8	131.7	53.7	169.3	156.0	39.4	124.2	0.0	7,069.3	14,390.5	21,459.7	0.0	100.0	0.0	17,167.8
22	Marah al Baqqar	215.0	40.0	5.4		5.1	11.0	92.3	36.9	156.0	2.6	1.0	0.0	58.4	3,138.5	3,196.9	0.0	100.0	0.0	2,557.5
23	Hadab al Fawwar	1,918.0	308.0	6.2	59	38.7	741.6	16.3	50.3	156.0	43.0	132.4	16,059.7	7,541.1	4,276.1	27,876.9	0.0	100.0	0.0	22,301.5
24	Deir al 'Asal at Tahta	555.0	89.0	6.2	59	31.0	172.2	4.6	4.1	156.0	64.4	57.3	3,729.8	3,261.9	347.8	7,339.6	0.0	100.0	0.0	5,871.7
25	Al Heila	1,277.0	169.0	7.6		0.0	0.0	86.1	145.4	156.0	13.9	23.6	0.0	1,341.4	12,362.6	13,704.0	0.0	100.0	0.0	10,963.2
26	Wadi ash Shajina	715.0	121.0	5.9		0.8	6.1	1.7	2.1	156.0	95.8	115.9	0.0	6,597.8	174.3	6,772.1	0.0	100.0	0.0	5,417.7
27	As Sura	1,925.0	293.0	6.6		1.4	27.0	8.8	25.7	156.0	89.5	262.2	0.0	14,927.3	2,184.6	17,111.9	0.0	100.0	0.0	13,689.5
28	Deir Razih	268.0	43.0	6.2	59	0.0	0.0	0.0	0.0	156.0	97.6	42.0	0.0	2,390.1	0.0	2,390.1	0.0	100.0	0.0	1,912.1
29	Ar Rihiya	3,949.0	511.0	7.7	25	99.2	3,917.3	0.8	4.1	156.0	0.0	0.0	35,887.5	0.0	348.9	36,236.3	0.0	100.0	0.0	28,989.1
30	Zif	848.0	98.0	8.7		52.1	441.7	45.8	44.9	156.0	0.0	0.0	0.0	0.0	3,817.9	3,817.9	0.0	100.0	0.0	3,054.3
31	Deir al 'Asal al Fauqa	1,598.0	244.0	6.5	59	1.3	20.1	37.0	90.2	156.0	61.3	149.7	436.2	8,522.8	7,668.6	16,627.6	0.0	100.0	0.0	13,302.1
32	Khallet al 'Aqed	272.0	42.0	6.5		0.0	0.0	63.4	26.6	156.0	34.1	14.3	0.0	816.6	2,263.9	3,080.5	0.0	100.0	0.0	2,464.4
33	Imreish	1,665.0	281.0	5.9		0.4	6.1	50.7	142.6	156.0	42.3	119.0	0.0	6,773.8	12,116.8	18,890.6	0.0	100.0	0.0	15,112.5
34	Al Buweib	607.0	76.0	8.0		0.0	0.0	93.2	70.9	156.0	6.8	5.1	0.0	292.4	6,023.5	6,315.9	0.0	100.0	0.0	5,052.7
35	Beit ar Rush at Tahta	373.0	62.0	6.0	14	46.7	174.1	1.7	1.0	156.0	51.7	32.0	905.3	1,824.0	87.8	2,817.1	0.0	100.0	0.0	2,253.7
36	Hadab al 'Alaqa	641.0	111.0	5.8		0.9	5.9	80.6	89.4	156.0	15.7	17.5	0.0	994.9	7,600.4	8,595.3	0.0	100.0	0.0	6,876.2
37	Beit Mirsim	318.0	58.0	5.5		0.0	0.0	80.7	46.8	156.0	19.3	11.2	0.0	637.3	3,978.6	4,615.9	0.0	100.0	0.0	3,692.7
38	Beit ar Rush al Fauqa	979.0	151.0	6.5		0.0	0.0	2.0	3.1	156.0	97.3	146.9	0.0	8,364.0	261.9	8,625.9	0.0	100.0	0.0	6,900.7
39	Karma	1,386.0	239.0	5.8		0.0	0.0	0.0	0.0	156.0	99.1	236.9	0.0	13,491.8	0.0	13,491.8	0.0	100.0	0.0	10,793.5
40	Beit 'Amra	2,165.0	289.0	7.5	15	85.8	1,857.9	7.1	20.5	156.0	6.0	17.4	10,122.2	992.0	1,742.2	12,856.4	0.0	100.0	0.0	10,285.1
41	Om Adaraj (Arab Al Ka'abneh)	813.0	76.0	10.7		93.2	758.1	1.4	1.0	156.0	5.4	4.1	0.0	233.9	87.3	321.2	0.0	100.0	0.0	257.0
42	Wadi al Kilab	47.0	6.0	7.8		0.0	0.0	0.0	0.0	156.0	100.0	6.0	0.0	341.6	0.0	341.6	0.0	100.0	0.0	273.3
43	Om Ashoqhan	296.0	41.0	7.2		0.0	0.0	47.5	19.5	156.0	52.5	21.5	0.0	1,225.6	1,655.4	2,881.0	0.0	100.0	0.0	2,304.8

