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RETROFITTING 30% OF GOVERNMENTAL LARGE WATER CONSUMERS

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Chapter 1

INTRODUCTION

1.1 Extent of Problem

Water is considered the most valuable of all natural resources in the Middle East. Continued population growth, limited water supplies, and political constraints have caused significant challenges to water resources management in the region. The Hashemite Kingdom of Jordan faces a chronic imbalance in the population–water resources equation. In 1990 the population was nearly four million and the nationwide demand on water was approximately 1,000 million cubic meters.

In 2001 the population was estimated at five million with water demand at 1,250 million cubic meters, representing an increase of nearly 25% in both population and demand for water. Available water supply, however, only increased by about 12% (from 850 million cubic meters to 950 million cubic meters) in the same period. The increase in water supply came through greater use of groundwater aquifers, sometimes to levels beyond the safe yield, wastewater reuse, and additional rights to water from the Jordan River System, which the country gained after signing a peace treaty with Israel in 1994. However, the water deficit is expected to continue rising and will likely reach 400 million cubic meters in the year 2020 as shown in Figure 1. Furthermore, the daily per capita share of water in Jordan is considered to be one of the lowest in comparison with both world and neighboring country averages. By the year 2025, available annual water sources per capita in Jordan are estimated at 91 cubic meters, compared to 645 cubic meters, 311 cubic meters, and 161 cubic meters in Egypt, Israel, and Syria, respectively.

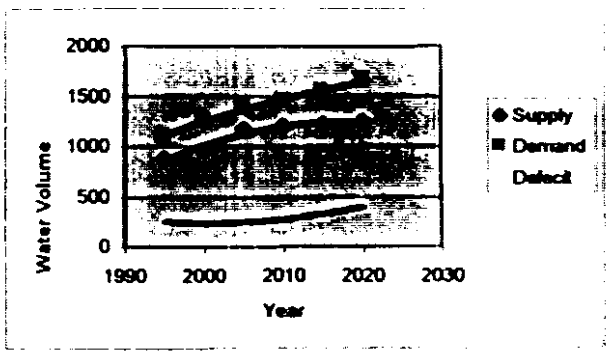

Figure 1. Water Supply/Demand Trends in Jordan

Because of its limited supply, the efficient and productive use of water has become a central goal of both domestic and international development projects. Measures have also been taken to mitigate problems related to permanent water shortages. These include public awareness campaigns, rehabilitation of existing networks, and rationing of water supplied for domestic and irrigation purposes. However, due to the scarcity of water, careful continued water use planning is required and should address various water rights, priority for reasonable domestic use, established socio-economic development and other uses such as agriculture, industry, and tourism. Despite huge investments in the water sector, Jordan will still face a considerable water deficit.

In past decades the government of Jordan has developed extensive water resources management schemes. Jordan is presently over-exploiting its water resources. Water levels are dropping, groundwater resources are being mined, and domestic water supplies do not reach adequate standards. One of the primary actions recommended as a remedy for this crisis is the reduction of water demand for domestic use, also known as *water demand management*. As new water supply sources have become less accessible, and as developing them has become more expensive and less environmentally acceptable, managing demand has taken on increasing importance globally. Demand management has proven to be very important for coping with climate change, both because it promotes efficiency and because it enables a considerable amount of flexibility in water resource management.

1.2 Water Efficiency and Public Information for Action

As part of its continuing efforts to develop water demand management strategies, Jordan's Ministry of Water and Irrigation launched the Water Efficiency and Public Information for Action (WEPIA) program. This three-year project is implemented in collaboration with the Academy for Educational Development and is funded by the United States Agency for International Development. The project deploys social marketing techniques to promote the use of water saving devices (WSDs) on domestic water fixtures. WEPIA's primary targets are large residential and commercial consumers of water.

An assessment conducted at the beginning of the program indicated that although Jordanians were aware of the water scarcity problem, they felt it was the government's responsibility to find solutions through the construction of dams and use of groundwater resources. The study also found that among Jordan's large consumers of water, large industries and corporations were familiar with WSDs and had interest in water conservation techniques but were using

"restrictors" on their faucets instead of "aerators." Even though restrictors reduce flow in faucets, they negatively impact the comfort of the user and do not meet official standards for being considered WSDs. By contrast, aerators compensate any reduction in water flow with air, which does not affect the comfort of the user and he/she often does not even realize that a WSD has been installed on the faucet. WEPIA's study also revealed a general lack of awareness about WSDs among average citizens. They were seldom used in residences and dwelling units simply because citizens believed it was the government's responsibility to ensure water availability.

In attempt to promote the usage of WSDs in large consuming public entities and governmental entities, the WEPIA project initiated a one-year program that aimed at convincing 30% of such consumers to install WSDs on their water outlets. The International Research Corporation (IRC) of Amman, Jordan was hired to implement this program under the supervision of the WEPIA project. It should be mentioned that preliminary findings of studies conducted by WEPIA revealed that Jordanians generally find personal cost savings to be a more compelling reason to conserve water than awareness of the country's water scarcity problem. As a result, WEPIA developed a procedure referred to as "water audits" to be used as a tool to promote the use of water saving devices. The "water Audit" procedure was the main tool used by the IRC to meet the desired target. The report at hand summarizes the results of the IRC activities in terms of water audits and WSD retrofits in the large consuming public entities and governmental buildings in Jordan.

1.3 Objective

The overall objective of this work was to convince 30% of large water consuming public entities and governmental buildings to install WSDs on their water outlets.

The specific objectives of this work are as follows:

1. Identify the large water consuming public entities' universe throughout the Kingdom.
2. Conduct Water Audits for as many public entities as possible.
3. Use the results of the audit to convince decision makers to install WSDs.
4. Provide technical assistance to public entities throughout the WSD procurement phase
5. Conduct "post-audit" inspections to verify if the installed WSDs were up to standard.

6. Conduct training workshops for public entities' maintenance engineers on water audits, and
7. Prepare a water audits training manual for public entities' maintenance engineers.

1.4 Summary of Other Chapters

The outcome of this work is presented in this report. The pertinent literature is reviewed in Chapter 2. The methodologies implemented in this research are presented in Chapter 3. The results are presented in Chapter 4. The conclusions and recommendations are presented in Chapter 5.

Chapter 2

LITERATURE REVIEW AND TECHNICAL BACKGROUND

When discussing Water Saving Devices and Water Saving Techniques, one cannot over look the concept of Water Demand Management (WDM). Water demand management can be defined as those conservation measures that improve water use efficiency, increase water use and recycling, and minimize water waste. Reducing water use can be equated through effective demand management with increasing supplies, keeping in mind that savings in water translate into increasing supplies. WDM concepts and practices are applicable in all sectors including domestic, agricultural, industrial, and other water consuming sectors. In general, demand management planning should incorporate; gathering information about existing and future supplies, identifying water-related problems and issues, profiling water demands by user groups, and detailing current and projected water demand and wastewater flow from each user group. Once these elements are secured, the feasibility, benefits, and costs of demand management measures should be evaluated. The most effective components of the program may then be selected and implemented. For instance, H. W. Hoffman, head of the Municipal and Commercial Conservation Unit of the Texas Water Development Board (TWDB), identified the main elements of programs that mandate water conservation. He emphasized that water conservation plans should include public information and education programs, tightened plumbing codes, leak detection and repair programs, drought contingency planning, water-saving landscaping, water recycling, and reuse and rate structures that encourage conservation. Most of those elements coincide with the objectives of the WEPIA program currently being implemented in Jordan. The leak detection/repair programs, and the structures that encourage conservation are in line with the WEPIA water audit activities.

The main components of WDM strategies that were undertaken by the effort at hand were to gather information about water consumption, identify water-related issues pertaining to consumption and flow of water in sanitary fixtures, investigate and model water demands and consumptions by the different user groups, and explore the feasibility, benefits, and costs of demand management measures. For the program at hand, the demand management measures were mainly through the utilization of water saving devices, which will be further defined in a following section.

A water audit can be considered as an accounting procedure. One of the purposes of a water audit is to accurately determine the amount of wasted water due to leakages and over-flowing water fixtures. With this determined, a water auditor can estimate the amount f water savings as a result of deploying water saving measures such as Water Saving Devices (WSDs). WSDs can be defined as water fixture attachments that reduce water consumption without compromising its function and without diminishing its user satisfaction. The main benefit of deploying WSDs on water fixtures is the reduction of water flow through the tap or shower and compensating the reduction by adding air, thus, eliminating the feeling of a reduction in the amount of flow. Other advantages of WSDs include ease of installation and maintenance, and availability in the local markets. The following paragraphs summarize a review of the literature pertaining to water efficiency programs and the advantages of utilizing WSDs.

2.1 Literature on the Importance of Residential Water Use Efficiency Programs and Campaigns

An assessment conducted by the U.S. Environmental Agency (EPA) reported that efficient water use could have major environmental, public health, and economic benefits by helping to improve water quality, maintain aquatic ecosystems, and protect drinking water resources. The EPA indicated that the efficient use of water, through *behavioral, operational, or equipment changes*, if practiced broadly could help mitigate the effects of drought. The EPA's assessment also indicated that efficiency measures could also save the homeowner money on their water and energy bills. They provided a number of measures that can be a step towards improved domestic water use efficiency. For instance, they indicated that the bathroom is where over half of all water use inside a house takes place, thus, practices such as not letting the water run while shaving or brushing teeth, taking short showers instead baths, turning off the water while soaping or shampooing could all result in significant savings at home. They also identified water saving practices in the kitchen. Thos included keeping drinking water in the refrigerator instead of letting the faucet run until the water is cool, wash fruits and vegetables in a basin, washing only full loads of laundry or use the appropriate water level or load size selection on the washing machine could also result in water savings. Finally, and most importantly, the assessment indicated that such behavioral practices MUST be supplemented with the utilization of proper water efficiency equipment (i.e., WSDs), since they could save about 30% of indoor water use and yield substantial savings on water, sewer, and energy bills. For instance, their study recommended the use of high-efficiency toilets, or placing a plastic container filled with water in the tank of a

conventional toilet. The study also recommended the installation of low-flow faucet aerators and showerheads after repair all leaks in such fixtures, especially that a leaky toilet, for example, can waste up to 200 gallons per day.

The EPA in cooperation with 17 local water systems in the U.S conducted another study. The involved water systems were able to arrive at saving substantial amounts of water through strategic water-efficiency programs. Savings that often translate into capital and operating savings, which allow systems to defer or avoid significant expenditures for water supply facilities and wastewater facilities. In many of the participating cities, the scope of water conservation programs has expanded to include not only residential customers, but commercial, institutional, and industrial customers, as well. Their efforts resulted in tangible outcomes achieved by water conservation programs implemented at the local level.

Ashland, Oregon, which is a small city of approximately 20,000 people, was one of the participating communities. The annual water usage is approximately 150 gallons per capita per day. Facing water shortages, the city had two options available to increase water supplies. The first was to create a reservoir by damming Ashland Creek at a cost of approximately $11 million. The second was to lay 13 miles of pipeline to the Rogue River at a cost of approximately $7.7 million. The city decided, however, that neither option was fiscally or politically feasible. Ashland, therefore, decided to implement a four-point water efficiency program to address its water supply problem. Their water conservation program became a natural addition to the city's existing resource conservation strategy, which addresses energy efficiency, regional air quality, recycling, composting, and land use. In 1991, the city council adopted a water efficiency program with four major components:

- System leak detection and repair,
- Conservation-based water rates,
- A high-efficiency showerhead replacement program, and
- A toilet retrofits and replacement program.

The city estimated that these programs would save 500,000 gallons of water per day at a cost of $825,875—approximately one-twelfth the cost of the proposed dam—and would delay the need for additional water-supply sources until 2021.

Implementation of the program began with a series of customer ***water audits***, which in turn led to high-efficiency showerhead and toilet replacements and a $75 rebate program (later

reduced to $60). Ashland also instituted an inverted block rate structure to encourage water conservation. Recently, Ashland began offering rebates for efficient clothes washers and dishwashers (including an energy rebate for customers with electric water heaters). The town provides a free review of irrigation and landscaping, as well. Implementation of Ashland's Water Conservation Program began in July 1992. By 2001, almost 1,900 residences had received a water audit. Almost 85 percent of the audited homes in Ashland participated in the showerhead and/or toilet replacement programs. Ashland has been able to reduce its water demand by 395,000 gallons per day (16 percent of winter use) and its wastewater flow by 159,000 gallons per day. An additional benefit of the program has been an estimated annual savings of 514,000 kilowatt-hours of electricity, primarily due to the use of efficient showerheads.

Faced with similar water problems, the city Cary, North Carolina recognized the need to incorporate conservation into its integrated resource management; the Cary town council adopted a water conservation program in 1996 with the following goals:

- Reduce the town's average per capita water use by 20 percent by 2014.
- Support the high quality of life in Cary by providing safe, reliable water service, while reducing per capita use of water.
- Conserve a limited natural resource.
- Reduce costs of infrastructure expansion.

In 1999, Cary decided to have its conservation programs place a greater emphasis on measures that could reduce peak-day demand during the high-volume summer months. The resulting 10-year Water Conservation and Peak Demand Management Plan was based on a careful benefit/cost analysis of numerous potential conservation programs. According to the plan, any conservation measures undertaken by the city was required to meet certain criteria:

- A benefit/cost ratio greater than 1.0
- Reasonable cost
- Significant water savings
- Non quantifiable but positive effects (community acceptance)

As a result, Cary's water conservation program consists of eight elements: Public Education, Landscape and Irrigation Codes, Toilet Flapper Rebates, Residential Audits, Conservation

Rate Structure, New Homes Points Program giving extra points for subdivisions that use selected water-efficient measures, Landscape Water Budget where Large public and private irrigation users are provided monthly water budgets that identify the appropriate watering needs for their situation, and a Water Reclamation Facility.

As a result of the program, water conservation in Cary will reduced retail water production. The city has delayed the two water plant expansions, projecting that the 10-year savings from water conservation will be 1 mgd and 2 mgd by 2019. Cary's water reclamation facility is expected to cut peak demand in the city by 8 percent. Also, City ordinances restricting water use considerably decreased usage during peak demand months. City residents have redeemed approximately 500 rebates and have purchased more than 1,000 flappers.

Houston, Texas, which receives an average of 50 inches of rain per year, has sufficient water supplies to meet demand through 2030. However, nearly 43 percent of Houston's water comes from groundwater sources that are threatened by increasing instances of land subsidence, saltwater intrusion, and flooding. In some areas, the land has actually subsided, or sunk, 10 feet. Conversion to surface sources or expanded use of surface water will require costly construction of water treatment plants and transmission mains. In addition, Houston is required by state regulations to reduce groundwater use 20 percent by 2030. These factors combined have led Houston to explore methods for managing its groundwater supplies. As a result, Houston implemented water conservation programs to help reduce city expenditures and capital investments. In 1993, the Texas Natural Resource Conservation Commission also required Houston to implement a conservation plan to meet state requirements. Their conservation program had four elements:

- Education program
- In-house program
- Contract customers program
- Conservation planning program

The education program consisted primarily of outreach initiatives, as well as efficiency retrofits for older structures. The in-house program included city irrigation audits, leak detection and repair for city pools and fountains, and analysis of city departments' water use. The contract customers program eliminated unnecessary requirements; required billing based on actual water use, and added penalties for excessive water usage during peak-demand

periods. The conservation-planning program began in 1994 when Houston was awarded a grant from the Texas Water Development Board that financed a conservation planning study. The study examined the costs and benefits of more than 200 conservation measures. The conservation plan adopted by the city council in 1998 expanded existing educational and other programs to include residential water audits, appliance labeling, commercial indoor audits, cooling tower audits, public indoor and exterior audits, pool and fountain audits and standards, an unaccounted-for water program, increased public education, and a "water-wise and energy-efficiency program." Houston also used an increasing-block rate structure with two tiers for single-family residents.

Since the program's inception, Houston has distributed 10,000 "Water Wise and Energy Efficient" conservation kits with high-efficiency showerheads and faucet aerators to area fifth graders as part of a comprehensive education program, the majority of which were installed in homes. In addition, a pilot program at a 60-unit low-income housing development in Houston replaced 5 gallons-per-flush toilets with 1.6 gallons-per-flush toilets, fixed leaks, and installed aerators. At a total cost of $22,000, shared between the utility and the housing authority, the program reduced water consumption by 72 percent, or 1 million gallons per month. Water and wastewater bills dropped from $8,644 to $1,810 per month. These dramatic results have led the Houston Housing Authority to develop plans to retrofit more than 3,000 additional housing units. The Houston City Council approved a new conservation plan on September 2, 1998 that included a forecast of the savings from implementing the recommended water conservation measures. The plan predicted that implementation would reduce water demand by 7.3 percent by 2006. Including savings from continued use of efficient plumbing products in new construction and renovation, the overall demand forecast for 2006 will be cut by 17.2 percent.

2.2 Literature on Water Efficient Building/Plumbing Codes

When discussing water saving initiatives and water savings campaigns and programs, one cannot overlook the importance of building codes. Within a relatively brief period of time the use of demand management in metropolitan water supply systems, especially increased efficiency of use, has become an accepted practice in long-term planning instead of being confined to its traditional role in drought emergencies. As of 1990 only seven states in the U.S. had adopted new plumbing codes to require low-flow toilets and showerheads in new housing units. By 1994, a large number of states had adopted these codes for new housing, and an impressive number of cities have initiated financial incentive programs for owners to

retrofit existing housing units. Seattle, Los Angeles, El Paso, and New York were among them. New York City's Department of Environmental Protection (NYC DEP) is counting on its retrofit program to effectively expand the city's supply by 91 million gallons per day at a unit cost that is 45 percent lower than its current average production cost. Although helpful, the implementation of water conservation programs without institutional changes in building and plumbing codes is short lived. Building and plumbing codes is an effective tool in increasing the life span of water conservation programs and in ensuring their sustainability. The following pages summarize some literature pertaining to water conservation programs coupled with plumbing codes modifications.

The city of Albuquerque adopted a Long-Range Water Conservation Strategy Resolution, which stated, "Conservation can extend the city's supply at a fraction of the cost of other alternatives." The resolution's goal was to reduce total water usage by 30 percent by 2004, a decrease of 75 gallons per capita per day over 9 years. The water conservation program included five components one of which was an amendment to the local Uniform Plumbing Code to require high efficiency toilets (1.6 gallons or less per flush) in all new residential construction. The city also adopted a Water Conservation Landscaping and Water Waste Ordinance. The ordinance included strict requirements for landscaping new developments, such as prohibiting the use of high-water-use grasses on more than 20 percent of the landscaped area. As a result, the Albuquerque's water conservation program has successfully slowed the draw down of the area's groundwater supply. Estimates indicated that the water conservation programs would decrease the level of water demand in Albuquerque until 2005.

Gilbert, Arizona's rapid population growth has strained water resources, particularly because Gilbert is located in a very arid region, receiving an annual average rainfall of 7.66 inches and losing substantial amounts of water annually to evaporation. To assist with its water shortage, Gilbert opted to implement a comprehensive water efficiency program to help meet increased water demand, and is recognized as the first community in Arizona to design and implement a 100-year water plan. A key component of its plan is the modification of its building/plumbing code. Building code requirements were introduced for all new construction and included requirements for efficient plumbing devices and the use of recycled water. Gilbert's conservation efforts are considered a success, particularly its efforts to modify the building codes to encourage the reuse and recharge all its reclaimed water. Water reclamation has helped the city meet groundwater management goals and has provided an additional resource for meeting water demand.

In Seattle, Washington, the area has experienced steady population growth. Although the city is known for its rain, Seattle experiences dry summers with water demand at its peak due to increases in watering, irrigation, and recreation use. The increasing demand and limits on existing supplies have forced the development of a dual strategy of demand reduction and cooperative supply management. The main strategy included a plumbing fixture codes and regulations, and operational improvements to reduce leaks and other water losses. Seattle's water conservation programs were very successful. In the 1990s, annual average water consumption dropped 12 percent. The regional water consumption in 1997 was the same as in 1980. The Plumbing codes and regulations have saved more than 4 mgd.

2.3 Discussion

As can be seen from the preceding sections, the combination of educational programs and plumbing codes have has a significant effect in reducing water consumption in a verity of communities in the U.S. Also, efforts such as "water audits" and programs encouraging the use of water efficient plumbing fixtures can be as effective. As seen in the given examples, such programs have alleviated the need for major infrastructure projects such as the construction of dam projects and treatment facilities, which results in significant capital improvement savings, yet covers any water shortages. The activities of the programs outlined above are similar in nature to the WEPIA programs' activities in Jordan. The program deploys social marketing techniques to promote the use of water saving devices (WSDs) on domestic water fixtures. WEPIA's primary targets are large residential and commercial consumers of water.

An assessment conducted at the beginning of the program (WEPIA, 2000) indicated that although Jordanians were aware of the water scarcity problem, they felt it was the government's responsibility to find solutions through the construction of dams and use of groundwater resources. The study also found that among Jordan's large consumers of water, large industries and corporations were familiar with WSDs and had interest in water conservation techniques but were using "restrictors" on their faucets instead of "aerators." Even though restrictors reduce flow in faucets, they negatively impact the comfort of the user and do not meet official standards for being considered WSDs. By contrast, aerators compensate any reduction in water flow with air, which does not affect the comfort of the user and he/she often does not even realize that a WSD has been installed on the faucet. WEPIA's study also revealed a general lack of awareness about WSDs among average

citizens. They were seldom used in residences and dwelling units simply because citizens believed it was the government's responsibility to ensure water availability.

Preliminary findings from studies conducted by WEPIA also revealed that Jordanians generally find personal cost savings to be a more compelling reason to conserve water than awareness of the country's water scarcity problem. As a result, WEPIA began to focus on water audits as a tool to promote the use of water saving devices. The "Water Audit" tool has been successfully used by the WEPIA project in convincing decision makers to install water saving devices. Tarawneh et al administered a water audit of the University of Jordan's Hospital, after which the economic feasibility results of the audit triggered the decision makers to retrofit the Hospital, and similar efforts proved effective in other large water consuming entities in various sectors. It is for this reason that the WEPIA program launched the "water audit" and retrofit program for large water consuming entities in the different sectors; governmental, commercial, industrial, private, etc. The report at hand summarizes the results of the efforts of the "water audit and retrofit programs" addressing large consumer governmental entities, with the objective of convincing 30% of large water consuming public entities to retrofit their water fixtures with WSDs.

Chapter 3

METHODOLOGY

As mentioned earlier, the main objective of this work was to convince 30% of the large water consuming public entities in Jordan to install WSDs on their water outlets. To meet the objective, a large water-consuming universe of public entities was developed. Following that, water audits were conducted at the majority of large water consuming entities in Amman and Aqaba. The results of the audits were then used to convince decision makers at those entities to retrofit their buildings and install WSDs on their water outlets. This chapter describes the methodology used to collect and analyze the data. The chapter includes four sections. The first one describes the site selection (i.e., universe definition) process for this research; the second describes the data collection (water audit) method used to obtain the data for this research; the third describes the mathematical analyses used to analyze the water consumption and anticipated water savings data, collected data, and the fourth describes the follow-up activities conducted to ensure the implementation of the recommendations based on the results of the water audits.

3.7 Universe Definition

For the purposes of the study at hand, a large water consuming public entity was defined as any public or governmental entity that consumes more that 500 cubic meters per a single billing cycle of three months, regardless of the number of buildings served by any given subscription. For instance, the University of Jordan, which is one of the largest consumers in Jordan, has 5 water subscriptions that serve nearly 57 buildings on the university's campus. Therefore, the study team dealt with subscriptions rather than buildings for the purposes of the study.

To arrive at such universe, the IRC team, and with the assistance of the WEPIA project obtained lists of subscribers consuming more than 500 cubic meters per cycle, nationwide. Those data were obtained from the Ministry of Water and Irrigation's Water Authority's (WAJ) computer database. Unfortunately, WAJ's database does not have the ability to reproduce subscribers according to a certain required criterion (i.e., public, private, industrial, etc.). Therefore, a complete list of all subscribers from the different categories with a water consumption rate in excess of 500 cubic meters per cycle was accumulated. The IRC technical team then sorted out all Governmental Buildings from among the accumulated list, and classified them according to which Ministry/ Public Agency has authority upon any

given subscription. Finally, lists of all large consuming governmental buildings, along with the responsible Ministry/ Governmental Agency, were generated. In total, 365 large consuming governmental subscribers were identified, nationwide. A list of the universe is included in Appendix A.

3.8 Data Collection – Water Audits

As mentioned earlier, previous studies have proven "Water Audits" to be one of the most effective tools in promoting the use of WSD's. Therefore, the IRC study team relied heavily on the water audit procedure as a means of achieving the goal of retrofitting 30% of the large consuming public entities.

As the name implies, a "Water Audit" can be simply defined as the process of conducting a complete inventory of all water fixtures and identifying leakage locations in a building, usually a large consumer. Such inventories include the numbers of the various fixtures (i.e., faucets, toilets, urinals, showers, etc.) and their respective water consumption as measured by their potential flow rates. The detailed procedure of conducting a water audit is outlined in the following section.

3.2.1 Water Audit Procedure

The conduct of a water audit entails the gathering of certain information relating to water consumption and water usage habits of the building's inhabitants. The first part relates to general information on the building and its logistics, which includes; type of use (e.g., hospital, school, ministry, etc.), building age, number of floors, number of employees, and the number of visitors per day. The second part of the information gathered is more related to the water consumption rates in the building and includes; total annual water consumption (from the water bills), annual amount of water brought in by tanks, well(s) production, if any, and the value of the water bill. The third part of information relates to non-domestic water usage in the building, which includes; source of irrigation water, irrigated area, water consumption per irrigation, irrigation frequency, and cars washed (number and frequency). The purpose of this data is to familiarize the auditor with the building being audited, and to accumulate data necessary in the calculations to follow the water audit.

As mentioned before, the water audit also entails counting the water fixtures in the building, measuring flow rates for the different water fixtures in the building, and determining the leakage conditions for those water fixtures. Since most of public buildings are big and are multi-floored, the IRC audit team usually audited one floor at a time. To keep track of all the

data collected, the auditors used an Audit Form for each audited site (Appendix B). The three main water fixtures that are audited are faucets (found mainly in restrooms, kitchens, and laboratories), toilets, and showers. The required information is gathered for each type as follows:

Faucets

The total numbers of faucets can be directly counted in the building. However, while counting the faucets, the auditor has to measure the faucets' flow rates, specify their type of threading, and indicate whether any faucets leak or not. To measure the flow rate of a faucet, the auditor must prepare a container of known volume (e.g. 1 liter), prepare a stopwatch, turn the faucet on all the way, place the bottle directly under the running water, and start stopwatch to measure the time required to fill the container to its capacity (i.e., 1 liter). Then, the flow rate can be calculated using the following equation

$$\text{Flow in liters per minute} = \frac{60 \text{ seconds}}{\text{Time measured (sec)}}$$

The type of the faucets' threading can be observed directly, and any faucets will be externally threaded, internally threaded, or not threaded at all. The purpose of observing the type of threading is to determine the most suitable type of WSD to be installed on the faucet.

Finally, the auditor must observe and record the numbers of leaking faucets, if any. This will help the auditor determine any maintenance requirements for the water fixtures in the building being audited. The importance of detecting and fixing leaks stems from the fact that a leaking faucets can dispense up to 43 liters of water per day.

Toilets

As with faucets, the total numbers of toilets can be directly counted in the building. The auditor has to also measure the toilets' flow rates, and specify their type as Turkish, gravity, hidden tank, etc. The size of the toilet tank is usually indicative of the toilet's flow rate per flush. Since some tanks, however, are not filled up completely, it is recommended to remove the toilet tank lid, mark the level of water in the tank with a marker, flush the toilet and close the supply faucet, refill the toilet with a known volume bottle to the mark, and calculate the volume of toilet tank (no of bottles needed x volume of the bottle). Most toilet tanks in Jordan, however, have capacities of 6-liters, 9-liters, or 12-liters.

Finally, to check a toilet for leakage; the auditor must remove the tank lid, check the overflow tube, drop in dye tablets, and wait for 15 minutes. If color appears in the bowel, then there is a leak in the toilet. Another approach is to evenly drop some powder on the inner walls of the bowel. If there is a leak, the leaking water will cause streaks in the powder. A leaking toilet can waste up to 800 liters per day.

Showers

The auditor has to also count the total numbers of showers in the building, measure their faucets' flow rates, specify their type, and indicate whether any showers leak or not. Flow rate for showers and detecting leaks is conducted in the same manner as for faucets.

3.2.2 Water Consumption Behavior

This type of information was essential in the conduct of the water audits. It centered on determining the frequencies and durations of use for the inventoried fixtures (i.e. numbers of times of use and the respective time-of-use of each type of fixture). This data were collected through direct questions asked to inhabitants (employees) of the governmental buildings, and from statistics previously gathered by the WEPIA and IRC technical teams. It mainly included the numbers of inhabitants/users by category (e.g., employees, students, residents, guards, visitors, etc.) as per the nature of the building. It also included the estimated numbers of fixture use and duration by each category of users.

As mentioned before, water audits as summarized above have been found to be a very convincing tool for homeowners and large water consumers to install WSD's. Once potential users realize that such simple devices pay for themselves, they usually do not hesitate to install them. The reason for conducting detailed audits as opposed to just performing the feasibility calculations based on total water consumption(s) as measured by the water bill is two fold:

1. The water bill may be exaggerated due to leaks in the piping system of the building.
2. The potential investor may be interested in partially installing WSD's, and would therefore be interested in the economic feasibility for certain parts of the building.

Therefore, it was necessary to conduct detailed water audits for the large consuming subscribers as defined by the prepared universe. Emphasis was placed on large consumers in Amman, Aqaba, Zarqa, Balqa, Irbid, Jerash, and Ajloun.

To conduct the actual audits, the IRC technical team needed the necessary political cover, and needed to obtain contact officers in each of the sites to be audited. This was obtained by the WEPIA project in two different ways;

1. A letter issued by the Prime Minister was distributed to public entities urging them to install WSDs as a means of easing the pressure on the national budget and to help cope with the Kingdom's water shortage problems.
2. The Minister of Water issued a second letter and Irrigation in reference to the letter issued by the Prime Minister informing all public entities of the ongoing WEPIA activities and the water audits to be conducted at those entities. The Minister's letter also requested those entities to nominate a contact officer to coordinate with the WEPIA/IRC teams in order to facilitate the conduct of the water audit.

Copies of the two letters are included in Appendix C

Following responses from the different public entities, and in coordination with the WEPIA project and the MoWI, the IRC technical team started communicating with contact officers, arranging for visits, and conducting the necessary water audits. The contact officer or his/her designee usually accompanied the audit team. As mentioned before, all the data collected during an audit were reduced on a pre-designed form to facilitate the conduct of the required analysis at a later stage.

3.9 Audit Data Analysis

As mentioned in the previous section, and using the data collected during the audit, the water consumption rates can be estimated by determining the frequencies and durations of use for the inventoried fixtures (i.e. numbers of times of use and the respective time-of-use). Such behavioral data where collected during the audit, where possible, and were obtained from previous audits conducted both by the WEPIA and the IRC technical teams. After conducting these calculations, the water auditor can estimate the amounts of water that could be saved through the utilization of WSD's and fixing all leaks. To better quantify those savings, they were converted into their equivalent monetary value according to the local water tariff. Simple cash flow analysis were then be conducted to justify the feasibility of investing in WSD's by showing that the monies saved will exceed the investment required to purchase and install WSD's.

The first step in conducting the analysis is to calculate the weighted average flow rate for each type of fixture in the audited building. Average flow rates were calculated using the following formulas

Average faucet flow rate $$Fq_{avg} = \frac{n_1q_1 + n_2q_1 + \ldots\ldots\ldots\ldots + n_mq_m}{n_1 + n_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + n_m}$$

where,

n_m = number of faucets with a measured flow rate equal to q_m liters per minute

Average toilet flow rate $$Tq_{avg} = \frac{n_1q_1 + n_2q_1 + \ldots\ldots\ldots\ldots + n_mq_m}{n_1 + n_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + n_m}$$

where,

n_m = number of toilets with a measured tank capacity of q_m liters per flush

Average shower flow rate $$Sq_{avg} = \frac{n_1q_1 + n_2q_1 + \ldots\ldots\ldots\ldots + n_mq_m}{n_1 + n_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + n_m}$$

where,

n_m = number of faucets with a measured flow rate equal to q_m liters per minute

Then, for each type of fixture, the audit data were used to extract the following variables:

- Number of people using the outlets daily
- Total number of days per year each fixture is used (365 minus holidays)
- Number of times each person uses each outlet per day
- Length of time (minutes) each person uses each outlet per use
- Recommended flow rates after installing WSD's for each type of outlet, which are 6 liter per flush for toilets, 6 liter per minute for faucets, 8 liter per minute for dish washing faucets, and 9 liters per minute for showers.

Using these data, the estimated water savings were calculated for the different fixtures as follows:

Faucets

$$W_{sf} = (Fq_{avg} - R) * N * T * Nu * L / 1000$$

where,

W_{sf} = water savings from faucets (m^3 per year)

Fq_{avg} = Average faucet flow rate (l/min)

N = Number of people using the faucet daily

T = Total number of days per year faucet is used (365 minus holidays)

Nu = Number of times each person uses faucet per day

L = Length of time (minutes) each person uses faucet per use

R = Recommended flow rates after installing WSD (6 liter per minute)

It should be mentioned, however, that whenever the audit revealed that the average flow rate for a faucet was higher than 10 liters per minute, a value of 10 liters per minute was used instead of the actual measured flow rate to calculate the anticipated savings. This was to avoid any unrealistic water savings that may result from significant reductions of flow rates.

Toilets

$$W_{st} = (Tq_{avg} - R) * N * T * Nu / 1000$$

where,

W_{st} = water savings from toilets (m^3 per year)

Tq_{avg} = Average toilet flow rate (l/flush)

N = Number of people using the toilet daily

T = Total number of days per year toilet is used (365 minus holidays)

Nu = Number of times each person uses toilet per day

R = Recommended flow rates after installing WSD (6 liter per flush)

Showers

$$W_{ss} = (Sq_{avg} - R) * N * T * Nu * L / 1000$$

where,

W_{ss} = water savings from showers (m^3 per year)

Sq_{avg} = Average shower flow rate (l/min)

N = Number of people using the shower daily

T = Total number of days per year shower is used (365 minus holidays)

Nu = Number of times each person uses shower per day

L = Length of time (minutes) each person uses shower per use

R = Recommended flow rates after installing WSD (9 liter per minute)

The total anticipated saving as a result of using WSD's can then be calculated using the following equation

$$W_s = W_{sf} + W_{st} + W_{ss}$$

After estimating the amount of water saved as a result of installing WSD's, the study team compared the cost of the saved water to the cost of installing WSD's. This is a very important step. Once potential users realize that such simple devices pay for themselves, they usually do not hesitate to install them. Two main monetary values were calculated and compared:

Value of Saved Water = Total water saved x unit price of water

Total Cost of fixtures = (No of faucets x unit price/aerator) + (No of showers x unit price/shower aerator) + No of toilets x unit price/trim)

The unit costs for WSD's were as follows:

Threaded faucet = JOD 3.5

Unthreaded faucet = JOD 9

Shower aerator = JOD 18

Toilet dam = JOD 3.5

Once those two values were calculated, the study team was able to compare the cost of purchasing WSD's to the cost of the saved water in order to determine the feasibility of investing in WSD's. The Audit Form in Appendix B summarizes all the necessary measurements and calculations needed for a complete audit.

3.10 Post-Audit Follow-Up

Following the completion of the audit, and since the main purpose of the audit was to convince the decision maker(s) at the audited entity to approve the retrofitting activities: it

was necessary to develop a post-audit approach to achieve this goal. As a result, a "post-audit" package was prepared for every audited entity and constituted of:

1. A cover letter from H.E. Minister of Water and Irrigation and/or the Secretary General addressed to the decision makers at the audited sites.
2. A summary sheet of the audit results summarizing the water savings, the cost of the retrofit and the financial feasibility of the investment.
3. Recommended WSD specifications.
4. List of local suppliers.

Appendix D is a typical post-audit package.

Once the packages were prepared, a joint IRC/WEPIA team arranged and made a visit to the decision maker(s) at the concerned entity. In those visits, the technical team gave the decision maker(s) a briefing on the WEPIA program and the results of water audit conducted at their building(s). In most cases, the decision maker(s) approved the recommendations of the WEPIA/IRC team and gave direction to initiate the retrofit process. Following that, the WEPIA/IRC team continued to follow up with the responsible person, which in most cases was the same contact officer originally appointed to facilitate the auditing activities. This follow up mostly included technical assistance in the tendering and procurement process. Considering the size of most tenders, the majority of them were tendered through direct solicitation of prices from the approved list of suppliers provided by the study team. Some tenders, however, were executed through a complete tender process. The technical assistance offered by the study team included provision of minimum required standards, and guidance throughout the tendering/award process. In some cases, members of the study team were asked to participate in the tendering committee responsible for the supplier selection, whereas, in other cases the concerned entity completed the entire procedure on their own.

Following the award of a contract the study team continued to coordinate with the winning supplier until the building(s) was completely retrofitted.

3.11 Post-Retrofit Follow-Up

Once a building was retrofitted, the study team re-visited the site and conducted another audit to verify that the post-retrofit flow rates were within recommended standard (i.e., 6 liters/min for faucets, 6 liters/flush for toilets, and 9 liters/minute for showers). It should be mentioned, however, that the majority of public buildings purchased faucet aerators.

Whenever a water fixture was found to have a non-compliant flow rate, the supplier that installed WSDs in the building was contacted again and asked to re-visit the site and calibrate all non-compliant fixtures.

3.6 Training Workshops

As mentioned earlier, previous studies have proven "Water Audits" to be one of the most effective tools in promoting the use of WSD's. As a result, it was necessary to compliment the work at hand with a series of training courses to familiarize maintenance staff in public entities "Water Audits" and how they can be used as a tool to promote the deployment f WSDs in public buildings. The main objective of the training courses was to promote the use of WSD's by large consumers through the training of individuals to conduct water audits and perform all the necessary water consumptions/savings calculations. Specific objectives for the training courses included

1. Conducting detailed water audits for
2. Introducing the trainees to the process of identifying suitable water saving techniques (WSD's) and their applicability to the various water outlets.
3. Familiarizing the trainees with the most qualified local suppliers capable of delivering the required technology.
4. Giving the trainees the capability to estimate the total cost of the retrofitting, estimate the anticipated water savings as a result of implementing water saving technology, and perform cash flow analyses to demonstrate the feasibility and soundness of the retrofitting program.

Actual audits were conducted of the training facilities. The trainees were usually divided into groups, where a trainer supervised each group and the groups were assigned to different parts of the study sites. The trainees collected the relevant data using the data collection sheets specifically designed for water audits. The training workshops were usually conducted in four parts over the course of one day or two days depending on the size of the audience and the size of the training facility, which was to be audited as part of the training. The following sections describe the work mechanism followed by the trainers to accomplish the desired objectives of the training courses.

Part 1:

In this part, the trainees were introduced to the water problem in Jordan. They were provided with general information regarding the scarcity of water in the Mid-East Region

The trainees were introduced to the following concepts:

1. Scarcity of water
2. Water resources limitations in the Middle-East
3. The hydrologic cycle
4. Misuse of water resources
5. Worldwide per capita water consumption rates
6. Reasons for variance in worldwide per capita water consumption rates
7. Sources of water pollution
8. Water management: Supplies Management and Demand Management
9. Methods of water demand management
10. WSD's as a tool for water demand management
11. Anticipated savings and recommended flow rates for water fixtures
12. Water audit planning
13. Conducting water audits; measuring flow rates and detecting leaks
14. Compiling water audit data
15. Behavioral assumptions pertaining to water consumption
16. Water saving calculations

Part 2

In this part, the trainees were assigned to the different locations and completed audits for the training facility. The trainees were taught how to measure flow using calibrated flasks and stopwatches, and were taught how to detect leaks in toilets using powder. The trainees were then given a detailed demonstration on WSD's and were briefed on the various types of WSD's, their functioning mechanism, their anticipated savings, maintenance, and availability.

Part 3

In this part, the trainees were introduced to the financial calculations for water savings resulting from using WSD's, and were trained to demonstrate the feasibility of WSD's through using the "Pay Back Period" concept. To enhance their understanding of those concepts, they were given a presentations on the results of water audits conducted for other locations. Finally, the trainees were briefly introduced to the concept of energy savings as a result of utilizing WSD's.

Part 4

Here, the trainees applied their newly acquired skills using the data that they collected at the study site. The trainees worked in groups to calculate water consumption rates for the various water fixtures at the study site. They then performed the financial calculations to assess the feasibility of investing in WSD's at the study site using the data that they collected.

In total, 3 training workshops were conducted throughout the period of November 2001 through October 2002. Table 1 summarizes the logistics of each workshop. A copy of the training materials used in those workshops is presented in Appendix E.

Table 1. Training Workshops Summary

Location	No. of Participants	Participants' Backgrounds	Duration	Training Team
Aqaba	35	Engineers/plumbers/technicians	2 days	IRC/WEPIA
Amman (HUDC)	25	Engineers/plumbers/technicians	1 day	IRC/WEPIA
Youth Council (Dana)	27	Engineers/plumbers/technicians	1 day	IRC

Chapter 4

RESULTS AND ANALYSES

Using the procedure outlined in the proceeding chapter, the IRC technical team audited 170 sites. The post-audit calculations were performed for each of the audited sites and were used to convince the decision makers at those buildings to issue directions to retrofit their buildings. This chapter summarizes the results of the feasibility studies that were performed for the audited sites. The purpose of this chapter is to demonstrate the potential savings that could be achieved in those sites. It also compares the cost of water savings versus the cost of investing in WSDs to achieve those savings.

4.1 Universe Statistics

As mentioned earlier, the IRC/WEPIA technical teams identified a universe consisting of 365 large water consumers. The universe was defined through an extensive review of water consumption rates, as per the Water Authority of Jordan database records. It should be mentioned that the size of the universe varied throughout the conduct of the study. The reason for this was that certain sites were deemed non-governmental upon visiting and further exploring them. For instance, some sites were found to be NGO's. Others were found to be non-domestic users such as water pumps and so on. Table 2 summarizes the universe as per geographic governorate and annual water consumption. Figures 2 and 3 demonstrate the distributions of the numbers of large consuming entities and water consumptions per governorate, respectively.