Hebron Governorate

no.	Locality name	Pop	No. of HHs	Avg Size of HH	Wc NW (l/c/d)	% HHs using NW	pop using NW	% HHs using cis	no. of HHs using cis	Wc Tanks (l/HH/d)	% HHs using tanks	no. of HH using tanks	Qw NW (m3/y)	Qw Tanks (m3/y)	Qw cis (m3/y)	Qw from 3 sources (m3/y)	% WW NW	% WW Cess	Q ww NW (m3/y)	Q ww cess (m3/y)
44	Khallet al Maiyya	1,412.0	187.0	7.6		0.0	0.0	68.7	128.4	156.0	26.4	49.3	0.0	2,808.2	10,916.9	13,725.1	0.0	100.0	0.0	10,980.1
45	Kheroshewesh Wal Hadedeyah	379.0	58.0	6.5		0.0	0.0	75.4	43.8	156.0	21.1	12.2	0.0	695.3	3,719.1	4,414.4	0.0	100.0	0.0	3,531.5
46	Om Al Amad (Sahel Wadi Elma)	152.0	29.0	5.2		0.0	0.0	0.0	0.0	156.0	100.0	29.0	0.0	1,651.3	0.0	1,651.3	0.0	100.0	0.0	1,321.0
47	Ad Deirat	795.0	98.0	8.1		0.0	0.0	22.9	22.5	156.0	44.8	43.9	0.0	2,499.4	1,909.0	4,408.4	0.0	100.0	0.0	3,526.7
48	Khashem Adaraj (Al-Hathaleen)	606.0	93.0	6.5		27.5	166.5	1.1	1.0	156.0	45.1	41.9	0.0	2,385.8	86.9	2,472.7	0.0	100.0	0.0	1,978.2
49	Kurza	771.0	137.0	5.6	59.3	1.5	11.5	1.5	2.0	156.0	96.3	131.9	249.2	7,509.7	173.8	7,932.7	0.0	100.0	0.0	6,346.2
50	Rabud	2,262.0	372.0	6.1	59.3	1.9	43.6	0.8	3.1	156.0	96.7	359.7	944.6	20,481.5	261.3	21,687.4	0.0	100.0	0.0	17,349.9
51	Umm Lasafa	853.0	110.0	7.8		5.6	47.8	20.6	22.6	156.0	72.0	79.2	0.0	4,507.3	1,922.4	6,429.7	0.0	100.0	0.0	5,143.8
52	Al Burj	2,578.0	418.0	6.2	0	0.5	12.7	2.7	11.3	156.0	96.1	401.6	0.0	22,865.3	960.3	23,825.5	0.0	100.0	0.0	19,060.4
53	Um Al-Khair	516.0	69.0	7.5		95.5	492.9	0.0	0.0	156.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
54	Al Karmil	3,741.0	552.0	6.8		2.4	90.4	22.7	125.2	156.0	74.0	408.4	0.0	23,251.8	10,639.9	33,891.7	0.0	100.0	0.0	27,113.4
55	Khallet Salih	1,093.0	166.0	6.6		4.3	47.2	69.1	114.8	156.0	22.8	37.9	0.0	2,158.8	9,755.1	11,913.9	0.0	100.0	0.0	9,531.1
56	At Tuwani	326.0	52.0	6.3		0.0	0.0	23.5	12.2	156.0	70.6	36.7	0.0	2,090.0	1,040.0	3,130.0	0.0	100.0	0.0	2,504.0