Table 2. Universe Distribution

Governorate	Number of Large Consuming Sites	Total Consumption (m^3/year)
Amman	101	971,312
Aqaba	62	430,732
Irbid	43	291,060
Zarqa	31	160,748
Balqaa	33	178,604
Karak	26	117,012
Ajloun	6	36,584
Jerash	2	19,144
Tafeeleh	4	20,316
Madaba	15	92,260
Mafrak	15	200,296
Ma'an	28	137,872
Total	**365**	**2,655,940**

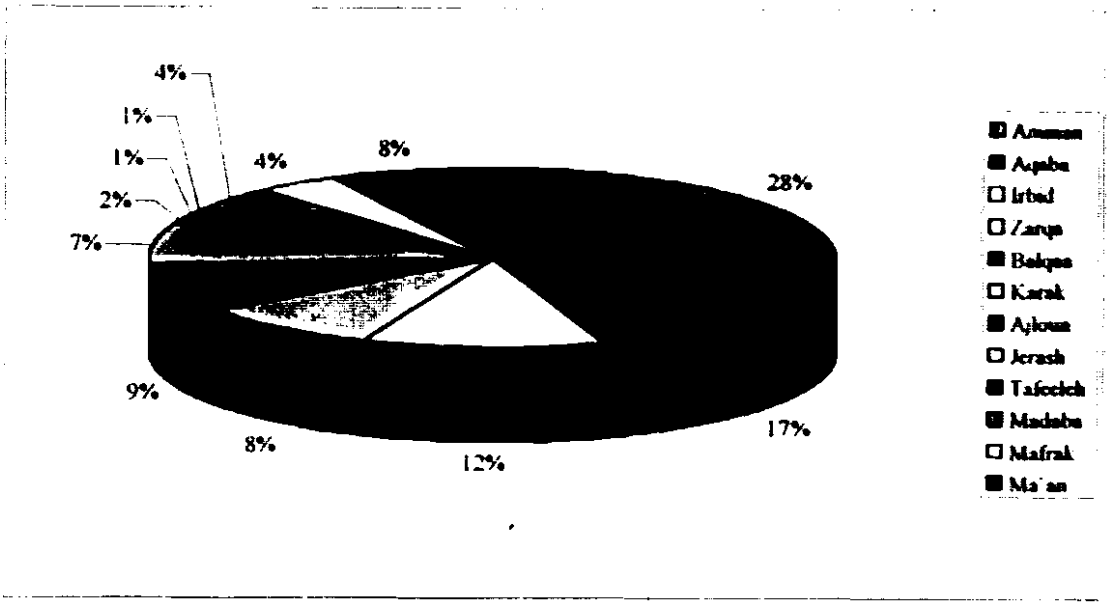

Figure 2. Geographic Distribution of Large Consuming Universe

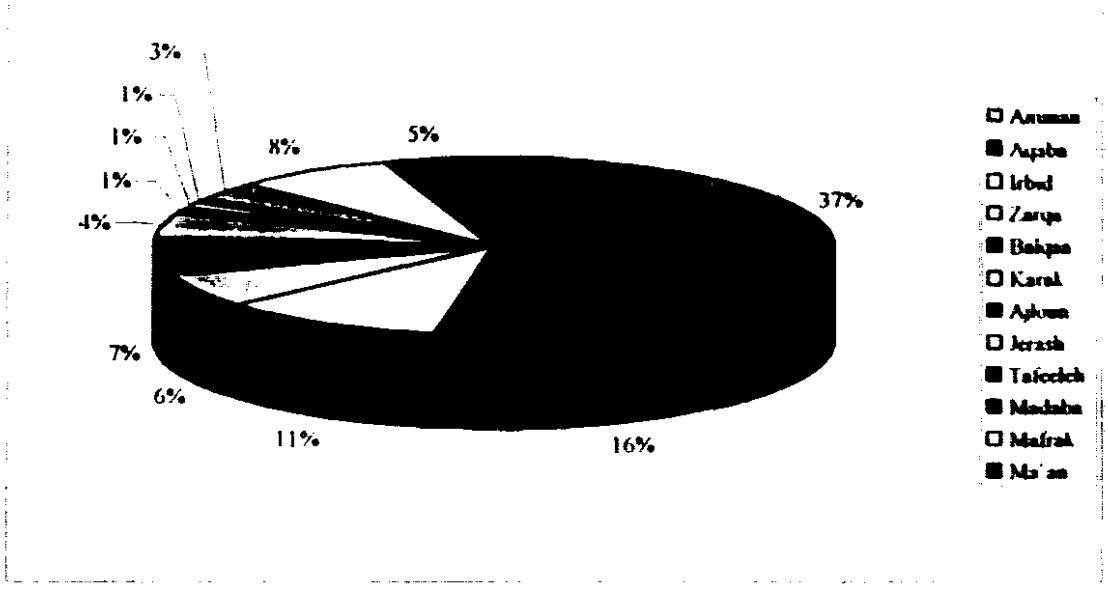

Figure 3. Water Consumption's Geographic Distribution

As can be seen in the Figures and the Table, the majority of the numbers of large consuming public entities, thus, the highest water consumption is in the Governorates of Amman (28%, 37%), Aqaba (17%, 16%), and Irbid (12%, 11%), respectively. The governorates of Amman and Aqaba alone account for 45% of the number of large consuming entities and 53% of the water consumed by large consuming public entities, nationwide. It is for this reason that the majority of the sites audited under this effort were in those two governorates. Sites in other governorates, however, were also audited as part of the activities in this project.

4.2 Auditing Statistics

In total, 220 sites were audited during the period of November 1, 2001 and December 1, 2002. Table 3 summarizes the distribution of those sites among the governorates, the consumption rates for the audited sites, and water consumption rates, the percentage of audit completions for each governrate.

Table 3. Audited Universe Distribution

Governorate	Number of Large Consuming Sites	Number of Audited and Visited Large Consuming Sites	Percentage of Audited Large Consuming Sites	Audited Sites Total Consumption (m^3/year)
Amman	101	90*	89%	368,867(687,588*)
Aqaba	62	32	51%	240,992
Irbid	43	30	69%	159,305
Zarqa	31	14	45%	90,696
Balqaa	33	11	33%	73,960
Karak	26	0	0	0
Ajloun	6	5	83%	30,660
Jerash	2	2	100%	19,144
Tafeeleh	4	0	0	0
Madaba	15	9	60%	38,712
Mafrak	15	3	20%	15,112
Ma'an	28	0	0	0
Total	**365**	**196*/220**	**60%**	**1,356,168**

*The difference is attributed to: sites that were audited prior to this phase of the study or sites audited by individuals trained by the IRC/WEPIA team, some sites were found to be already retrofitted upon visiting them, and sites for which feasibility studies were not prepared

As can be seen in the Table, the audited sites cover nearly 60% of the large water consuming public universe. The consumption of the audited sites accounts for nearly 51% of the water consumed by large consuming public entities, nationwide. It was believed that with such an audit completion rate, the target retrofit percentage (i.e., 30%) would be arrived at.

4.3 Water Savings

As mentioned in section 3.3 the data collected in the audit were used to estimate the potential quantity and value of water savings, and the cost incurred as a result of deploying WSDs in the audited sites. The demonstration of the economic feasibility of WSDs was used as the main tool to convince decision makers to install WSDs in their buildings. The following sections summarize the results of the water savings and the economic feasibility of installing WSDs in the audited sites. ***It should be mentioned that the results shown are not for the entire audited Amman large consuming universe***. Certain sites were intentionally not included in the summary for a variety of reasons. Among other reasons, this was mainly because some of the sites that were audited were found to have been already retrofitted;

therefore, it was difficult to estimate water savings as a result of deploying WSDs. Other sites' recorded water consumptions, for instance, did not reflect the actual water consumption by those sites. Those sites were charged a flat rate by the Water Authority. Other sites had a long history of vandalism and were, therefore, deemed infeasible to retrofit. Finally, staff that had been trained by the study team as part of the workshops described earlier audited some sites. The results were summarized per governorate and classified according to the type of building use (i.e., schools, hospitals, ministries, public corporations, etc.).

4.3.1 Amman

Six main categories were identified; schools, mosques, health centers, ministries, corporations, and other governmental entities. Table 4 summarizes the main findings of the audit results in Amman.

Table 4. Amman Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	62,728	21,643	32,467	4,606	35%
Mosques	17,936	5,788	8,681	1,864	32%
Health Centers	6,984	2,697	4,047	569	39%
Ministries	44,288	15,701	23,566	8,701	35%
Corporations	23,684	7,785	11,681	2,959	33%
Other	209,368	63,830	95,732	17,282	30%
Total	**364,988***	**117,444**	**176,174**	**35,981**	**32%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 3 months. Figures 4 and 5 demonstrate the findings.

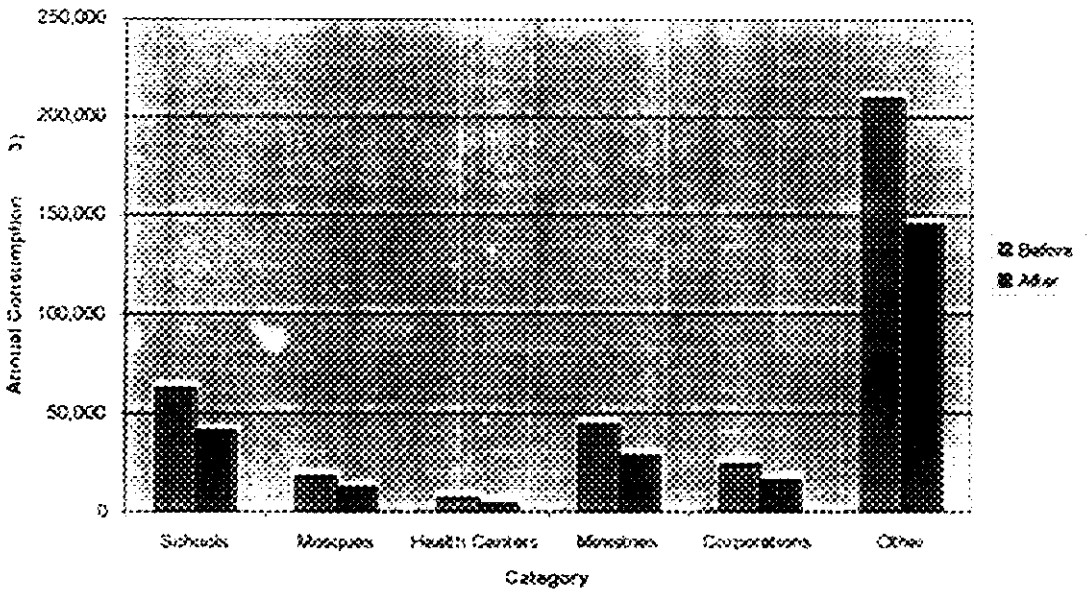

Figure 4. Before-and-After Annual Water Consumptions

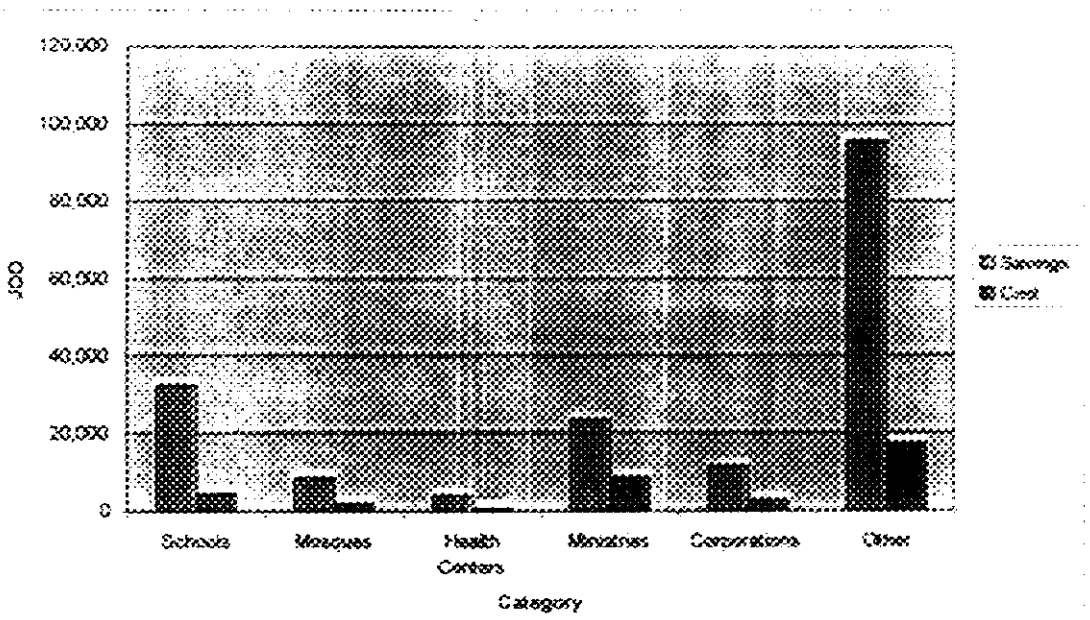

Figure 5. Savings vs Retrofit Cost

4.3.2 Aqaba

Four main categories were identified; schools, mosques, health centers, and other governmental entities. Table 5 summarizes the main findings of the audit results in Aqaba.

Table 5. Aqaba Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	58,748	19,778	29,668	1,878	34%
Mosques	5,272	1,976	2,965	585	37%
Health Centers	5,320	1,656	2,484	568	25%
Other	171,652	57,429	86,129	37,559	33%
Total	**240,992**	**80,839**	**121,246**	**40,590**	**33%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly4 months. Figures 6 and 7 demonstrate the findings.

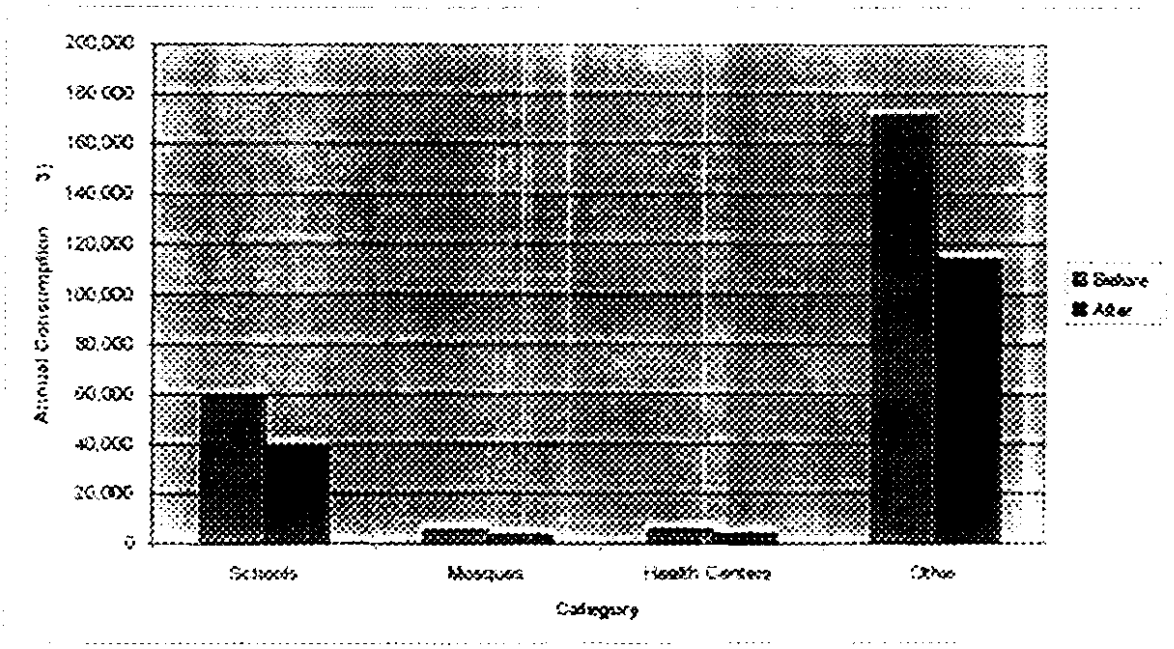

Figure 6. Before-and-After Annual Water Consumptions

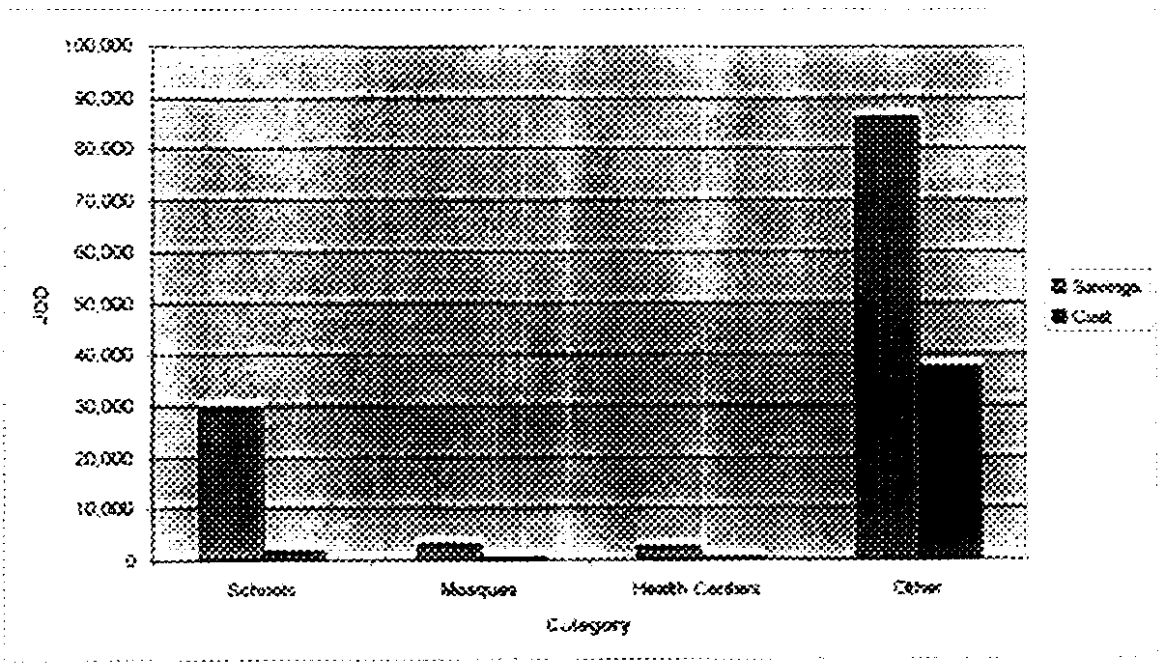

Figure 7. Savings vs Retrofit Cost

4.3.3 Irbid

Four main categories were identified; schools, mosques, health centers, and other governmental entities. Table 6 summarizes the main findings of the audit results in Irbid.

Table 6. Irbid Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)*	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	29,225	11,905	17,857	5,352	41%
Mosques	16,928	6,716	10,074	798	40%
Health Centers	103,884	34,486	51,730	9,513	33%
Other	9,268	3,895	5,482	2,325	42%
Total	**159,305**	**57,000**	**85,143**	**17,988**	**35%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 3 months. Figures 8 and 9 demonstrate the findings.

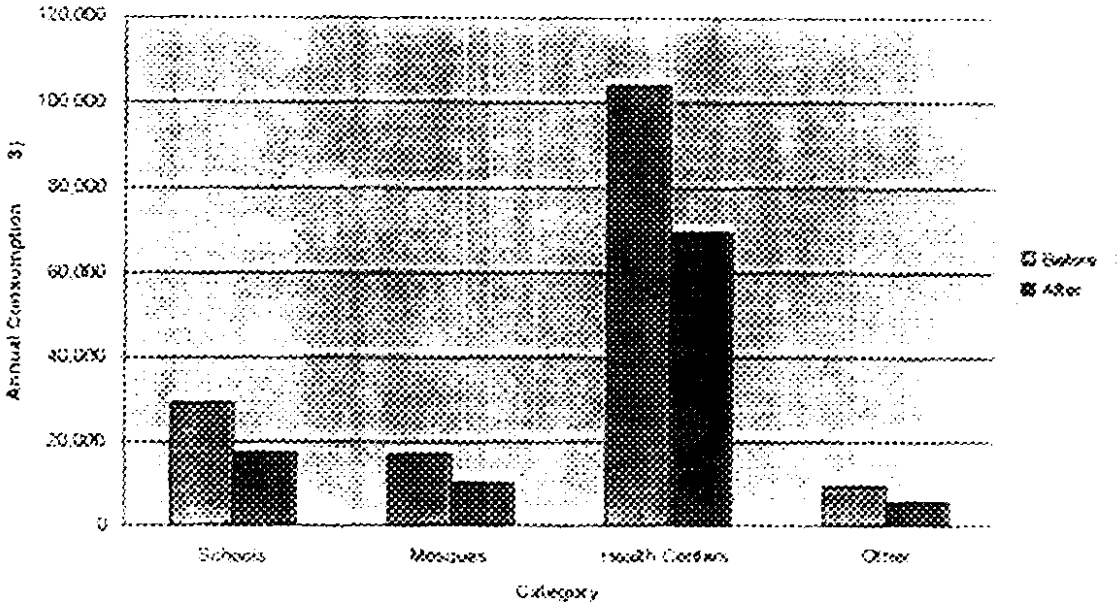

Figure 8. Before-and-After Annual Water Consumptions

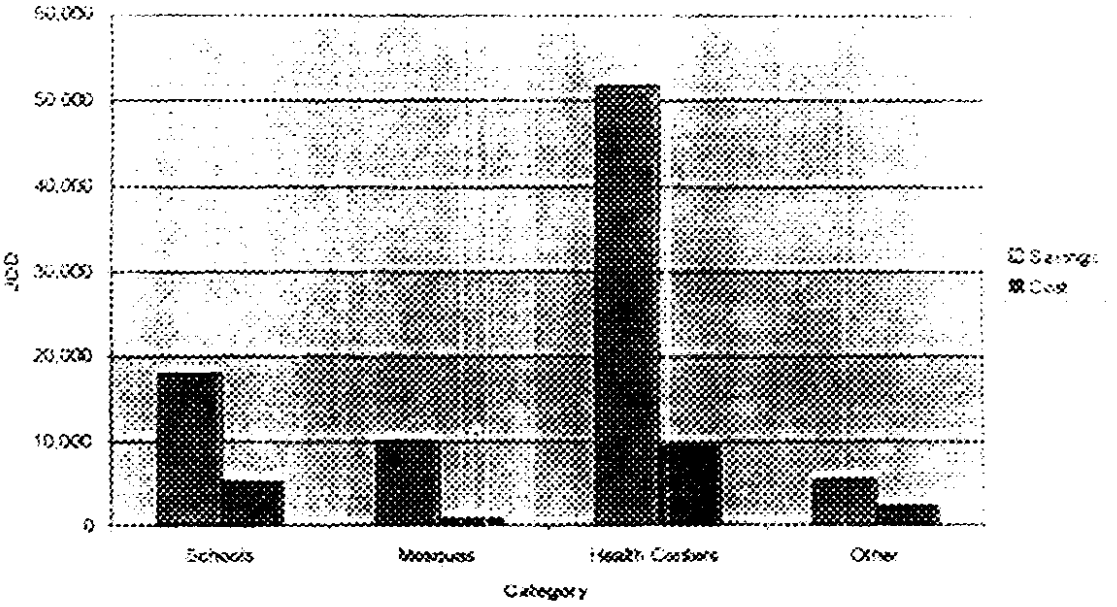

Figure 9. Savings vs Retrofit Cost

4.3.4 Zarqa

Four main categories were identified; schools, health centers/hospitals, and other governmental entities. Table 7 summarizes the main findings of the audit results in Zarqa.

Table 7. Zarqa Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	32,616	11,301	16,955	2,001	35%
Health Centers	42,512	14,250	21,375	3,937	34%
Other	15,568	3,830	5,744	1,137	24%
Total	**90,696**	**29,381**	**44,074**	**7,075**	**32%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 2 months. Figures 10 and 11 demonstrate the findings.

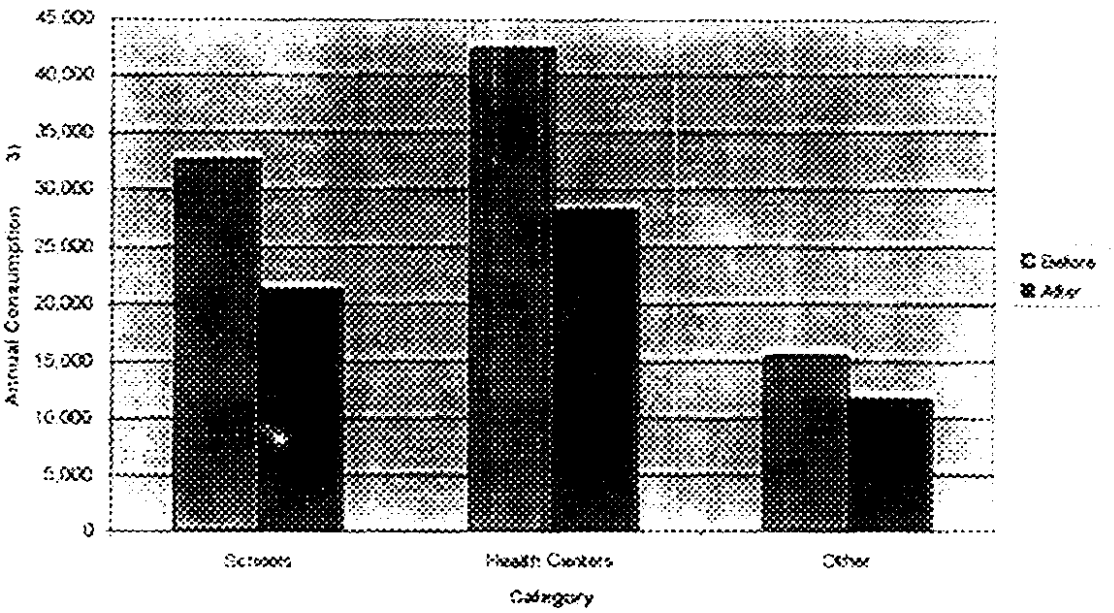

Figure 10. Before-and-After Annual Water Consumptions

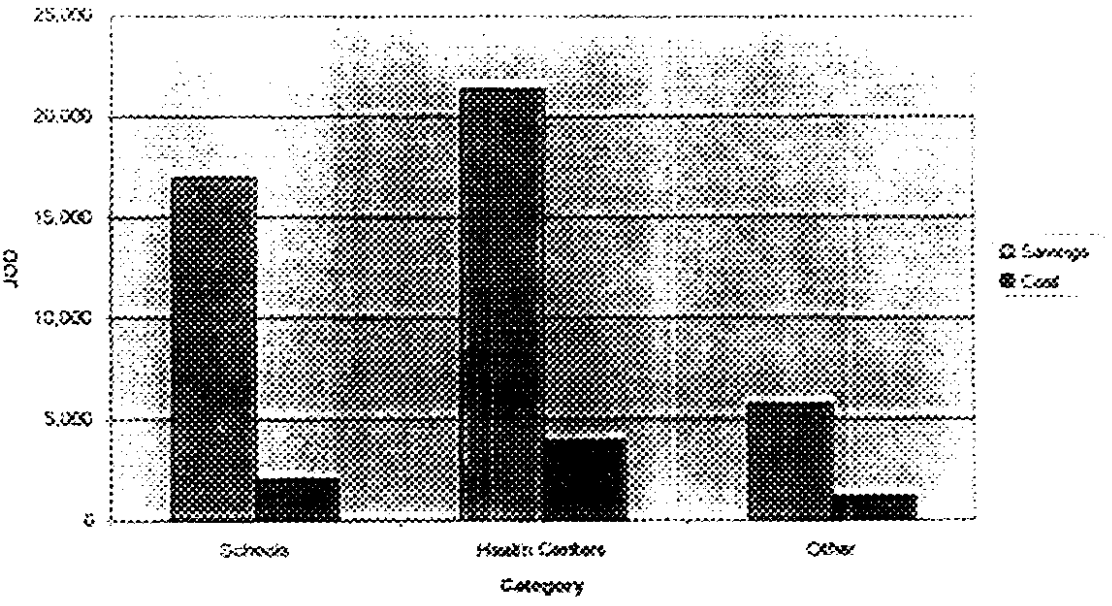

Figure 11. Savings vs Retrofit Cost

4.3.5 Balqaa

Three main categories were identified; schools, health centers/hospitals, and other governmental entities. Table 8 summarizes the main findings of the audit results in Balqaa.

Table 8. Balqa Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	30,864	8,523	12,785	2,236	28%
Health Centers	39,728	13,801	20,702	3,394	35%
Other	3,368	1,572	2,358	949	49%
Total	**73,960**	**23,896**	**35,845**	**6,579**	**32%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 3 months. Figures 12 and 13 demonstrate the findings.

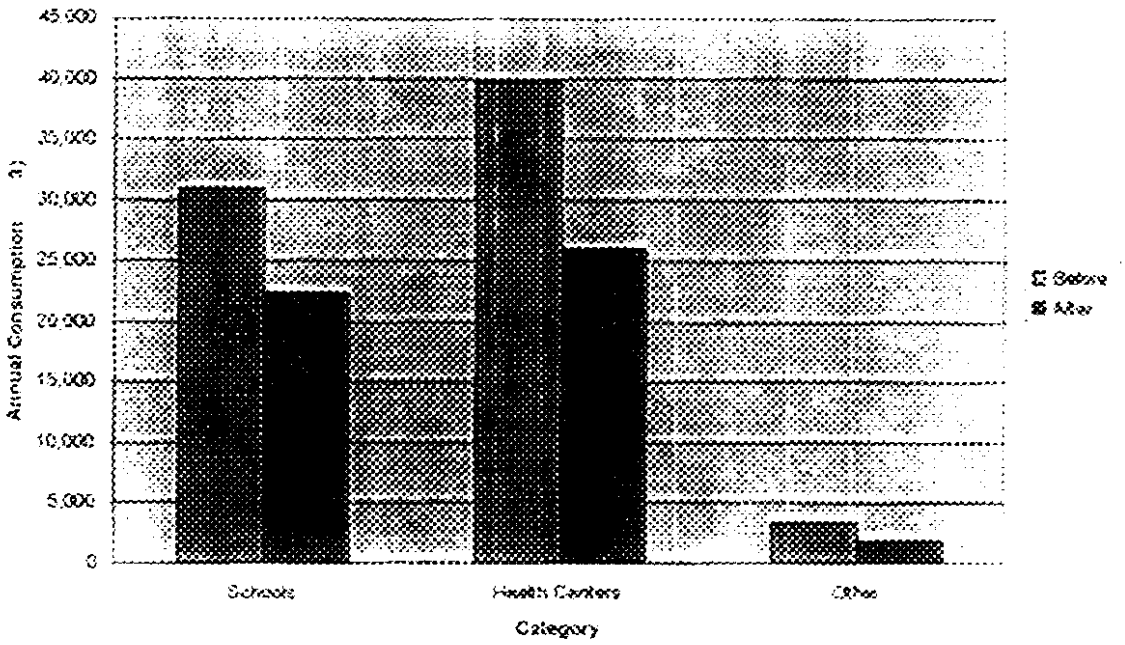

Figure 12. Before-and-After Annual Water Consumptions

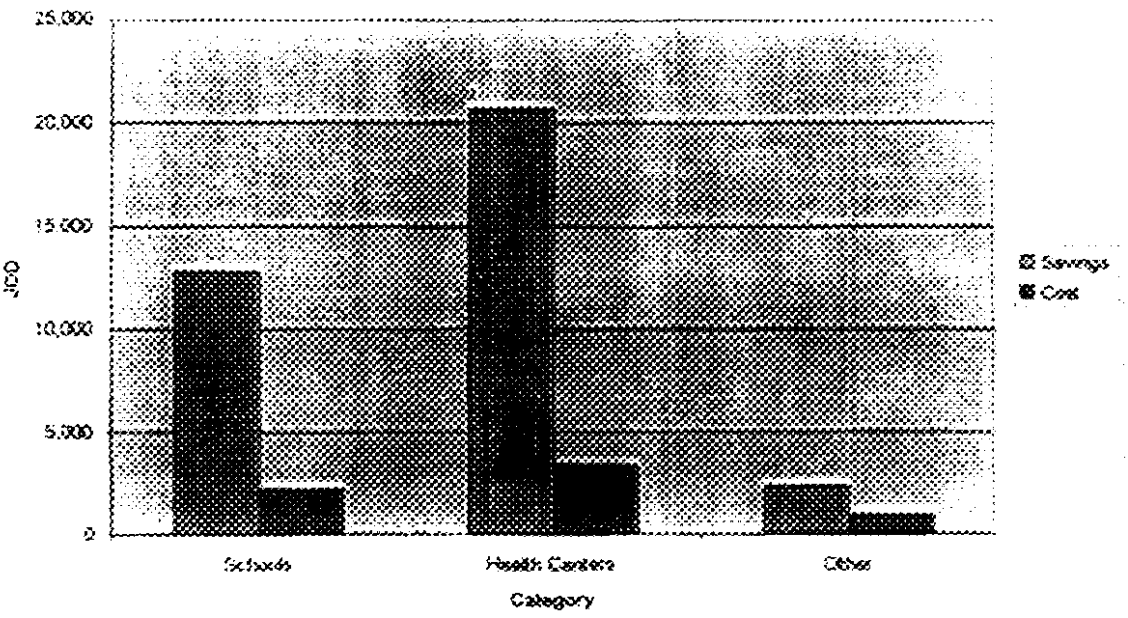

Figure 13. Savings vs Retrofit Cost

4.3.6 Ajloun

Two main categories were identified; schools and health centers. Table 9 summarizes the main findings of the audit results in Ajloun.

Table 9. Ajloun Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	8,468	3,328	4,992	567	39%
Health Centers	22,192	4,771	7,157	1,100	21%
Total	**30,660**	**8,099**	**12,149**	**1,667**	**26%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 2 months. Figures 14 and 15 demonstrate the findings.

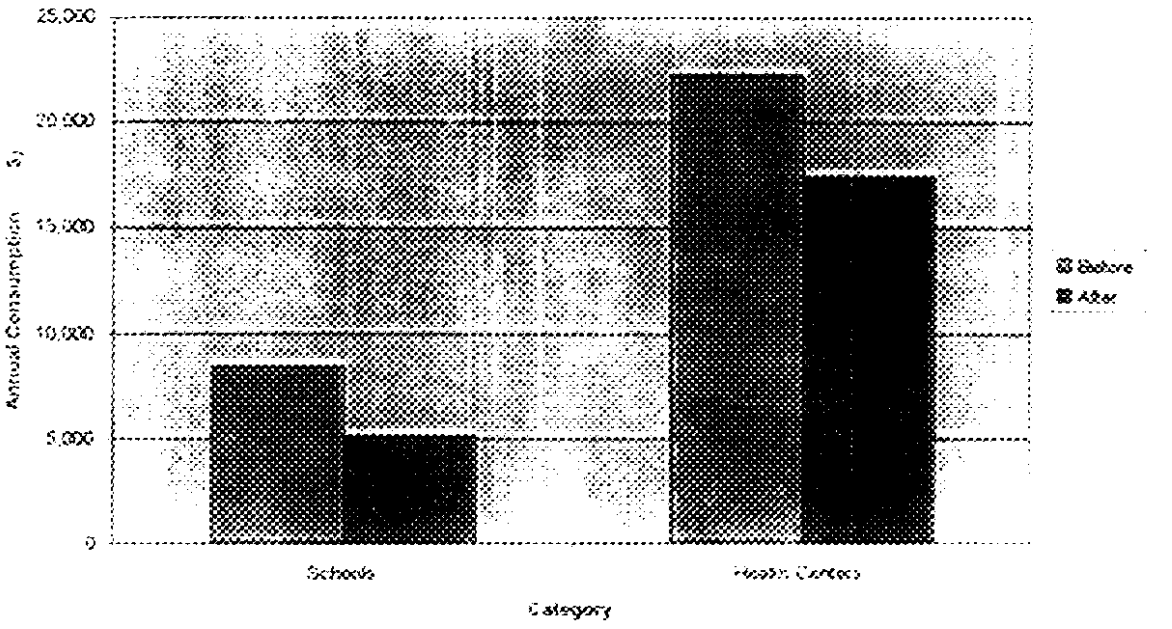

Figure 14. Before-and-After Annual Water Consumptions

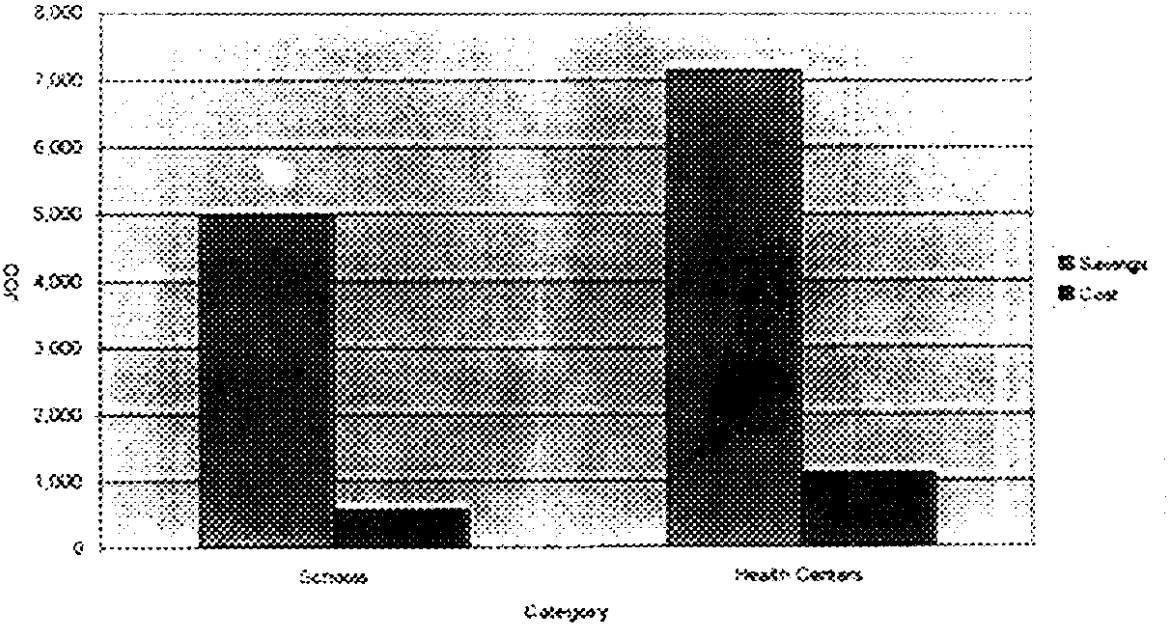

Figure 15. Savings vs Retrofit Cost

4.3.7 Jerash

Only two large consuming sites were found in Jerash, both of which were audited. One site (Jerash Water Authority) had already been retrofitted. The other site (Jerash Hospital) had a total annual consumption of 13,964 m^3, annual savings of 5,968 m^3 (40%) valued at JOD 8,952 with a total retrofit cost of JOD 1,028. The estimated return period for retrofitting this site was found to be nearly 2 months.

4.3.8 Madaba

Two main categories were identified; schools and health centers. Table 10 summarizes the main findings of the audit results in Madaba.

Table 10. Madaba Water Saving Calculations

Category	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Schools	30,827	12,526	18,789	3,036	39%
Health Centers	7,885	2,627	3,940	1,700	33%
Total	**38,712**	**15,153**	**22,729**	**4,736**	**39%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 3 months. Figures 16 and 17 demonstrate the findings.

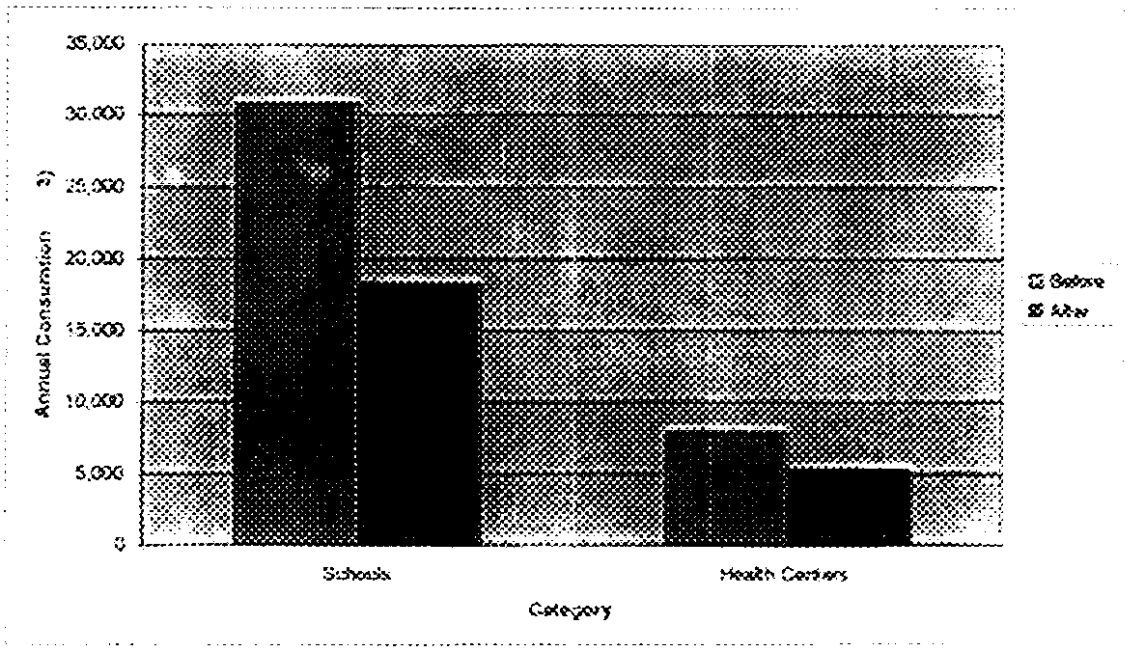

Figure 16. Before-and-After Annual Water Consumptions

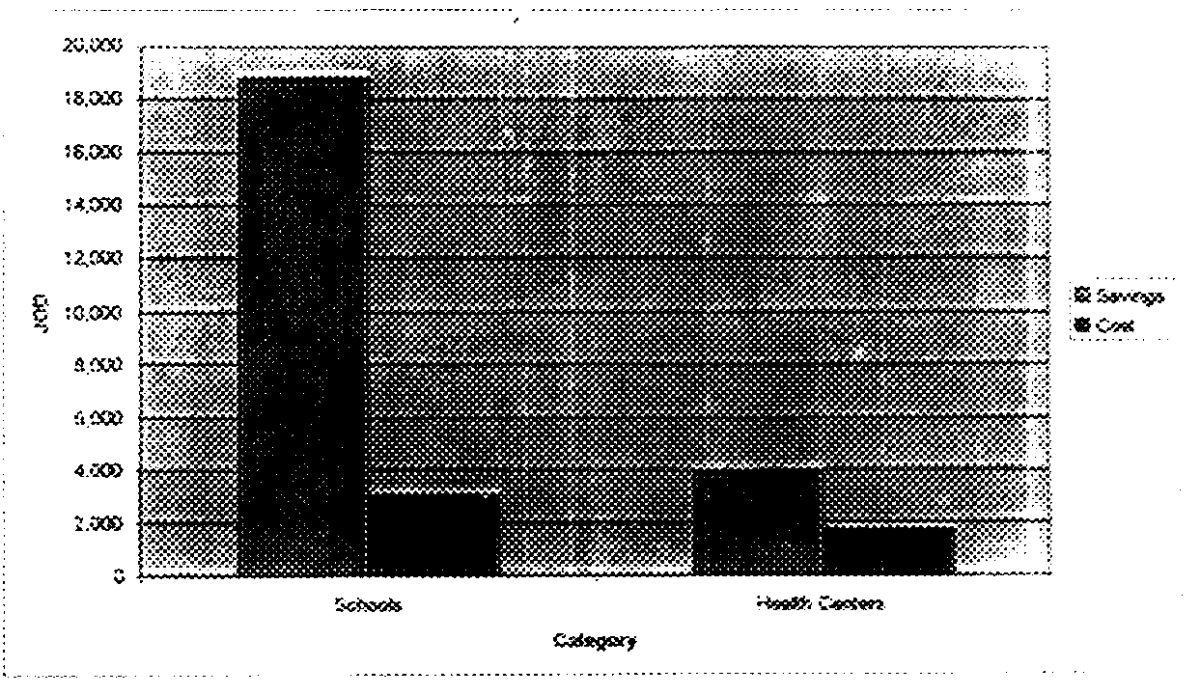

Figure 17. Savings vs Retrofit Cost

4.3.9 Mafrak

Only three sites were audited, one of which had been retrofitted when audited. Table 11 summarizes the main findings of the audit results in Mafrak.

Table 11. Mafrak Water Saving Calculations

Subscriber	Annual Consumption (m^3)	Annual Water Savings (m^3)	Annual Value of Savings (JOD)	Total Retrofit Cost (JOD)	% Savings
Mafrak Industrial School	2,436	915	1,372	872	37%
Rahab Health Center	2,186	854	1,287	136	39%
Total	**4,622**	**1,769**	**2,653**	**1,008**	**38%**

Some sites were excluded (see section 4.3)

The estimated return period for retrofitting those sites was found to be nearly 5 months. Figures 18 and 19 demonstrate the findings.