57	Ma'in	459.0	58.0	7.9		0.0	0.0	87.7	50.9	156.0	12.3	7.1	0.0	405.6	4,324.6	4,730.1	0.0	100.0	0.0	3,784.1
58	An Najada	413.0	51.0	8.1		98.0	404.7	2.0	1.0	156.0	0.0	0.0	0.0	0.0	86.7	86.7	0.0	100.0	0.0	69.4
59	'Anab al Kabir	335.0	50.0	6.7		4.1	13.7	6.1	3.1	156.0	89.8	44.9	0.0	2,556.5	260.2	2,816.7	0.0	100.0	0.0	2,253.4
60	Khirbet Asafi	95.0	10.0	9.5		0.0	0.0	80.0	8.0	156.0	10.0	1.0	0.0	56.9	680.0	736.9	0.0	100.0	0.0	589.6
61	Mantiqat Shi'b al Batin	137.0	23.0	6.0		22.7	31.1	0.0	0.0	156.0	50.0	11.5	0.0	654.8	0.0	654.8	0.0	100.0	0.0	523.8
62	Wadi Al Amayer	481.0	58.0	8.3		3.5	16.9	31.6	18.3	156.0	64.9	37.6	0.0	2,143.7	1,556.8	3,700.6	0.0	100.0	0.0	2,960.5
63	Khirbet Tawil ash Shih	182.0	24.0	7.6		95.7	174.1	4.3	1.0	156.0	0.0	0.0	0.0	0.0	88.7	88.7	0.0	100.0	0.0	71.0
64	Ar Ramadin	3,281.0	487.0	6.7	31.0	4.2	138.1	6.3	30.8	156.0	88.2	429.6	1,563.1	24,460.6	2,614.4	28,638.1	0.0	100.0	0.0	22,910.5
65	Maghayir al 'Abeed	4.0	1.0	4.0		0.0	0.0	100.0	1.0	156.0	0.0	0.0	0.0	0.0	85.0	85.0	0.0	100.0	0.0	68.0
66	Khirbet al Fakheit	231.0	41.0	5.6		0.0	0.0	7.5	3.1	156.0	90.0	36.9	0.0	2,101.1	261.4	2,362.5	0.0	100.0	0.0	1,890.0
67	Khirbet Bir al 'Idd	119.0	23.0	5.2		0.0	0.0	68.2	15.7	156.0	31.8	7.3	0.0	416.7	1,333.0	1,749.7	0.0	100.0	0.0	1,399.7
68	Khirbet Zanuta	60.0	13.0	4.6		0.0	0.0	23.1	3.0	156.0	76.9	10.0	0.0	569.4	255.0	824.4	0.0	100.0	0.0	659.5
69	Imneizil	390.0	49.0	8.0		0.0	0.0	31.3	15.3	156.0	62.5	30.6	0.0	1,743.8	1,301.6	3,045.4	0.0	100.0	0.0	2,436.3
70	'Arab al Fureijat	572.0	85.0	6.7		0.0	0.0	32.5	27.7	156.0	66.3	56.3	0.0	3,207.2	2,350.3	5,557.5	0.0	100.0	0.0	4,446.0
		66,518.0	**10,074.0**	**6.6**	**48.1**	**23.5**		**30.7**			**43.3**		**169,598.1**	**267,697.9**	**190,575.5**	**627,871.5**	**1.3**	**98.7**	**41.2**	**502,256.0**

Annex B

Tables of results of wastewater samples collected from the wastewater treatment units at Attil, Zeita, Bidya and Seir During October 2008-September 2009