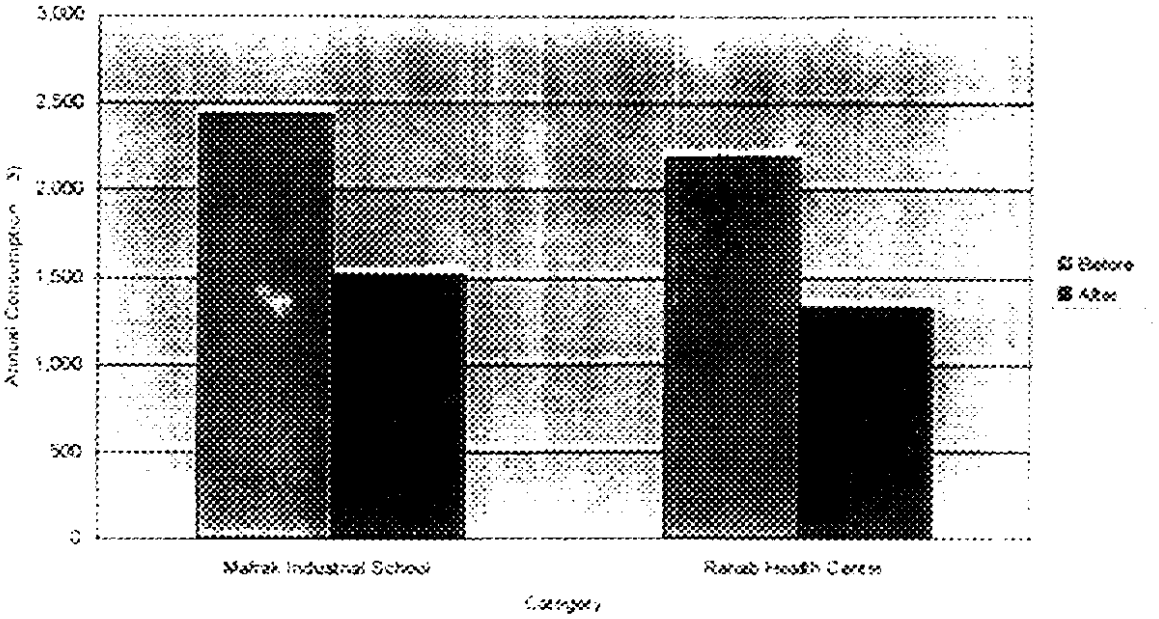

Figure 18. Before-and-After Annual Water Consumptions

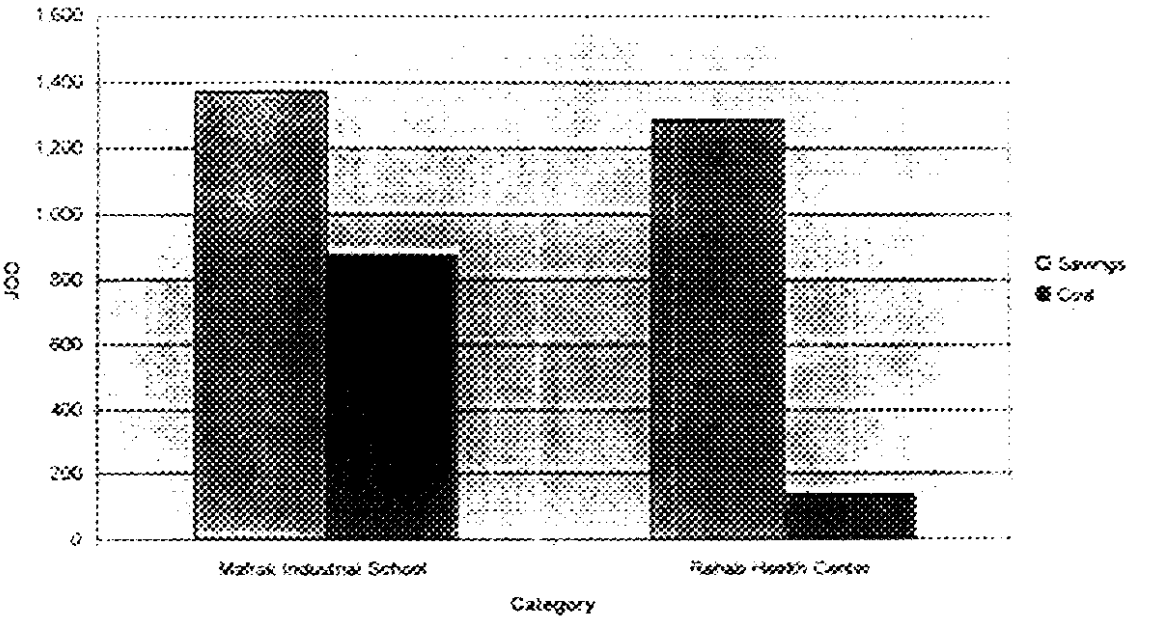

Figure 19. Savings vs Retrofit Cost

4.4 Retrofit Statistics

As a result of the efforts conducted under this endeavor, a total of 75 sites were retrofitted. The majority of the retrofitted sites were in Amman, while a very small number of sites in the other governorates were retrofitted. It is for this reason that future audit/retrofit activities will concentrate on the other governorates. In addition to the 75 retrofitted sites, the contract for the retrofit of 10 additional sites has been awarded and is currently being executed. Finally, an RFP for 31 public schools is under preparation. It is believed that the contract will be awarded towards the end of December 2002, and will be executed by the end of January 2003. This will bring the total number of retrofits/awards/RFPs as a result of this effort to 116 subscriptions, which represents nearly 32% of the universe. Figure 20 summarizes the universe status. A list of the retrofitted site is presented in Appendix F.

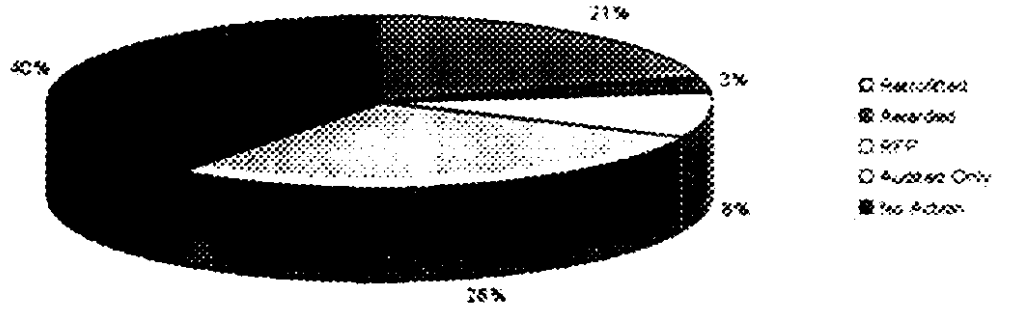

Figure 20. Universe Retrofit Status

4.5 Persistence Studies

Persistence studies were defined as a post-retrofit check to verify if the actual water savings as a result of installing WSDs were in line with the water audit estimated savings. The actual post-retrofit water consumption rates were obtained from the Water Authority of Jordan, and compared to the pre-retrofit water consumption rates. The difference in water consumption was compared to the savings calculated using the water audit data. Unfortunately, two main obstacles were found. First, the great majority of the retrofitted sites were retrofitted in a late stage of the study due to the lengthy governmental procurement procedures. This prevented the study team from being able to obtain a post-retrofit water consumption rate for a period long enough to reflect anticipated savings. Second, on the sites that were retrofitted at an early stage, quarterly water before-and-after consumption rates for coinciding times of the year were not available. Also, some post-retrofit readings were for time periods exceeding three months as was the case with pre-retrofit readings. To overcome this, the study team converted the post-retrofit cycle consumptions to daily consumptions and compared them to daily consumptions for a pre-retrofit period, which did not coincide with the time period used to define the large consuming universe. Due to such limitations, only three sites were included for comparison purposes. The results are summarized in Table 12.

Table 12. Persistence Study Results

Site	Consumption	Pre-Retrofit Consumption Weighted	Savings %	Estimated Savings %
Agricultural Credit	377	684	44.8	29.9
Ministry of Higher Education	573	786	27.17	40.5
Department of Statistics	829	1141.865	27.4	39

As can bee seen in the Table, except for the Agricultural Credit Corporation, the actual savings were lower than the anticipated savings. In addition to the reasons specified above,

this was due to the fact that those sites only deployed aerators. The estimated savings were calculated based on the deployment of WSDs both for faucets and toilet tanks. The reason that the Agricultural Credit Corporation resulted in savings greater than anticipated is that during the audit, it was noticed that many cars were washed there using a hose. The water audit feasibility study presented included a recommendation to switch to using a bucket to wash cars. It is believed that this strategy resulted in such savings.

4.6 Water Usage Behavioral Models

It was mentioned earlier that water use behavioral data were necessary to perform the water audit analysis in order to calculate the water savings. Also, it was mentioned that such data were obtained through asking questions of the contact officers while performing the audit. This approach, however, is not the most accurate way to obtain such data. Lengthy extensive surveys would be required to arrive at the most accurate figures describing domestic water use (i.e., frequency and duration of use for the different water fixtures). Such survey was beyond the scope of this work. An effort was conducted to estimate such figures using regression analysis and the data collected during the audits. It should be mentioned that such analysis were only conducted for the public schools in the study universe. The reason for this is that the sizes of the other categories were not large enough to give reliable results that were statistically sound. This section summarizes the findings of the water use behavior regression analyses that were conducted for public schools.

Simple multiple linear regression analysis was used to develop the water use behavior/water consumption model. The general form of the model was as follows

$$Q = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$$

Where,

β_1 = Total daily faucet use (minutes per day)

β_2 = Total daily toilet use (times per day)

β_3 = Total daily shower use (minutes per day)

x_n = (Users * duration of use * average flow * usage days) for fixture n

The independent variable used in the analysis (Q) was the actual water consumption rate. The values of the variables x_1, x_2, and x_3 were calculated using the data collected in the water audit procedure, while the constants β_1, β_2, β_3 were found using simple linear regression, which yielded the following model

$$Q = 1.586\,x_1 + .683\,x_2 + 10.65\,x_3$$

This model indicates that on average, a public school water user uses the faucet for an average of 1.586 minutes per day, the toilet .683 times per day, and the shower for 10.65 minutes per day (for the schools that have showers in them. The R^2 for this model was found to be 60%, which is considered reasonable for the sample size and the nature of the data included in the study. It is recommended that the analysis be repeated using a larger sample size, and be applied to the other water consumption categories as well.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

As mentioned earlier, the main purpose of the effort at hand was to promote the usage of WSDs in large consuming public entities and governmental entities. This one-year program aimed at convincing 30% of such consumers to install WSDs on their water outlets. Water audit procedures were used to assist in achieving this goal. As was seen in the results, the usage of WSDs has promising potential in reducing water consumption in governmental entities. Achieving the goal, however, was a very cumbersome experience. The study team has identified certain weakness areas that need to be addressed in order to achieve the goal under the WEPIA extension, which aims at retrofitting 60% of large consuming governmental entities. This chapter summarizes those areas, and presents recommendations to help overcome those difficulties.

5.1 Ministry of Water and Irrigation Support

Considering that neither the WEPIA nor the IRC are governmental entities, approaching governmental entities with the idea of using WSDs required governmental cover. Although this was provided via the Prime Minister's and the Minister of Water and Irrigation's letters, this was not enough for a reasonably paced process of retrofits. Governmental bureauracracy was always a problem that the study team faced. Even when the decision maker presented with the economic feasibility of deploying WSDs approved the retrofit, the procurement process underwent unnecessary and lengthy delays. Returning to the decision maker to speed up the process was never easy considering the difficulty in obtaining appointments with such individuals.

To overcome such difficulties in future activities, the IRC study team recommends that a regular weekly meeting be held with the MoWI Secretary General, during which the study team can brief the S.G. on progress, and point out the various departments that the study team is facing problems with. This way, the S.G. can officially contact/correspond the decision makers at those locations.

5.2 WSD Suppliers

Ten local suppliers were identified by the WEPIA/IRC study teams as suppliers with products compliant with the WSD standards and specifications. Every time a feasibility study was submitted, a list of those suppliers, along with their contact information, was submitted to the concerned entity. The products of the different suppliers varied in origin,

quality, and durability. In addition, the suppliers' technical installation teams varied in quality. Unfortunately, the majority of suppliers did not have a technical installation crew, thus, were only interested in bidding for "WSD supply" tenders. The specifications, however, required that the supplier supply and install the WSDs at the site to be retrofitted. This created a problem that on many occasions, less that three suppliers bid on the governmental retrofit contracts. The Government of Jordan procurement law requires that at least 3 bidders compete for a contract. As a result of this, many WSD procurement contracts were terminated. For instance, the Aqaba Special Economic Zone Authority floated an RFP to retrofit 22 sites twice. Both times only two suppliers bid on the contract, which was canceled as a result. In addition to the absence of technical crews for some suppliers, the majority of suppliers were not interested in bidding on governmental projects due to the lengthy governmental procurement and payment procedure(s). The involvement of the MoWI Secretary General as recommended above can help speed up the procurement process. However, it is highly recommended that the WEPIA/IRC team hold a prolonged meeting with the WSD suppliers to receive some feedback from them and to help eliminate some of the problems faced by them that discourage them from bidding on the various contracts.

5.3 Audit Data Collection Forms

As mentioned in section 4.6, it is important that an accurate water usage behavioral model be developed for a statistically sound sample population. This calls for a more accurate way of collecting water use behavioral statistics. To facilitate this process, the IRC study team recommends a modified water audit form that includes specific items on water use behaviors, as opposed to the current practice of asking questions and writing the numbers anywhere on the audit form. A copy of the recommended audit form is included in Appendix G.

5.4 Large Consumers Identification Criteria

As mentioned before, a large water consumer was defined as any entity that consumes more than 500 m^3 per billing cycle. This means that an entity that consumes 600 m^3 per billing cycle is equivalent to an entity that consumes 10,000 m^3 per billing cycle and each would be considered as one large consuming site. Considering that the main purpose of retrofitting a site it is recommended that a different criterion for defining large consumers be adopted. One suggestion is to retrofit the required number of sites that would result in a total savings in water consumption of 30% of the entire universe consumption, regardless of the number of buildings. This was, the study team could focus their efforts on a smaller number of sites, yet

obtain equivalent results in terms of savings. Another recommendation is to stratify the universe into categories according to consumption, and to attempt to retrofit a certain percentage of each category. For instance, retrofitting 5% of the category of sites consuming more than 30,000 m^3 per billing cycle, retrofitting 10% of the category of sites consuming more between 10,000 and 30,000 m^3 per billing cycle, and so on.

APPENDIX A

Universe

No.	Amman	Quarterly Consumption (m^3)
1	M/King Abdallah The Second Bin Al Hussein	60855
2	Ministry Of Health/Al Ashrafeyeh Hospital	26763
3	Aviation Authority/Civil	10824
4	Hussein Sports City	10553
5	Jordan University/Pump	10154
6	Jordan University Hospital	10000
7	RSS	6950
8	Amman College University/Balqua'a University	5000
9	Jordan University/Main Meter	5000
10	King Hussein Institution	4557
11	King Abdallah The First Park	4282
12	Ministry of Justice	3683
13	Ministry Of Culture/Royal Cultural Center	3500
14	Jordan University/Doctor's Residence	3450
15	Jordan University/Pharmasutical Departement	2706
16	Social Development Institution	2157
17	Hussein Sports City / GYM	2000
18	Jordan University	2000
19	Abu Alya Schol For Girls	1975
20	Jordan Television/Tank	1844
21	Stock Exchange Market	1802
22	Greater Amman Municipality/Region's Directory	1664
23	The Suweifyeh School	1557
24	Jordan University / COOERCIAL CXOMPLEX	1522
25	Ministry Of Youth / Hussain Sport City	1500
26	Prime Ministry	1475
27	Greater Amman Municipality/Isalmic Semetary	1300
28	Ministry Of Public Work And housing	1228
29	Ministry Of Water And Irrigation / LABS	1224
30	Natural Resources Authority	1220
31	Airport	1216
32	The Housing Institution Of Abu Ensair/Project	1208
33	Ministry Of Health	1184

34	Fun Park / Jubeha	1181
35	King Abdallah The First Mosque	1043
36	E'mar AL Asemah Company / AMMAN DEV. CORP.	1030
37	Hetten HighSchool For Boys	1028
38	Greater Amman Municipality/Amman Hall	1000
39	Greater Amman Municipality/Mosque Toilets	972
40	Ministry Of Finance	939
41	General Statistics Departement	874
42	Um ALRAsas School	848
43	Central Bank	845
44	MWI	826
45	Greater Amman Municipality/King Hussein Center	823
46	The General Institution For Protection Of Nature	815
47	Hospital University/Outdoor Clinics	800
48	Parlement	800
49	Ministry Of Education/Al Ubeel School	795
50	Ministry Of Education/Al EZ Bin Eb	780
51	Abed Al Jabbar School	757
52	Zaid Bin AL Khattab School	755
53	Al Foquaha'a HighSchool for Boys	753
54	Wadi AL Seer High School For Boys	750
55	Housing Etablishment	744
56	Parlement	742
57	Um AL Kaseer & AL Mugabalain School	727
58	Ministry Of Higher Education	710
59	Greater Amman Municipality/Employees Buildings	700
60	Safeya Bint Abed Al Muttaleb School	696
61	Ministry Of Religious /Al Amareyeh Mosque	686
62	AL Mo'tasem Mosque	677
63	MOA / PR BUILDING	673
64	Ministry Of Religious Affairs/AL Ekwaysmeh Mosque	662
65	Amman Municipality/Departement for Food Safety	660
66	Civil Avaiation Authoroty	642
67	Bader HighSchool For Girls	625
68	Um Anas School	623

69	Dab'ah School	620
70	Ministry of Food And Supply	616
71	Ministry Of Interior	615
72	Agricultural Loans Corporation	610
73	Greater Amman Municipality/Library Building	600
74	AL Nuzha Vocational School	590
75	Ministry Of Energy/Neuclear Energy	588
76	Ministry Of Health	587
77	Jordan Radio	582
78	Al Hussein Health Center	581
79	Tareq Bin Zyad HighSchool	580
80	Ministry Of Health /Sahab Health Center	578
81	Ministry Of Youth	573
82	Ministry Of Social Development /CHILD CARE CENTER	570
83	AL EZ Bin Abed AL Sallam	570
84	Ministry Of Interior / NEW BUILDING	570
85	Central Bank	562
86	Ministry Of Health/AL Naser Health Centre	561
87	Layla AL Ghafareyah Mix School	560
88	Ministry Of Education /AGRAG AL-AMER SCHOOL	559
89	Rab'ah Al Adaweyah HighSchool	556
90	Geographic Center	550
91	AL Nageerah School For Girls	549
92	Safaneh Bent Hatem School	542
93	Ministry Of Agriculture/Nurseries	536
94	Mansour Khuraishan HighSchool	532
95	AL Haj Abed Al Rahman Mosque	521
96	Customs Department(Ministry Of Finance)	520
97	Vocational Center Institution	513
98	The Husseiny Mosque	502
99	Ruqayya Bent Al Rassoul School	501
100	Greater Amman Municipality/Health Unit	500
101	The Mosque Of Wehdat Schools	500

	Aqaba	
1	Port Corporation	14301
2	Aqaba Special Ecconomic Zone	8900
3	The Port Corporation	7982
4	Ministry Of Education/Vocational School	6182
5	Civil Airport Directorate	6157
6	Port Corporation (REHAB)	5009
7	Ministry Of Youth/Southern Beach	2583
8	Aqaba Authority	2561
9	Water Authority	2533
10	Aqaba Authority/Diving Center	2365
11	Ministry Of Religious Affairs	2144
12	Princess Basma School	2062
13	Civil Aviation Directorate	2024
14	Aqaba Special Zone	1900
15	The Jordan University/Science Section	1659
16	Aqaba Authority	1602
17	AL Quwayrah Health Center/Minister Of Health	1598
18	Municipality Of Quwayrah	1577
19	Railroad Association	1531
20	Ministry Of Education/Camp	1529
21	Religious Affairs Directorate Of Aqaba	1434
22	The Jordan Central Bank	1355
23	Company For Iron /Aqaba	1246
24	Ministry Of Education	1203
25	Aqaba Authority/Al Rabyah	1049
26	Aqaba Authority / AL Quwayrah	1014
27	Aqaba Water Management	940
28	AL Aqaba HighSchool	905
29	Ministry Of Justice	890
30	Port Corporation	888
31	Water Authority	875
32	Ministry Of Health/The New Medical Center	853
33	Ministry Of Public Works	849

34	Vocational Trainning Establishment	843
35	Ministry Of Health/The New Medical Center	761
36	Ministry Of Youth/The Youth House	730
37	Ministry Of Interior	724
38	Ministry Of Religious Affairs	696
39	Ministry Of Education	683
40	Properties Department	676
41	Ministry Of Religious Affairs/Awqaf	665
42	Jordan Television Establishment	658
43	Ministry Of Religious Affairs/Al Shuwaik	653
44	Ministry Of Education	650
45	Directorate Of Education	643
46	Ministry Of Education	640
47	Ministry Of Education/Abu Ayyoub AL Ansari	635
48	Al Hussein Bin Ali School	615
49	Civilian Stores	611
50	Ministry Of Youth	597
51	Vocational Trainning Establishment	585
52	The School Of Faisal The First	570
53	Ministry Of Health	569
54	Ministry Of Information	568
55	Al Quwayrah High School For Girls	555
56	Ministry Of Education	551
57	Ministry Of Health	548
58	Ministry Of Finnance /Customs	524
59	Khawla Bint AL Azwar School	514
60	Ministry Of Education	514
61	Ministry Of Justice	505
62	Municipality Of Quwayrah	500
	Irbed	
1	Yarmouk University	6001
2	Vocational Training Center For Girls	511
3	The Eastern Mosque Of Irbid	725

4	Teachers Club-Ministry Of Education	982
5	Rehabilitation Center	905
6	Rehabilitation Center	511
7	Princess Basma Hospital	6626
8	Princess Badee'ah Hospital	9936
9	Nuseibeh AL Mazeneyah College	1000
10	Khalid Bin ALWaleed Center	1476
11	JUST Medical Center	1227
12	Hekma Health Center	799
13	Health Directorate/Irbid Governerate	810
14	Deir Yassin School For Boys	658
15	Daheyet AL Hussein School	552
16	Al Zarnoogy High School	500
17	Al Yarmouk Mosque	745
18	AL Taybeh School For Girls	652
19	Al Tarabeyeh Directorate And Education	510
20	Al Quadeseyeh School	525
21	AL Mazar High School For Girls	1992
22	AL Hussein Training Health Center	611
23	Al Hoson Vocational School For Girls	710
24	AL Hassan Sport City	3000
25	AL Hassan Sport City	5034
26	AL Balqa' University-AL Hoson College	1366
27	Omar Fa'ek Al Shalaby School	563
28	Sama Al Rousan Vocational School	514
29	AL Manarah School For Boys	502
30	Princess Raya Hospital/ Al Kourah	2757
31	Deir Abu Saeid Vocational School	670
32	Mu'ath Bin Jabal AL Shouneh Hospital	1705
33	Abu Ubaydah AL Yabes Hospital	750
34	Sleykat School	743
35	AL Mansheyeh School For Boys	633
36	A lMansheyeh School For Girls	614
37	Ramtha Municipality	951
38	Princess Haya Bint Al Hussein School	524

39	Ministry Of Religious Affairs/Mu'ath Mosque	2762
40	Ministry Of Finance/Customs Center	500
41	Hassan Industrial Zone	9463
42	AL Ramtha Public Hospital	750
	Zarqa	
1	First Instance Zarqa Court	552
2	AL Azraq Health Center	620
3	AL Delayl Agricultural Center	681
4	ALZarqa Public Hospital	4302
5	Girls Care Center	605
6	Jana'ah High School For Boys	850
7	Khalid Abu ALHuda Industrial School	650
8	Kidney Center	2057
9	Municipality Of Zarqa/AL Hashmeyeh Semetery	891
10	Municipality Of Zarqa/Second Area	1067
11	Prince Hassan Sport City	2000
12	Prince Mohammad For Boys School	530
13	Prince Talal School For Boys	554
14	Public Work/ Zarqa	900
15	Vocational School Association/ AL Hashmeyeh	1566
16	Vocational Training ASsociation	509
17	Zarqa Governerate Building	1277
18	Zarqa Municipality	687
19	Zarqa New School	817
20	Al Dulayl High School For Boys	3033
21	AL Hashmeyah High School For Girls	1132
22	AL Hussein New School Avenue.	906
23	AL Hussein Vocational School For Girls	500
24	AL Marwa School	1183
25	AL Shamla School For Girls	830
26	Hay Ma'soum School	823
27	Rageedah Of Islamic Faith College	2206
28	Prince Faisal Bin Al Hussein Hospital	6326

29	Pilgrims City Mosque	913
30	Awagan High School For Girls	651
31	Al Rusayfeh Vocational School For Boys	569
	Balqa	
1	Princess Iman Hospital	2171
2	Jordan University Farm	2114
3	Deir Alla Regional Center	828
4	Center For Rural Development	730
5	Agricultural Directorate OF Jordan Valley	706
6	AL Twal Southern High School	714
7	Pilgrims City	2959
8	Ministry Of Health	1535
9	Jordan Valley Authority	501
10	Dead Sea Rest House	1298
11	Southern Shooneh Vocational School	620
12	AL Shoooneh High School For Girls	648
13	Minsitry "Of Water	4122
14	Ministry Of Youth	703
15	Ministry Of Youth	612
16	Ministry Of Health/Nurses Dorm	733
17	Ministry Of Health	2207
18	Ministry Of Health	1452
19	Ministry Of Education	929
20	AL Salt Community College	3773
21	Zay School For Girls	657
22	Um Goazeh School	1037
23	Ministry Of Education/ Khaolah Bint AL Azwar School	663
24	Burqa High School For Girls	650
25	AL Salt School For Girls	685
26	AL Salt High School	817
27	Vocational Training Center	735
28	National Center For Agricultural Researches	842
29	AL Bak'ah School For Girls	625

30	Ministry Of Religious Affairs	1039
31	Hospital For Mental illness	6273
32	Al Fuheis High School For Girls	1273
	Karak	
1	Social Security Corperation	573
2	Religious Affairs / AL Karak Mosque	754
3	Public Hospital	700
4	Mo'tah University / Agr. Dept.	5360
5	Mo'tah University / Nursing Dept.	505
6	Ministry Of Health	3500
7	Karak Community College	500
8	The New School For Girls	625
9	Fgoo' High School for Girls	737
10	Eder School	1837
11	AL Yarout School For Girls	513
12	Mo'tah University	686
13	AL Huseineyeh High School For Girls	510
14	Vocational School	1173
15	The New School For Girls	626
16	The Jorda Valley School For Girls	814
17	Monistry Of Justice	511
18	Minucipality OF Jordan Valley	660
19	Ministry Of Health (The Jordan Valley Hospital)	571
20	Jordan Valley Hospital / AL Mateek	1098
21	Jordan Valley Agricultural Station	3137
22	Fifa Jordan Valley Mosque	1344
23	Directorate Of Jordan Valley	561
24	AL Ramleh Jordan Valley Authority	583
25	Al Thaher Babers School	783
26	AL Safee High School For Boys	592

	Ajloun	
1	Ministry OF Health/Arjan Center	513
2	Eman Hospital	5035
3	Ajloun Community College	1481
4	Oasreh School For Girls	691
5	King Abduallah Bin AL Hussein School	513
6	Al Amreyeh School For Girls	913
	Jearsh	
1	Water Authority	1295
2	Jerash Hospital	3491
	Tafeleh	
1	Tafeelah Community College	1809
2	Ministry Of Health	1414
3	Anas Bin Malek School	1293
4	AL Hessa High School For Boys	563
	Madaba	
1	AL aRshy School For Girls	712
2	Al Kansa'a School For Girls	1124
3	AL Nadeem Hospital/ Ministry OF Health	1970
4	AL Sawa'deh School	832
5	Eskan Haneena School	508
6	Hamad Salman AL Ma'ayah	1553
7	Lub High School For Girls	624
8	Ministry Of Agriculture/Madaba	840
9	Ministry OF Education/AL Gerayneh School	714
10	Ministry Of Health	1357
11	Ministry Of Health/Ewayty Health Center	5571
12	Ministry Of Interior	2674

13	Ministry OF Religious Affairs/The Arab Mosque	1392
14	Princess Basma High School	1092
15	Vocatioanl School OF Madaba	2102
	Mafrak	
1	Abu Ayyat Mosque	707
2	Al ALBAit University	32831
3	AL Kaldeyeh Irrigation Center	1785
4	Al Kaldeyeh Station	1528
5	AL Za'tary Water Stationary	500
6	Aydoun High School For Girls	701
7	Jaber Al Sarhan Border Point Center	4058
8	Mafraq Municipality	559
9	Mafraq Vocatonal High School	609
10	Mafraq Water Management Authority	2632
11	Mageer AL Sarhan School	753
12	Rahab Health Center	537
13	School Health Care	721
14	Rewayshed Public Hospital	1137
15	Al Rewayshed Customs Center	1016
	Ma'an	
1	Al Hussein Bin Talal University	1665
2	Antiquities	594
3	Directorate Of Agriculture In Ma'an	508
4	Health Units For Petra City	4045
5	Jordan Television and Radio Stationary	860
6	Ma'an Hospital	3975
7	Ma'an Vocational School For Girls	889
8	Ministry Of Education/AL Khalil School	985
9	Ministry Of Health/ Al Husseineyeh Health Center	707
10	Ministry Of Interior	780
11	Ministry Of Public Works	1217

12	Ministry Of Religious Affairs	572
13	Ministry Of Religious Affairs / Al Hashmy Mosque	592
14	Ministry Of Religious Affairs / AL Wehdat Mosque	551
15	Ministry Of Religious Affairs / Uthman Bin Affan Mosque	510
16	Ministry Of Social Development	1320
17	Ministry Of Supply	900
18	Ministry OF Tourisim / Visitors of Petra City Center	581
19	Ministry Of Tourisim/ Aqaba Terotery	1049
20	Ministy Of Transportation	729
21	Railroad Corp.	1000
22	Railroad Corp.	800
23	Railroad Corp.	2672
24	Sport Complex	550
25	The Health Unit for Petra City	4045
26	AL Husseyneyeh Girls School	500
27	AL Shoabak School For Girls	982
28	Salah AlDeen High School	890

APPENDIX B

Audit Forms

تدقيق مائي

معلومات المبنى

الاستعمال: _____

العمر: _____

عدد الطوابق: _____

عدد الموظفين: _____

عدد الزوار في اليوم: _____

معلومات المدقق

اسم المدقق : _____

العنوان: _____

المؤسسة: _____

هاتف/فاكس: _____

التاريخ : _____

رقم التدقيق: _____

معلومات إضافية

مجموع الاستهلاك الشهري من المياه: _____ م^3

بواسطة الصهاريج في السنة: _____ م^3

النتيجة الابار ان وجدت: _____ م^3/ساعة, الساعات باليوم _____

فاتورة سلطة المياه: _____ دينار أردني _____ م^3

استخدامات الماء الخارجية

ما هو مصدر مياه الري؟ _____

مساحة الحديقة/المنتزه المروية _____ م٢

كمية المياه المستعملة في كل سقاية _____ م٣

كم مرة في الأسبوع يتم ري الحديقة ولكم ساعة؟ عدد المرات

هل يوجد نظام حصاد مائي أو تدوير مياه في الموقع؟ نعم ☐ لا ☐

عدد السيارات التي يتم غسلها : صالون _____ مركبات كبيرة _____

عدد مرات غسل السيارات بالأسبوع _____؟

المراحيض

معدل عمر المراحيض:----------

الأنواع: (أ) مرحاض إفرنجي (ب) مرحاض تركي (ج) قابل للمعايرة (ح) خزان مخفي.

معدل التدفق للمراحيض:

(١) + (٢) + (٣)

العدد الكلي للمراحيض

= ---- + ---- + ----

= ------- لتر/دفقة

الطابق	أعداد المراحيض التي سعة خزانها (لتر)			أعداد المراحيض التي نوعها				أعداد المراحيض التي بها سيلان
	٦	٩	١٢	أ	ب	ج	ح	
١								
٢								
٣								
٤								
٥								
٦								
٧								
٨								
٩								
١٠								
المجموع								
المجموع *السعة								

المغاسل

الطابق	تدفقات المغاسل												عدد المغاسل التي تمنينها			عدد المغاسل التي بها سيلان
	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق				بدون	داخلي	خارجي	
١																
٢																
٣																
٤																
٥																
٦																
٧																
٨																
٩																
١٠																
المجموع																

الدوشات

الطابق	تدفقات الدوشات										عدد الدوشات من نوع		عدد الدوشات التي بها سيلان
	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق		يدوي	بالحاقط	
١													
٢													
٣													
٤													
٥													
٦													
٧													
٨													
٩													
١٠													
المجموع													

أحواض الجلي

الطابق	تدفقات أحواض الجلي										عدد المغاسل التي تسنينها			عدد المغاسل التي بها سيلان
	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق		بدون	داخلي	خارجي	
١														
٢														
٣														
٤														
٥														
٦														
٧														
٨														
٩														
١٠														
المجموع														

حسابات توفير المياه

المغاسل

معدلات التدفق المقترحة = ٤ إلى ٦ لتر/دقيقة
معدل التدفق في المغاسل (من النماذج السابقة) = ---------- لتر/دقيقة = س

كمية التوفير = (س - ٦) * عدد المستعملين * عدد أيام السنة * عدد مرات الإستعمال الفردي اليومي * طول فترة الإستعمال بالمرة

= (س - ٦) * ------ * ------ * ------ * ------

= ---------- لتر/سنة = ---------- متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين + زوار
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام المغسلة للفرد الواحد باليوم
طول فترة الإستعمال بالمرة = طول الفترة الزمنية اللازمة لإستخدام المغسلة بالدقائق

أحواض الجلي

معدل التدفق المقترح = ٨ لتر/دقيقة
معدل التدفق في أحواض الجلي (من النماذج السابقة) = ---------- لتر/دقيقة = ص

كمية التوفير = (ص - ٨) * عدد المستعملين * عدد أيام السنة * عدد مرات الإستعمال الفردي اليومي * طول فترة الإستعمال بالمرة

= (ص - ٨) * ------ * ------ * ------ * ------

= ---------- لتر/سنة = ---------- متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام المجلى للفرد الواحد باليوم
طول فترة الإستعمال بالمرة = طول الفترة الزمنية اللازمة لإستخدام المجلى بالدقائق

الدوشات

معدلات التدفق المقترحة =٩ لتر/دقيقة
معدل التدفق في الدوشات (من النماذج السابقة) = ---------- لتر/دقيقة = ع

كمية التوفير = (ع - ٩) * عدد المستعملين * عدد أيام السنة * عدد مرات الإستعمال الفردي اليومي * طول فترة الإستعمال بالمرة

= (س - ٦) * ------ * ------ * ------ * ------

= ---------- لتر/سنة =---------- متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام الدوش للفرد الواحد باليوم
طول فترة الإستعمال بالمرة = طول الفترة الزمنية اللازمة لإستخدام الدوش بالدقائق

المراحيض

معدل التدفق المقترح = ٦ لتر/دفقة
معدل التدفق في المراحيض (من النماذج السابقة) = ---------- لتر/دفقة = غ

كمية التوفير = (غ - ٦) * عدد المستعملين * عدد أيام السنة * الإستعمال الفردي اليومي

= (غ - ٦) * ------ * ------ * ------

= ---------- لتر/سنة = متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين + زوار
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام المرحاض للفرد الواحد باليوم

تحليل اقتصادي

التوفير النقدي

(١) كمية الماء التي تم توفيرها=

الماء التي تم توفيره من حنفيات الحمامات + الماء التي تم توفيره من حنفيات المجلى + الماء التي تم توفيره من showers + الماء التي تم توفيره من المراحيض

= ---------- + ---------- + ---------- + ---------- = ---------- م^{3} سنويا

(٢)المبلغ الموفر =

كمية المياه التي تم توفيرها سنويا (م^{3}) * ١,٥ دينار/م^{3}

= ---------- * ---------- = ---------- دينار سنويا

التكلفة الكلية

المغاسل = العدد الكلي * سعر الوحدة = ---------- * ---------- = ---------- دينار

أحواض الجلي = العدد الكلي * سعر الوحدة= ---------- * ---------- = ---------- دينار

الدوشات = العدد الكلي * سعر الوحدة= ---------- * ---------- = ---------- دينار

المراحيض = العدد الكلي * سعر الوحدة=---------- * ---------- = ---------- دينار

إجمالي الكلفة = ---------- دينار

عوامل اقتصادية

فترة إسترداد الكلفة = الكلفة الكلية/الوفر = ------/------

APPENDIX C

Letters

بسم الله الرحمن الرحيم

رئاسة الوزراء

رقم ٧٤٧٨
تاريخ ٢٧/صفر/١٤٢٢

المملكة الأردنية الهاشمية
وزارة المياه والري
٢٢ أيار ٢٠٠١
(ورد)
الرقم المتسلسل ١٦٣٥

معالي
عطوفة

انطلاقا من الاهمية الاستراتيجية للمياه التي تتطلب المحافظة على مصادرها وطرق صرفها، ونظرا لطبيعة الوضع المائي في المملكة وترشيدا لاستهلاك المياه، فإنني اؤكد على ضرورة إستخدام اجهزة ترشيد استهلاك المياه في الوزارات والدوائر الرسمية ،علما بأن وزارة المياه والري - إدارة الاعلام والتوعية على إستعداد لتقديم المساعدة الفنية بهذا الخصوص وتزويدكم بمواصفات اجهزة ترشيد الاستهلاك ذات الكفاءة العالية للتقيد بها .

واقبلوا فائق الاحترام.

رئيس الوزراء بالوكاله

	للعلم	للتنفيذ	للتدقيق	للتأشير
امين عام وزارة المياه والري				
امين عام سلطة المياه				
امين عام سلطة وادي الاردن				
المستشار/				

نسخة/الى معالي وزير المياه والري اشارة لكتابه رقم و م ر/١/٥/٣٧/٩٦٦ تاريخ ٢٠٠١/٤/٢٥.

المساعد العام للعلم والمتابعة

DATE/TIME	TIME	DISTANT STATION	PAGES	RESULT	ERROR PAGES	S.CODE
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بسم الله الرحمن الرحيم

المملكة الأردنية الهاشمية
وزارة المياه والري

The Hashemite Kingdom Of Jordan
Ministry of Water & Irrigation

الرقم ٣٥/١/٨/١/٢/٥/٢٥٢٦
التاريخ : ٨/١١/٢٠٠١

Ref.No.
Date :

معالي وزير .....

عطوفة .....

اشارة الى كتاب دولة رئيس الوزراء الافخم رقم رقم ٧٤٧٨/١/١١/٥٧ تاريخ ٢٠/٥/٢٠٠١ الذي يقتضي من كافة دوائر الدولة تركيب قطع توفير لترشيد استهلاك المياه وضبط الانفاق الحكومي في قطاع المياه.

لرجو التكرم بالعلم بأن مشروع الكفاءة المائية والتوعية احد مشاريع هذه الوزارة ستقوم بدراسة الوضع المائي لجميع مباني الدولة لمعرفة المباني التي تستهلك اكثر من ٥٠٠ مترمكعب في الدورة الواحدة والقيام بإجراء عمليات الاحتساب المائي لهذه المباني، لتحديد المباني التي تحتاج الى تركيب قطع توفير مياه وتقديم المواصفات لقسم المشتريات عند تركيب قطع التوفير بهدف القيام بعمل موازنة مالية لتحديد قيمة الاحتياجات للمباشرة بالتركيب حسب قرار دولة رئيس الوزراء الافخم والتي ستوفر على الدولة ما قيمته ٣٥% من استهلاك المياه داخل هذه المباني والتي تعود بالفائدة على قطاع المياه والانفاق الحكومي.

وعليه أرجو التكرم بتنسيب من ترونه مناسباً للتنسيق ما بين وزارتكم/مؤسستكم وبين مشروع الكفاءة المائية والتوعية والمؤسسة البحثية الدولية للدراسات التي ستقوم بهذه المهمة في موعد اقصاه ١٨/١١/٢٠٠١ على فاكس رقم ٥٦٨٠٠٧٥ .

وتفضلوا بقبول فائق الاحترام ،،،

وزير المياه والري
الدكتور حازم الناصر

نسخة: دولة رئيس الوزراء الافخم للتكرم بالاطلاع.

هاتف : ٥٦٨٣١٠٠ - ٥٦٨٠١٠٠ - ٥٦٨٣١١٥ - ٥٦٨٠٥١٦ فاكس : ٥٦٨٠٠٧٥ العنوان البرقي : المياه ص . ب ٢٤١٢ - ٥٠١٢ عمان - الأردن
Tel. : 5683100 - 5680100 - 5683115 - 5680516 Fax : 5680075 Tlx. 22439 WAJ Jo. Cable: WATER JO. P.O.Box 2412 - 5012 Amman - Jordan

قرار رقم ٩٨/٦٧

APPENDIX D

Post Audit Package

بسم الله الرحمن الرحيم

المملكة الأردنية الهاشمية
وزارة المياه والري

The Hashemite Kingdom Of Jordan
Ministry of Water & Irrigation

الرقم وم د/٦/٨/٢/٤٢٤٢
التاريخ : ١٢/١٢/٢٠٠١

Ref.No. .....
Date : .....

عطوفة ..... المحترم

لاحقا لكتابي رقم وم ر/٦/٨/٣/٥/٣٥٢٤ تاريخ ٢٠٠١/١١/٨ وإشارة لكتابكم المتضمن التعاون مع مشروع الكفاءة المائية والتوعية وتنسيب احد موظفيكم للتنسيق مع المشروع والمؤسسة البحثية الدولية للدراسات من اجل القيام بعمليات الاحتساب والتسرب المائي للمباني التابعة لمؤسستكم.

مرفق طيه نتائج عمليات الاحتساب والتسرب المائي والجدوى الاقتصادية بعد تركيب قطع توفير المياه في مباني مؤسستكم وكذلك مرفق مواصفات الاجهزة ذات الكفاءة العالية التي ستعمل على التوفير في استهلاك المياه .

راجين معاليكم التكرم بالايعاز لتركيب قطع توفير المياه بناء على تعميم دولة رئيس الوزراء الافخم بكتابه رقم ٧٤٧٨/١/١١/٥٧ تاريخ ٢٠٠١/٥/٢٠ الذي يقتضي من دوائر الدولة تركيب قطع توفير المياه لضبط الانفاق الحكومي.

شاكرين لكم تعاونكم خدمة لقطاع المياه في الاردن.

واقبلوا فائق الاحترام،،،

أمين عام وزارة المياه والري
المهندس سعد البكري

هاتف : ٥٦٨٣١٠٠ - ٥٦٨٠١٠٠ - ٥٦٨٣١١٥ - ٥٦٨٠٥١٦ فاكس : ٥٦٨٠٠٧٥ العنوان البرقي : المياه ص.ب ٢٤١٢ - ٥٠١٢ عمان - الاردن
Tel. : 5683100 - 5680100 - 5683115 - 5680516 Fax : 5680075 Tlx. 22439 WAJ Jo. Cable: WATER JO. P.O.Box 2412 - 5012 Amman - Jordan

قرار رقم ٩٨/٦٧

ملخص لنتائج دراسات المسح المائي في مجلس النواب

بعد أن تم إجراء المسح المائي في مجلس النواب وبالتنسيق مع ضابط الإتصال مروان المدفعي وبعد أن تم الإنتهاء من عملية التدقيق، فقد وجد ما يلي:

- إن ارتفاع كمية استهلاك المياه يعزى لارتفاع معدلات التدفق في المخارج المائية الرئيسية (المغاسل، خزانات المراحيض)، لذلك فإن تركيب قطع توفير المياه على هذه المخارج يؤدي إلى نسبة توفير ٤٤% كما هو مفصل أدناه:

معدل التدفق في الحنفيات	١٠ لتر/دقيقة
كمية استهلاك المياه السنوية من المغاسل	١٦٣٨ م^3
كمية استهلاك المياه السنوية بعد تركيب قطع توفير المياه على جميع المغاسل	٩٨٣ م^3
كمية التوفير السنوية في المياه بعد تركيب قطع توفير المياه على جميع المغاسل	٦٥٥م^3
المبلغ الممكن توفيره سنويا بعد تركيب قطع توفير المياه على جميع المغاسل	

معدل حجوم خزانات المراحيض	١١,٢ لتر
كمية استهلاك المياه السنوية من المراحيض	١٣١٠ م^3
كمية استهلاك المياه السنوية بعد تركيب قطع توفير المياه على جميع المراحيض	٧٠٢ م^3
كمية التوفير السنوية في المياه بعد تركيب قطع توفير المياه على جميع المراحيض	٦٠٨ م^3
المبلغ الممكن توفيره سنويا بعد تركيب قطع توفير المياه على جميع المراحيض	

- وبالتالي فالمياه الممكن توفيرها سنويا بعد تركيب قطع توفير المياه على جميع المخارج المائية في المجلس تقدر بحوالي ١٢٦٣ م^3

- والمبلغ الممكن توفيره سنويا بعد تركيب قطع توفير المياه على جميع المخارج المائية في المجلس يقدر بحوالي ١٨٩٥ دينار

- كلفة تركيب قطع توفير المياه على جميع المخارج المائية في المجلس والجدوى الاقتصادية نتيجة ذلك فهي كما هو مبين في الجدول أدناه:

المغاسل بدون تسنين	٥	٩	٤٥
المغاسل تسنين	٦٧	٣,٥	٢٣٤,٥
المراحيض	٤٥	١٨	٨١٠
الكلفة الإجمالية			

- كما هو مبين أعلاه، عملية تركيب قطع توفير المياه طبقا للمواصفات المرفقة ذات جدوى اقتصادية عالية بالاضافة الى أهميتها في حل مشكلة ندرة المياه في المملكة.