Water and Environmental Studies Institute (WESI)
An-Najah National University

Results of Wastewater Samples for Collective Systems

	Ser. No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
October 2008	1	ATTIL	Influent	16/10/2008	6.5E6	470	880	324	1132	127
	2		Effluent	16/10/2008	140E3	86	320	249	994	118
	3	ZEITA	Influent	16/10/2008	15E6	659	1600	2508	1214	399
	4		Effluent	16/10/2008	500E3	129	320	255	1020	110
	5	BIDYA	Influent	21/10/2008	30E6	962	3200	1405	2750	212
	6		Effluent	21/10/2008	100E3	20	240	28	2930	72
	7	SEIR	Influent	21/10/2008	8E6	346	1280	280	844	127
	8		Effluent	21/10/2008	150E3	194	340	82	1128	72
November 2008	9	ATTIL	Influent	5/11/2008	50E6	400	1440	264	934	148.6
	10		Effluent	5/11/2008	5E6	59	160	36	996	101.9
	11	ZEITA	Influent	5/11/2008	40E6	520	1100	884	783	152.8
	12		Effluent	5/11/2008	2E6	70	320	52	898	89.1
	13	BIDYA	Influent	11/11/2008	40E6	616	1600	430	1134	116.7
	14		Effluent	11/11/2008	70E3	232	160	18	1352	78.5
	15	SEIR	Influent	11/11/2008	7E6	362	960	308	1052	152.8
	16		Effluent	11/11/2008	0.6E6	232	192	20	1074	129.5

Results of Wastewater Samples for Collective Systems

	Ser. No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
December 2008	1	ATTIL	Influent	16/12/2008	4.5E6	400	800	354	1156	154
	2		Effluent	16/12/2008	100E3	108	200	58	942	133
	3	ZEITA	Influent	16/12/2008	12E6	350	1600	490	1318	108
	4		Effluent	16/12/2008	300E3	227	350	40	890	82
	5	BIDYA	Influent	24/12/2008	20E6	194	480	178	760	72
	6		Effluent	24/12/2008	100E3	64	200	56	1042	62
	7	SEIR	Influent	24/12/2008	10E6	235	880	218	860	144
	8		Effluent	24/12/2008	500E3	178	336	54	1030	93
January 2009	1	ATTIL	Influent	13/1/2009	30E6	406	1280	350	1236	206
	2		Effluent	13/1/2009	3E6	270	240	48	1058	168
	3	ZEITA	Influent	13/1/2009	35E6	576	1792	1116	1560	136
	4		Effluent	13/1/2009	4E6	183	320	124	1112	136
	5	BIDYA	Influent	28/1/2009	50E6	512	960	336	1792	220
	6		Effluent	28/1/2009	60E3	135	640	24	1920	86
	7	SEIR	Influent	28/1/2009	45E6	850	2560	603	1740	185
	8		Effluent	28/1/2009	4E6	410	960	62	1800	181

Results of Wastewater Samples for Collective Systems

	Ser No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
February 2009	1	**ATTIL**	**Influent**	11/2/2009	26E6	286	360	194	838	124
	2		**Effluent**	11/2/2009	5E6	208	80	62	932	471
	3	**ZEITA**	**Influent**	11/2/2009	44E6	562	1520	706	1073	124
	4		**Effluent**	11/2/2009	6E6	243	400	283	970	104
	5	**BIDYA**	**Influent**	18/2/2009	25E6	596	640	1225	1500	183
	6		**Effluent**	18/2/2009	0.8E6	80	80	38	1418	54
	7	**SEIR**	**Influent**	18/2/2009	55E6	340	450	405	1805	145
	8		**Effluent**	18/2/2009	3.5E6	275	160	56	1870	133
March 2009	1	**ATTIL**	**Influent**	18/3/2009	24E6	843	1920	920	1034	134
	2		**Effluent**	18/3/2009	0.47E6	196	320	114	988	104
	3	**ZEITA**	**Influent**	18/3/2009	20E6	416	1040	240	922	131
	4		**Effluent**	18/3/2009	0.3E6	125	400	66	946	98
	5	**BIDYA**	**Influent**	25/3/2009	27E6	1100	2880	668	1636	82
	6		**Effluent**	25/3/2009	14E6	324	560	520	1425	60
	7	**SEIR**	**Influent**	25/3/2009	46E6	1800	6400	2200	2980	262
	8		**Effluent**	25/3/2009	10E6	567	640	80	1632	186