- جهة إعداد الدراسة: المؤسسة البحثية الدولية للدراسات (IRC)
- أعضاء فريق المسح المائي: م. بيدر عويس، م. نديم خيطان

المواصفات و المقاييس الأردنية لقطع توفير المياه

١.المواصفات العامة:

١. استخدام قطع ذات نوعية عالية و يفضل أن تكون مصنوعة من Stainless Steel أو PVC
٢. أن تتحمل القطع درجات الحرارة المختلفة و على مدى عمر القطعة العملي على ان لا تقل درجة الحرارة عن ٧٠ درجة مئوية بشكل متواصل
٣. أن تكون هذه القطع سهلة الصيانة
٤. أن يكون هناك أنواع من هذه القطع تعمل على الضغط المختلف و الذي يتراوح(٣ و٠- ٣ بار) مع مراعاة معدل التدفق (خاص بالحنفيات و الدوشات) .

٢.المواصفات الخاصة:

أ.القطع التي تركب على الحنفيات :

يشترط في هذه القطع أن تتوفر فيها المقاييس و المواصفات العامة بالإضافة إلى:

- أن لا يتجاوز معدل التدفق ٦ لتر/ دقيقة كقيمة قصوى
- أن تكون مغيبة لتجنب تكلسها نتيجة لعسر الماء
- أن تكون مضادة للسرقة (تفك و تركب بواسطة مفتاح خاص)
- أن تقوم على مبدأ عمل خلط الهواء بالماء . (Acrator) و ليس على مبدأ تخفيض كمية التدفق فقط (Restrictor)
- أن يكون قطر المياه المتدفقة من الحنفية (١٥-١٩) ملم و ذلك لضمان الراحة.
- في حالة عدم تسنين المغاسل يجب تغيير قصبة الحنفية كاماة

ب. القطع التي تركب على الدوشات:

يشترط في هذه القطع أن تتوفر فيها المقاييس و المواصفات العامة بالإضافة إلى :

- أن لا يتجاوز معدل التدفق ٩ لتر/ دقيقة كقيمة قصوى.
- ضمان راحة المستخدم (و تقاس بالنظر)

ج. القطع التي تركب في المراحيض:

يشترط في هذه القطع أن تتوفر فيها المقاييس و المواصفات العامة بالإضافة إلى:

- ألا يتجاوز حجم الماء المتدفق عن ٦لتر/ دقيقة الواحدة مع ضمان آلية التصريف.
- يفضل استخدام المراحيض ذات ثنائية التدفق (٣ لتر/دفقة أو ٦ لتر/دفقة)

شروط عامة لموردي هذه القطع:

- على المورد تقديم عرض أسعار هذه القطع على أساس التوريد و التركيب.
- على المورد عمل مسح مائي نهائي وزيارة للموقع قبل تقديم عرضه المالي تركيب القطع.
- على المورد أن يلتزم بعمل الصيانة اللازمة لهذه القطع لمدة سنة واحدة من تاريخ التركيب بحيث تشمل هذه الصيانة تبديل القطع التي تتعرض للتلف نتيجة سوء المصنعية و / أو عدم التزام المورد بعمل الصيانة اللازمة لهذه القطع.

لمزيد من المعلومات يرجى الاتصال بمشروع الكفاءة المائية و التوعية. رقم الهاتف: ٥٥٢٧٨٩٣ أو ٥٥٢٧٨٩٥، رقم الفاكس: ٥٥٢٧٨٩٤

أسماء الموردين و الموزعين لقطع توفير المياه

اسم المورد	الماركة	العنوان	رقم الهاتف
الرونق	RST	بيادر وادي السير	٥٨١٤٩٨٥
ارشيدات	Niagara	العبدلي	٤٦٢١٦٢٢
جروهي	GROHE	عمان	٥٥١١٤٧٥
شركة المنى	Ideal Standard	جبل عمان	٥٦٧٥٨٥١
مؤسسة رامي	Mannseman	خلف فندق أوركيدا	٥٥٣٠٣٢٣
شركة جورج مشحور	Twyford	خلدا	٥٥٣١٩٦٠
بندر سطعان الحسن	GROHE	وادي صقرة	٤٦٣٢٦٤٣٣
تكنولوجيا توفير المياه	NEOPERL	أم السماق	٠٧٧٣٩٣٣٦٠

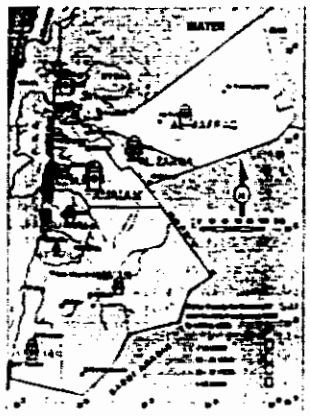
APPENDIX E Workshop

Training Manual

المياة في الأردن

توزع مصادر المياة في العالم الى أربع أنواع. مياة الأمطار, المياة الجوفية, الأنهار و البحيرات. جميع هذة المصادر هي مصادر غير منتظمة, مثلا معدلات سقوط الأمطار تختلف من سنة لأخرى و من فصل للأخر. أما مصادر المياة في الأردن فهي تقسم الى أربع أنواع:

١. المياة السطحية
٢. المياة الجوفية
٣. مياة الأمطار
٤. المياة العادمة



الشكل المجاور هو خريطة للمملكة الأردنية الهاشمية, توضح المدن الرئيسية و كميات سقوط الأمطار في المناطق المختلفة.

المياة السطحية في الأردن:

هي مياه جارية بشكل دائم في أنهار أو سيول , وجريان المياه غير ثابت ويعتمد على كمية المطر, فترة المطر, والجزء المتفذ إلى المياه الجوفية. مياه الأردن السطحية مقسمة في ١٥ حوض مائي , اهمها حوض اليرموك و هو يشكل ما نسبتة ٤١% من مصادر المياة السطحية. و من ابرز الأحواض الأخرى الموجب, وادي عربة و الحسا.

المياة الجوفية في الأردن:

يوجد في الأردن ١٢ حوض للمياة الجوفية, و هي تعتبر المصدر الرئيسي للمياة في الأردن, و تقسم لنوعان: ١. مصادر متجددة ٢. مصادر غير متجددة .

الجدول التالي يبين استغلال المياة الجوفية في الأردن

الحوض	الاستخراج الأمن م.م٣/سنويا	مجموع الاستعمالات	النسبة(%) من الاستخراج الأمن
اليرموك	40	52.817	132
عمان/الزرقاء	87.5	137.436	157
الدبسي	125	72.856	58
وادي عربة	3.5	4.573	131
الأزرق	24	53.9	225

المياة العادمة في الأردن:

هي المياه الخارجة من محطات التنقية (١٧ محطة) و تعتبر مصدر هام للمياه. معظمها يضخ إلى وادي الأردن حيث تضخ إلى المجاري المائية أو تستخدم للري و هي ذات مواصفات نوعية معينة.

اعادة استخدام المياة العادمة :

يعاد استخدام ٦١٧٠٣٠٠٠ م^3 من المياة العادمة سنويا للري و هو ما يعادل ١٠% من المياة المتاحة للري و استغلت لغايات الري المقيد (أعلاف, أزهار, أشجار مثمرة, أشجار حرجية) وبمساحة إجمالية تقدر بنحو (١٤٠٠٠) دونم. المياه الزائدة عن حاجة الأراضي يتم إسالتها إلى مجاري الأودية حيث تخلط مع المياه السطحية وخصوصاً في سد الملك طلال و تستغل لغايات الري غير المقيد في مناطق الأغوار الوسطى بشكل رئيسي.

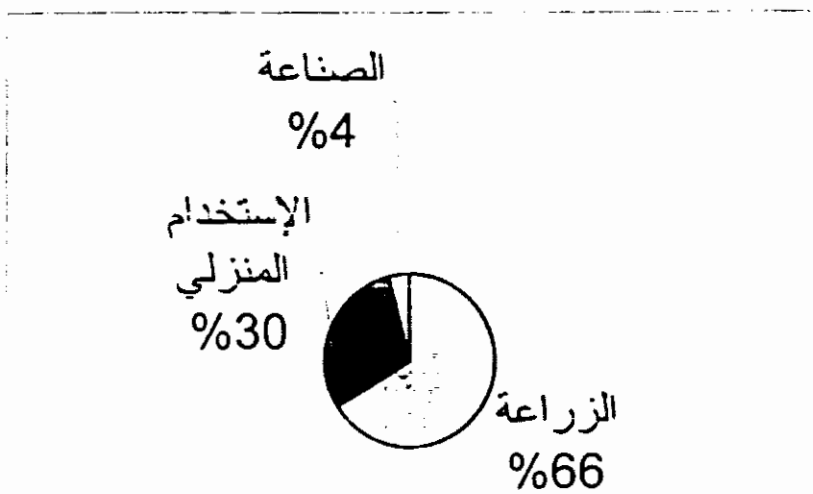
السؤال المطروح هنا هو كيف يتم ادارة هذة المصادر المائية؟

يتم ادارة المصادر المائية المتاحة عن طريق انشاء السدود, انشاء قنوات الري و التحويل, حفر الابار, و تجميع مياة الأمطار.

قطاعات الإستهلاك:

يتم استهلاك المياة في الأردن في ثلاث قطاعات رئيسية:

١. القطاع الزراعي.
٢. القطاع الصناعي.
٣. القطاع المنزلي.



يتم ايصال المياة الى المستهلك عن طريق قنوات التحويل, محطات الضخ, خزانات, و شبكات المياة. و تعتمد كمية المياة التي يتم ايصالها للمستهلك على كمية المياة المتوفرة , كمية المياة المستخرجة و سعة الإيصال.

الجدول التالي يبين استهلاك الأردن و دول العالم للفرد. و يوضح تدني هذا الرقم بالنسبة للأردن

استهلاك المياه في دول العالم المختلفة (لتر/يوم-فرد)

البلد	الاستهلاك
أمريكا	5920
كندا	4800
أستراليا	3570
اليابان	2530
ألمانيا	1765
الصين	1265
كولومبيا	490
كينيا	133
الأردن	120

تعزى اسباب التباعد في معدلات استخدام المياه الى الأسباب التالية:

١. إختلاف وفرة المياة
٢. إختلاف كلفة المياة
٣. الإختلاف في التطور التكنولوجي
٤. إختلاف في انماط الحياة
٥. إختلاف في انماط الترشيد
٦. إختلاف في الإجراءات المتبعة فيما يتعلق بتلوث المياة

عملية استخراج و توصيل المياة:

هي مسؤولية السلطات المحلية مثل سلطة المياة و سلطة وادي الأردن . هذة السلطات مسؤولة عن كل ما يلزم لتأمين المياة للمستهلك من حفر آبار, بناء سدود, ضخ مياة, معالجة مياة تمديد شبكات, أعمال الصيانة, و التخطيط و التنسيق و الدراسة.

ادارة الموارد المائية:

هي عملية إدارة وتنظيم وتخزين الموارد المائية للاستعمال البشري و الزراعي والصناعي. تتم عن طريق انشاء السدود, قنوات الري, شبكات المياه و معالجة المياه العادمة واعادة استخدامها.

تذهب هذة الموارد الى المستهلك : منزلي، زراعي، او صناعي

و يصنف الوضع المائي إلى ثلاثة أقسام:

الوضع الفوق المثالي: الموارد أكبر من الطلب (ممكن؟)

الوضع المثالي: الموارد تساوي الطلب (هل يدوم؟)

الوضع في الأردن: الموارد أقل من الطلب

الحل هو في إدارة الطلب للمياة و يتمحورذلك حول زيادة كفاءة إستهلاك المياه وإستعمالها بشكل حكيم، وتقع مسؤولية تفعيل هذا المبدأ على المستهلك. أحدى طرق إدارة الطلب على المياه و ذلك بتقليل إستهلاك المياه دون التأثير على فعالية الأداء وراحة المستهلك و يمكن إنجازه عن طريق تقليل هدر الماء ووقف التسريب في البيت والشبكات.

مثال (١):

عملية تنظيف الأسنان تستغرق حوالي ٣ دقائق ممكن عملها مع ترك الحنفية مفتوحة طوال ال ٣ دقائق أو فتح الحنفية في عملية المضمضة فقط لمدة دقيقة واحدة

إذا كان تدفق الحنفية ١٥ لتر بالدقيقة
١.الطريقة الأولى تستهلك ٣ * ١٥ = ٤٥ لتر
٢.الطريقة الثانية تستهلك ١ * ١٥ = ١٥ لتر

الفرق ٣٠ لتر يوميا
على مدار السنة: ٣٠ * ٣٦٥ = ١٠٩٥٠ لتر = ١٠ م^3
١٠٠٠٠ شخص يمكن أن يوفروا ١٠٠٠٠٠م^3 سنويا

مثال (٢)

مغسلة تسرب نقطة واحدة في الثانية، حجم النقطة ٠,٥ مللتر

في اليوم الواحد:

٠,٥ * ٦٠ ثانية * ٦٠ دقيقة * ٢٤ ساعة = ٤٣ لتر
على مدار السنة: ٤٣ * ٣٦٥ = ١٥م^3
تصليح ١٠٠٠٠ مغسلة يوفر ١٥٠٠٠٠ م^3 سنويا

تكلفة تصليح المغسلة الواحدة = ؟؟؟؟

مثال (٣)

عملية غسيل السيارة تستغرق حوالي ١٠ دقائق، ممكن عملها باستعمال الخرطوم وترك الحنفية مفتوحة طوال ال ١٠ دقائق, أو باستعمال ٤ دلاء سعة الدلو الواحد ٢٠ لتر

مقارنة

إذا كان تدفق الحنفية ١٥ لتر بالدقيقة

١

الطريقة الأولى تستهلك ١٠ * ١٥ = ١٥٠ لتر

٢ الطريقة الثانية تستهلك ٤ * ٢٠ = ٨٠ لتر

الفرق ٧٠ لتر لكل غسلة

على مدار السنة: ٧٠ * ٥٢ = ٣٦٤٠ لتر = ٣,٦ م^{٣}

١٠٠٠٠ شخص يمكن أن يوفروا ٣٦٠٠٠م^{٣} سنويا

مثال (٤)

مرحاض سعة خزانه ١٢ لتر يستعمل ٥ مرات في اليوم، الإستهلاك اليومي = ١٢ * ٥ = ٦٠ لتر

ممكن وضع زجاجة مياه بالخزان بسعة ١,٥ لتر فيصبح الإستهلاك اليومي =

١٠,٥ * ٥ = ٥٢,٥ لتر

التوفير:

اليومي = ٧,٥ لتر

السنوي = ٧,٥ * ٣٦٥ = ٢,٧ م٣

١٠٠٠٠ مرحاض يمكن توفير ٢٧٠٠٠م٣ سنويا

امثلة اخرى

- التقليل من إلقاء النفايات
- إستعمال الغسالة بوجبات كاملة
- إستعمال مساحيق غسيل قابلة للتحلل
- التقليل من إستعمال المبيدات في الزراعة

كل الأمثلة السابقة هي أساليب لترشيد إستهلاك المياه: فعالية الإستعمال وراحة المستهلك لم تتأثر، وتم تخفيض الأستهلاك. و هذه الأساليب تساهم بدرجة كبيرة في إدارة الطلب على المياه, كما انها ليست مقتصرة على الإستعمال المنزلي.

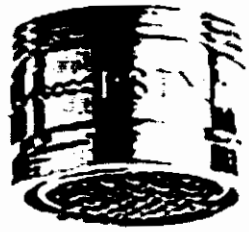
الترشيد في المنازل:

السؤال المطروح هنا, هل هناك طريقة بالإضافة إلى تغيير السلوك لجعل المستهلك يستعمل حاجته من الماء فقط؟ فمثلا: إذا كان المستهلك يحتاج ١٠ لتر لتغسيل اليدين كيف يمكن أن يستعمل ١٠ لتر و ليس أكثر؟

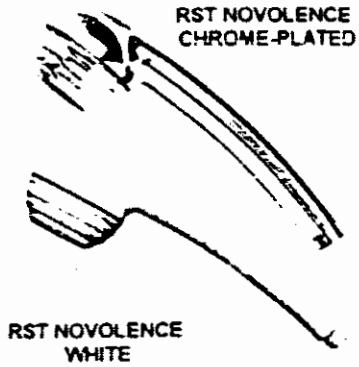
يمكن ذلك باستخدام قطع ترشيد الإستهلاك, فهي من أنجح الأساليب ترشيد إستهلاك المياه, و تتمحور حول إستعمال قطع رخيصة وسهلة التركيب قد يصل مقدار التوفير إلى ٤٠% دون التأثير على الكفاءة و راحة المستهلك.

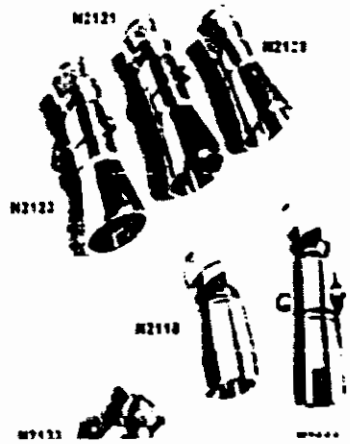
تقسم قطع ترشيد استهلاك المياة الى ثلا ث انواع:

١. قطع المغاسل (بتدفق ٦ لتر/دقيقة)

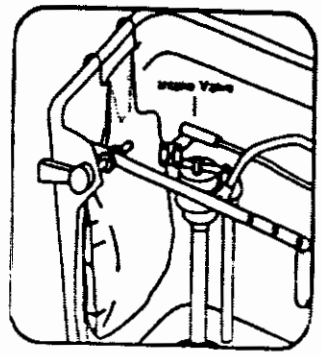


٢. قطع الدوشات (بتدفق ٩ لتر/دقيقة)





٣. قطع المراحيض (٦ لتر للدفقة)



فعالية قطع توفير المياه:

- بتركيب هذه القطع على المغاسل ينخفض التدفق من ١٨ لتر/دقيقة الى ٦ - ٨ لتر/دقيقة
- بتركيب هذه القطع على الدوشات ينخفض التدفق من ١٨ لتر/دقيقة الى ٩ لتر/دقيقة
- بتركيب هذه القطع على المراحيض ينخفض الاستهلاك من ١٢ لتر/ دفقه الى ٦ -٩ لتر/ دفقه

مميزات قطع ترشيد إستهلاك المياة:

- تقلل التدفق دون التأثير على الكفاءة
- تعطي أحسن نتائج عند دعمها بتغييرات سلوكية
- حل أمثل في المباني العامة
- متوفرة بكثرة في الأسواق المحلية
- قليلة التكاليف
- مجدية إقتصاديا
- سهلة التركيب
- متطلبات صيانتها بسيطة

عملية اجراء المسح المائي

الهدف من عملية المسح المائي هو معرفة كمية المياه المستخدمة قبل و بعد تركيب قطع توفير المياه و من اجل معرفة الجدوى الاقتصادية بعد التركيب، عمليةالمسح المائي هي عملية جرد للمخارج المائية في مبنى ما و تشمل أصناف المخارج المائية التي (مغاسل، دوشات، مراحيض)، اعداد كل صنف، حالة اي صنف من ناحية اي سيلان، معدل التدفق لكل صنف، عدد المستعملين، و عدد مرات الاستعمال في اليوم

لماذا نجري مسح مائي؟

- لفحص وجود اي سيلان في المخارج المائية
- للتعرف على المخارج المائية الاكثر استعمالا
- لمقارنة معدلات التدفق مع المواصفات وتحديد الحاجة إلى إستعمال قطع توفير المياه

السبب الاهم للمسح المائي:

- حساب معدلات إستهلاك المياه
- تحديد كمية المياه التي يتم توفيرها نتيجة لتركيب قطع توفير المياه
- بيان الجدوى الإقتصادية من تركيب قطع توفير المياه
- إقناع أصحاب القرار بأهمية تركيب قطع توفير المياه

التخطيط لاجراء مسح مائي:

- يجب التعرف على المواقع الاكثر استهلاكا للماء
- تشكيل عدة مجموعات لاجراء مسوحات مائية في المواقع المختلفة
- توزيع المجموعات على الأجزاء المختلفة من المبنى اجمع المعلومات

عملية قياس التدفق من المخارج المائية:

يتم قياس التدفق للمغاسل والدوشات بقياس الوقت المستغرق لملء دورق مدرج سعته ١ لتر، حيث ان التدفق = ٦٠ ثانية ÷ الزمن = لتر/ دقيقة، و يتم قياس التدفق للمراحيض بقياس أحجام خزاناتها (لتر)التدفق = لتر/ دقيقة.

فحص السيلان او التسرب:

يتم فحص السيلان للمغاسل والدوشات عن طريق المراقبة وملاحظة أي سيلان و يتم فحص السيلان للمراحيض عن طريق وضع بودرة في المرحاض وملاحظة أي سيلان.

عملية تفريغ البيانات في نماذج خاصة:

تدقيق مائي

١. معلومات المبنى

الاستعمال: _____

العمر _____

عدد الطوابق _____

عدد الموظفين _____

عدد الزوار في اليوم _____

معلومات المدقق

اسم المدقق _____

العنوان _____

المؤسسة _____

منصب المدقق _____

التاريخ _____

رقم التدقيق _____

معلومات إضافية

مجموع الاستهلاك السنوي من المياه م٣

وسطية الصهاريج في السنة م٣

التعبئة الأخيرة في وقت ..... ساعة الساعات باليوم.....

فاتورة مضخة المياه ..... دينار أردني م٣

استخدامات الماء الخارجية

ما هو مصدر مياه الري؟ .....

مساحة الحديقة المتنزه المروية م٢

كمية المياه المستعملة في كل سقاية م٣

كم مرة في الأسبوع يتم ري الحديقة وكم ساعة؟ عدد المرات ☐

هل يوجد نظام حصاد مائي أو تدوير مياه في الموقع؟ نعم ☐ لا ☐

عدد السيارات التي يتم غسلها : صالون..... مركبات كبيرة.....

عدد مرات غسل السيارات بالأسبوع .....؟

المراحيض

معدل عمر المراحيض:.....

الأنواع: (أ) مرحاض افرنجي (ب) مرحاض تركي (ج) قفل للمغاورة (ج) خزان سحبي.