Results of Wastewater Samples for Collective Systems

	Ser No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
April 2009	1	ATTIL	Influent	8/4/2009	14E6	448	1520	306	1053	120
	2		Effluent	8/4/2009	2E6	356	440	12	958	117
	3	ZEITA	Influent	8/4/2009	50E6	1200	8000	1468	1250	164
	4		Effluent	8/4/2009	0.4E6	189	480	58	1230	56
	5	BIDYA	Influent	14/4/2009	56E6	1700	3520	1040	1345	136
	6		Effluent	14/4/2009	5E6	529	1440	325	1350	164
	7	SEIR	Influent	14/4/2009	60E6	1645	3360	704	1608	60
	8		Effluent	14/4/2009	7E6	762	800	86	1622	49
May 2009	1	ATTIL	Influent	20/5/2009	33E6	1400	1120	313	1190	104
	2		Effluent	20/5/2009	3.4E6	320	800	50	1140	88
	3	ZEITA	Influent	20/5/2009	35E6	1450	2880	990	1167	99
	4		Effluent	20/5/2009	4.3E6	390	480	188	1050	77
	5	BIDYA	Influent	27/5/2009	18E6	1135	1280	835	1790	192
	6		Effluent	27/5/2009	8E6	362	960	410	1830	82
	7	SEIR	Influent	27/5/2009	25E6	1730	3200	820	1550	198
	8		Effluent	27/5/2009	2.5E6	356	320	144	1600	131

Results of Wastewater Samples for Collective Systems

	Ser No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
June 2009	1	ATTIL	Influent	22/6/2009	20.0E6	1160	800	274	944	127
	2		Effluent	22/6/2009	1.5E6	340	640	28	936	99
	3	ZEITA	Influent	22/6/2009	20.0E6	1750	2880	6010	1210	138
	4		Effluent	22/6/2009	9.0E6	102	240	102	1140	116
	5	BIDYA	Influent	24/6/2009	40.0E6	1455	1920	1572	1100	88
	6		Effluent	24/6/2009	3.5E6	243	400	128	1228	77
	7	SEIR	Influent	24/6/2009	35E6	1270	800	366	1126	66
	8		Effluent	24/6/2009	2.5E6	232	160	157	1120	55
July 2009	1	ATTIL	Influent	13/7/2009	34.0E6	1375	1920	160	1337	122
	2		Effluent	13/7/2009	3.0E6	259	480	24	1250	92
	3	ZEITA	Influent	13/7/2009	40.0E6	1500	2080	1430	1380	130
	4		Effluent	13/7/2009	3.5E6	324	720	112	1360	105
	5	BIDYA	Influent	15/7/2009	30.0E6	2160	1600	293	2080	91
	6		Effluent	15/7/2009	3.0E3	240	480	142	2022	80
	7	SEIR	Influent	15/7/2009	35.0E6	1645	2000	242	1433	70
	8		Effluent	15/7/2009	1.5E6	156	240	50	1484	60

Results of Wastewater Samples for Collective Systems

	Ser No.	Location	Exact location of sampling	Date of sampling	F.Coliform cfu/100ml	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	Nitrogen mg/l
August 2009	1	**ATTIL**	**Influent**	17/8/2009	70.0E6	1020	1734	620	1420	191
	2		**Effluent**	17/8/2009	1.3E6	194	369	80	1395	72
	3	**ZEITA**	**Influent**	17/8/2009	120.0E6	1200	1920	2155	1280	148
	4		**Effluent**	17/8/2009	10.0E6	286	384	68	1230	134
	5	**BIDYA**	**Influent**	19/8/2009	20.0E6	1215	1850	624	1920	234
	6		**Effluent**	19/8/2009	0.2E3	208	345	34	1856	76
	7	**SEIR**	**Influent**	19/8/2009	120.0E6	1085	1600	472	1152	144
	8		**Effluent**	19/8/2009	10.0E6	237	320	78	1216	120
September 2009	1	**ATTIL**	**Influent**	9/9/2009	70.0E6	550	1000	262	1203	182
	2		**Effluent**	9/9/2009	3.5E6	167	320	30	1185	172
	3	**ZEITA**	**Influent**	9/9/2009	50.0E6	1638	2400	6610	1075	258
	4		**Effluent**	9/9/2009	3.5E6	227	400	62	1062	148
	5	**BIDYA**	**Influent**	10/9/2009	90.0E6	1570	2400	948	2016	182
	6		**Effluent**	10/9/2009	8.0E6	373	800	178	1920	158
	7	**SEIR**	**Influent**	10/9/2009	150.0E6	1176	1600	196	1472	302
	8		**Effluent**	10/9/2009	40.0E6	240	400	40	1452	96