معدل التدفق للمراحيض:

(١) + (٢) - (٣)

العدد الكلي للمراحيض

= ---- + ---- - ----

= ---------- لتر/ساعة

الطابق							
	٦	٩					
١							
٢							
٣							
٤							
٥							
٦							
٧							
٨							
٩							
١٠							
المجموع							
المجموع *السعة	(١)=	(٢)=	(٣)=	العدد الكلي للمراحيض =			

المغاسل

الطابق	تدفقات المغاسل												عدد المغاسل التي تسببها			عدد المغاسل التي تسببها سيلان
	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق	العدد	التدفق	العدد*تدفق				بدون	داخلي	خارجي	
١																
٢																
٣																
٤																
٥																
٦																
٧																
٨																
٩																
١٠																
المجموع	أ=			أ=			أ=									
عدد المغاسل الكلي = أ١ + أ٢ + أ٣													معدل تدفق المغاسل = (ب١ + ب٢ + ب٣) / (أ١ + أ٢ + أ٣)			

الدوشات

الطابق	تدفقات الدوشات										عدد الدوشات من نوع		عدد الدوشات التي بها سيلان
	العدد	التدفق	العدد×التدفق	العدد	التدفق	العدد×التدفق	العدد	التدفق	العدد×التدفق	العدد×التدفق	يدوي	بالخلط	
١													
٢													
٣													
٤													
٥													
٦													
٧													
٨													
٩													
١٠													
المجموع	أ=		ب=			ب=	أ=		ب=	ب=			

عدد الدوشات الكلي = أ١ + أ٢ + أ٣
=

معدل تدفق الدوشات = $\frac{ب_1 + ب_2 + ب_3}{أ_1 + أ_2 + أ_3}$

حسابات توفير المياه

المغاسل

معدلات التدفق المقترحة = ٤ إلى ٦ لتر/دقيقة
معدل التدفق في المغاسل (من النماذج السابقة) = ---------- لتر/دقيقة = س

كمية التوفير = (س - ٦) * عدد المستعملين * عدد أيام السنة * عدد مرات الإستعمال الفردي اليومي * طول فترة الإستعمال بالمرة

= (س - ٦) * ------ * ------- * ------- * -------

= ---------- لتر/سنة =---------- متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين + زوار
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام المغسلة للفرد الواحد باليوم
طول فترة الاستعمال بالمرة = طول الفترة الزمنية اللازمة لإستخدام المغسلة بالدقائق

الدوشات

معدلات التدفق المقترحة =٩ لتر/دقيقة
معدل التدفق في الدوشات (من النماذج السابقة) = ---------- لتر/دقيقة = ع

كمية التوفير = (ع - ٩) * عدد المستعملين * عدد أيام السنة * عدد مرات الإستعمال الفردي اليومي * طول فترة الإستعمال بالمرة

= (س - ٦) * ------ * ------- * ------- * -------

= ---------- لتر/سنة =---------- متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام الدوش للفرد الواحد باليوم
طول فترة الإستعمال بالمرة = طول الفترة الزمنية اللازمة لإستخدام الدوش بالدقائق

المراحيض

معدل التدفق المقترح = ٦ لتر/دفقة
معدل التدفق في المراحيض (من النماذج السابقة) = ---------- لتر/دفقة = غ

كمية التوفير = (غ - ٦) * عدد المستعملين * عدد أيام السنة * الإستعمال الفردي اليومي

= (غ - ٦) * ------ * ------- * ------

= ---------- لتر/سنة = متر مكعب/السنة

ملاحظات

عدد المستعملين = موظفين + زوار
عدد أيام السنة = أيام العمل =(٣٦٥ - العطل)
عدد مرات الإستعمال الفردي اليومي = معدل عدد مرات إستخدام المرحاض للفرد الواحد باليوم

تحليل اقتصادي

التوفير النقدي

(١) كمية الماء التي تم توفيرها=

الماء التي تم توفيره من حنفيات الحمامات + الماء التي تم توفيره من حنفيات المجلى
+ الماء التي تم توفيره من showers + الماء التي تم توفيره من المراحيض

= ---------- + ---------- + ---------- + ---------- = ---------- م^3 سنويا

(٢)المبلغ الموفر =

كمية المياه التي تم توفيرها سنويا (م^3) * ١,٥ دينار/م^3

= ---------- * ---------- = ---------- دينار سنويا

التكلفة الكلية

المغاسل	=	العدد الكلي * سعر الوحدة = ---------- * ---------- = ---------- دينار		
أحواض الجلي	=	العدد الكلي * سعر الوحدة= ---------- * ---------- = ---------- دينار		
الدوشات	=	العدد الكلي * سعر الوحدة= ---------- * ---------- = ---------- دينار		
المراحيض	=	العدد الكلي * سعر الوحدة=---------- * ---------- = ---------- دينار		

اجمالي التكلفة = ---------- دينار

عوامل اقتصادية

فترة إسترداد الكلفة = الكلفة الكلية/الوفر = ------/------

حساب الاستهلاك الكلي:

- باستعمال معدلات التدفق التي تم قياسها وبمعرفة سلوك الفرد من حيث استعماله للمرافق الصحية يمكن حساب الاستهلاك الكلي
- سلوك الفرد يتضمن عدد مرات استعمال كل مرفق وطول فترة الاستعمال
- تعتمد السلوكيات على نمط الحياة و طبيعة الموقع المستعمل

مثال: شقة في عمارة تحتوي على

النوع	التدفق(لتر/ دقيقة)
مغسلة	١٢
مجلى	١٤
دوش	١١
مرحاض	١٢

السلوكيات:

عدد الاشخاص : ٢
معدلات الاستعمال اليومية:

المغسلة : ١٠ مرات لمدة ٠,٥ دقيقة
الدوش : ١ مرة لمدة ٨ دقائق
المرحاض: ٥ مرات
المجلى: ٣ مرات لمدة ٨ دقائق

عند تركيب قطع توفير مياه نحصل على النتائج التالية:

النوع	التدفق قبل التركيب (لتر/ دقيقة)	التدفق بعد التركيب (لتر/ دقيقة)
مغسلة	١٢	٦
مجلى	١٤	٨
دوش	١١	٩
مرحاض	١٢	٩

كمية المياه الممكن توفيرها:

كمية التوفير = (التدفق الفعلي- التدفق بعد التركيب) × عدد مرات الإستعمال × فترة الاستعمال

المغسلة: (٢ لـ ٦) × ١٠ × ½ = ٣٠ لتر/يوم
الدوش: (١ لـ ٩) × ١ × ٨ = ١٦ لتر/يوم
المرحاض: (٢ لـ ٩) × ٥ = ١٥ لتر/يوم
المجلى: (٤ لـ ٨) × ٣ × ٨ = ١٤٤ لتر/يوم

المجموع =

٣٠× ٢ + ١٦×٢ + ١٥×٢ + ١٤٤ = ٢٦٦ل/يوم = ٠,٢٦٦×٣٠×٣ = ٢٣،٩٤ م^{٣}/دورة

الجدوى الاقتصادية:

تجرى الجدوى الاقتصادية من اجل معرفة ثمن المياه التي يتم توفيرها سنويا، حيث يتم مقارنة المبلغ الممكن توفيره مع ثمن قطع توفير المياه، حيث نجد ان بأمكاننا ان نسترد كلفة القطع المركبة بعد فترة وجيزة بسبب التوفير الحاصل في كمية المياه

وبعد اجراء هذه الجدوى الاقتصادية نجد ان تركيب قطع توفير المياه هي عملية مجدية اقتصاديا.

جدوى تركيب قطع توفير المياه للشقة:

كمية المياه التي يتم توفيرها = ٢٣،٩٤ م^{٣}/دورة
كمية المياه سنويا = ١٩،١٥ × ٤ = ٧٦،٦ م^{٣}/سنة
ثمن المياه الموفرة = ٧٦،٦ × ١،٥ = ١١٤،٩ د/سنة

ينصح بتركيب القطع التالية:

موفر المياه عدد ٢ (مجلى + مغسلة)
راس دش عدد ١ مرحاض جديد عدد ١

اسعار القطع:

موفر المياه عدد ٢ × ٣،٥ = ٧ دينار
راس دش عدد ١ × ٩ = ٩ دينار
مرحاض جديد عدد ١ × ٦٠ = ٦٠ دينار
اجمالي الكلفة = ٧٦ دينار

الجدوى الاقتصادية:

المردود = ١١٤،٩ د/سنة

الكلفة = ٧٦ دينار

الكلفة أقل من المردود

فترة المردود المالي = ٧٦ ÷ ١١٤،٩ = ٠،٦٦ سنة

فترة المردود المالي = ٨ أشهر تقريبا

إذا فالإستثمار مجدي جدا و خاصة في المباني التي تستهلك كميات كبيرة من المياه

تطبيق عملي

قصر العدل

صنف مجلس قصر العدل بأنة من كبار مستهلكي المياة, حيث أن استهلاكة السنوي ١٠٦٥٦م٣. عين السيد نائل الرفاد ضابط اتصال. توجة فريق المسح المائي بتاريخ ٢٠٠٢/٣/٥ الى الموقع, و اخذت بيانات لوجستية عن المبنى من حيث عدد الموظفين و الزوار لكل يوم, للقيام بعملية حساب تقديرية لكمية المياة المستهلكة سنويا. تم قياس التدفقات من المخارج المائية و ذلك باستخدام اناء سعتة لتر و ساعة توقيت, كما اخذت اعداد و حجوم المراحيض و اعداد الدوشات و الحنفيات و انواعها من حيث شكل السن.

حسب التدفق من كل حنفية و ذلك بقسمة الرقم (٦٠) على الزمن لتعبئة التر. كما تم قياس معدل التدفق من جميع الحنفيات و ذلك بضرب تدفق كل حنفية بعدد الحنفيات من نفس التدفق, و قسمة المجموع على عدد الحنفيات الكلي. فكان معدل تدفق الحنفيات ٢٦,٣لتر/دقيقة.

الطابق	تدفقات المغاسل			عدد المغاسل التي تسنينها		
	العدد	التدفق	التدفق*العدد	بدون	خارجي	داخلي
١	٢٢	٣٠	٦٦٠	١٨	١	٣
٢	٥٧	٣٠	١٧١٠	٥١	٠	٦
٣	٣١	٣٠	٩٣٠	٢٤	١	٦
٤	٢٣	٢٤,٤	٥٦١,٢	٢٢	٠	١
٥	٢٧	٢٠	٥٤٠	٢١	٤	٢
٦	١٣	٢٠	٢٦٠	١١	٠	٠
٧	١٥	١٣	١٩٥	١٠	١	٤
المجموع	١٨٨		٤٨٥٦,٢	١٥٧	٧	٢٢
	التدفق = ٤٨٥٦,٢/١٨٨ = ٢٦,٣لتر/د			العدد الكلي=١٨٨		

يمكن تقدير معدل الإستهلاك السنوي من المغاسل من خلال المعادلة التالية:

الإستهلاك = معدل التدفق*عدد المستخدمين*عدد مرات الإستخدام*عدد أيام الدوام*فترة الإستعمال

= {(٢٦,٣)*(٢٠٠٠)*(١)*(٢٦٠)*(٠,٥)}/١٠٠٠

=٦٨٣٨ م٣

يمكن حساب كمية التوفير السنوية من المغاسل من المعادلة التالية:

التوفير في المياة = (التدفق الحالي-المثالي)*(عدد المستخدمين)*(مرات الإستخدام)*(فترة الإستخدام)*(عدد الأيام).

= {(٢٦,٣-٦)*(٢٠٠٠)*(١)*(٠,٥)*(٢٦٠)}/١٠٠٠

= ٥٢٧٨م٣

كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)

= (٦٨٣٨-٥٢٧٨)

= (١٥٦٠م٣)

المبلغ الممكن توفيرة سنويا = التوفير*سعر (م٣)

= ٥٢٧٨*١,٥= ٧٩١٧ دينار

تم حساب معدل حجوم خزانات المراحيض بضرب عدد الخزانات من نفس الحجم بعددها, و قسمة الناتج على أعداد المراحيض.
كان معدل حجوم الخزانات المراحيض ١٢ لتر

الطابق	اعداد المراحيض التي سعتها			اعداد المراحيض التي نوعها	
	٦	٩	١٢	افرنجي	عربي
١	٠	٠	٨	٨	
٢	٠	٠	٦	٦	
٣	٠	٠	١٢	١٢	
٤	٠	٠	٩	٩	
٥	٠	٠	١٠	١٠	
٦	٠	٠	٨	٨	
٧	٠	٠	٨	٨	
المجموع	٠	٠	٦١	٦١	
السعة*المجموع			٧٣٢	عدد المراحيض=٦١	

معدل حجوم خزانات المراحيض= (٧٣٢)/٦١
= ١٢ لتر/الدفقة
كمية استهلاك المياه السنوية من المراحيض بدون تركيب قطع الترشيد
الإستهلاك = (حجم الخزان)*(عدد المستخدمين)*(مرات الإستخدام)*(الأيام)
= {(١٢)*(٢٠٠٠)*(١)*(٢٦٠)}/١٠٠٠
= ٦٢٤٠ م^{٣}
التوفير= (حجم الخزان-الحجم المثالي)*(عدد المستخدمين)*(مرات الإستخدام)*(الأيام)
={(١٢-٦)*(٢٠٠٠)*(١)*(٢٦٠)}/١٠٠٠
= ٣١٢٠م^{٣}
كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)
= (٦٢٤٠ - ٣١٢٠)
= ٣١٢٠م^{٣}
المبلغ الممكن توفيرة سنويا = (كمية الماء الموفرة*السعر)
= (٣١٢٠ م^{٣} *١,٥)
= ٤٦٨٠دينار

تم قياس معدل التدفق من جميع الدوشات و ذلك بضرب تدفق كل دوش بعدد الدوشات من نفس التدفق, و قسمة المجموع على عدد الدوشات الكلي فكان التدفق ١٥لتر/دقيقة.

	التدفقات			عدد الدوشات بنوع	
	العدد	التدفق	عدد*تدفق	حائط	يدوي
١	٢	١٥	٣٠	٢	٠
المجموع	٢		٣٠		
	التدفق الكلي = ١٥ لتر/د			العدد الكلي= ٢	

كمية استهلاك المياه السنوية من الدوشات بدون تركيب قطع الترشيد

الإستهلاك = معدل التدفق*عدد المستخدمين*عدد مرات الإستخدام*عدد أيام الدولم*فترة الإستعمال

= {(١٥)*(١٠)*(١)*(٢٦٠)*(١٠)}/١٠٠٠

= ٣٩٠م٣

التوفير في المياة = (التدفق الحالي-الإفتراضي)*(عدد المستخدمين)*(مرات الإستخدام)*(فترة الإستخدام)*(عدد الأيام).

= {(١٥-٩)*(١٠)*(١)*(١٠)*(٢٦٠)}/١٠٠٠

=١٥٦م٣

كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)

= (٣٩٠-١٥٦)

=٣٢٤م٣

المبلغ الممكن توفيرة سنويا = التوفير*سعر (م٣)

= ١٥٦*١,٥

= ٢٣٤ دينار

مجموع المياة الممكن توفيرها سنويا = ٥٢٧٨+٣١٢٠+١٥٦

= ٨٥٥٤م٣

المبالغ الممكن توفيرها سنويا = ٨٥٥٤*١,٥ = ١٢٨٣١دينار

كلفة تركيب القطع:

الصنف	العدد الكلي	كلفة الوحدة (دينار)	الكلفة الكلية (دينار)
المغاسل بدون تسنين	١٦١	٩	١٤٤٩
المغاسل بتسنين	٢٥	٣,٥	٨٧,٥
المراحيض	٦١	١٨	١٠٨٩
الدوشات	٢	٩	١٨
الكلفة الإجمالية			٢٦٥٢,٥
الفترة الزمنية اللازمة لاسترجاع كلفة شراء وتركيب قطع توفير المياه = ٢,٥ اشهر			

الفترة الزمنية اللازمة لاسترجاع كلفة شراء وتركيب قطع توفير المياه = (الكلفة÷ التوفير)*١٢

= (٢٦٥٢,٥÷١٢٨٣١)*١٢

=٢,٥ أشهر

يمكن حساب نسبة التوفير و ذلك بقسمة كمية التوفير على كمية الإستهلاك

نسبة التوفير= ٨٥٥٤÷١٦٩٧٨

=٥٠ %

مجلس الأعيان

صنف مجلس الأعيان بأنة من كبار مستهلكي المياة, حيث أن استهلاكة السنوي ٣٢٠٠م٣. عين السيد عصام نوغان ضابط اتصال. توجة فريق المسح المائي بتاريخ ٢٠٠١/١٢/١٥ الى موقع المجلس, و اخذت بيانات لوجستية عن المبنى من حيث عدد الموظفين و الزوار لكل يوم, للقيام بعملية حساب تقديرية لكمية المياة المستهلكة سنويا. تم قياس التدفقات من المخارج المائية و ذلك باستخدام اناء سعتة لتر و ساعة توقيت, كما اخذت اعداد و حجوم المراحيض و اعداد الدوشات و الحنفيات و انواعها من حيث شكل السن.

حسب التدفق من كل حنفية و ذلك بقسمة الرقم (٦٠) على الزمن لتعبئة التر. كما تم قياس معدل التدفق من جميع الحنفيات و ذلك بضرب تدفق كل حنفية بعدد الحنفيات من نفس التدفق, و قسمة المجموع على عدد الحنفيات الكلي. فكان معدل تدفق الحنفيات ٩لتر/دقيقة.

الطابق	تدفقات المغاسل			عدد المغاسل التي تسنينها		
	العدد	التدفق	التدفق*العدد	بدون	خارجي	داخلي
١	١٩	٩	١٧١		٩	١٠
٢	١١	٢,٩	٣٢,٩			١١
الجيش	٦	٢٠	١٢٠			٦
المجموع			٣٢٣,٩			
	التدفق = ٣٢٣,٩/٣٦ = ٩لتر/د			العدد الكلي=٣٦		

يمكن تقدير معدل الإستهلاك السنوي من المغاسل من خلال المعادلة التالية:

الإستهلاك = معدل التدفق*عدد المستخدمين*عدد مرات الإستخدام*عدد أيام الدوام*فترة الإستعمال

= {(٩)*(١٧٠)*(٣,١)*(٢٨٠)*(٠,٥)}/١٠٠٠

=٦٦٤ م٣

يمكن حساب كمية التوفير السنوية من المغاسل من المعادلة التالية:

التوفير في المياة = (التدفق الحالي-المثالي)*(عدد المستخدمين)*(مرات الإستخدام)*(فترة الإستخدام)*(عدد الأيام).

= {(٩-٦)*(١٧٠)*(٣,١)*(٠,٥)*(٢٨٠)}/١٠٠٠

= ٢٢١م٣

كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)

= (٦٦٤-٢٢١)

= (٤٤٣م٣)

المبلغ الممكن توفيرة سنويا = التوفير*سعر (م٣)

= ٢٢١*١,٥

= ٣٣٢ دينار

تم حساب معدل حجوم خزانات المراحيض بضرب عدد الخزانات من نفس الحجم بعددها, و قسمة الناتج

الطابق	اعداد المراحيض التي سعتها			اعداد المراحيض التي نوعها	
				افرنجي	عربي
	٦	٩	١٢		
١		٤	٤	٨	
٢		٤	٢	٦	
الجيش		٢			٢
المجموع		١٠	٦		
السعة*المجموع		٩٠	٧٢	عدد المراحيض=١٦	

على أعداد المراحيض.

كان معدل حجوم الخزانات المراحيض١٠,١٢٥ لتر

معدل حجوم خزانات المراحيض= (٩٠+٧٢)/١٦

= ١٠,١٢٥

كمية استهلاك المياه السنوية من المراحيض بدون تركيب قطع الترشيد

الإستهلاك = (حجم الخزان)*(عدد المستخدمين)*(مرات الإستخدام)*(الأيام)

= {(١٠,٢٨)*(١٧٠)*(٢,٥)*(٢٨٠)}/١٠٠٠

= ١٢٢٣,٣ م^{٣}

التوفير = (حجم الخزان-الحجم المثالي)*(عدد المستخدمين)*(مرات الإستخدام)*(الأيام)

= {(١٠,٢٨-٦)*(١٧٠)*(٢,٥)*(٢٨٠)}/١٠٠٠

= ٥٠٩,٣ م^{٣}

كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)

= (١٢٢٣,٣ -٥٠٩,٣)

= ٧١٤م^{٣}

المبلغ الممكن توفيرة سنويا = (كمية الماء الموفرة*السعر)

= (٥٠٩,٣ م^{٣} *١,٥)

= ٧٦٣,٩ دينار

تم قياس معدل التدفق من جميع التوشات و ذلك بضرب تدفق كل توش بعدد التوشات من نفس التدفق. و قسمة المجموع على عدد التوشات الكلي فكان التدفق ١٢لتر/دقيقة.

	التدفقات			عدد التوشات بنوع	
	العدد	التدفق	عدد*تدفق	حائط	يدوي
الجيش	٣	١٢	٣٦	٣	٠
المجموع					
	التدفق الكلي = ١٢ لتر/د			العدد الكلي= ٣	

كمية استهلاك المياه السنوية من الدوشات بدون تركيب قطع الترشيد

الإستهلاك = معدل التدفق*عدد المستخدمين*عدد مرات الإستخدام*عدد أيام الدوام*فترة الإستعمال

= {(١٢)*(٣٠)*(١)*(٣٦٥)*(٧)}/١٠٠٠

= ٩١٩,٨ م٣

التوفير في المياة = (التدفق الحالي-الإفتراضي)*(عدد المستخدمين)*(مرات الإستخدام)*(فترة الإستخدام)*(عدد الأيام).

= {(١٢-٩)*(٣٠)*(١)*(٠,٧)*(٣٦٥)}/١٠٠٠

=٢٢٩,٩ م٣

كمية الإستهلاك بعد التركيب = (الإستهلاك-التوفير)

= (٩١٩,٨-٢٢٩,٩)

=٦٨٩,٨ م٣

المبلغ الممكن توفيرة سنويا = التوفير*سعر (م٣)

= ٢٢٩,٩*١,٥

= ٣٤٥ دينار

مجموع المياة الممكن توفيرها سنويا = ٢٢١+٥٠٩,٣+٢٢٩,٩

= ٩٦٠,٢م٣

المبالغ الممكن توفيرها سنويا = ٣٣٢+٧٦٣,٩+٣٤٥

= ١٤٤٠,٩ دينار

كلفة تركيب القطع:

الصنف	العدد الكلي	كلفة الوحدة (دينار)	الكلفة الكلية (دينار)
المغاسل	٣٦	٣,٥	١٢٦
المراحيض	١٤	١٨	٢٥٢
الدوشات	٣	٩	٢٧
الكلفة الإجمالية			٤٠٥
الفترة الزمنية اللازمة لاسترجاع كلفة شراء وتركيب قطع توفير المياه = ٣ اشهر			

الفترة الزمنية اللازمة لاسترجاع كلفة شراء وتركيب قطع توفير المياه = (الكلفة÷ التوفير)*١٢

= (٤٠٥÷١٤٤٠,٩)*١٢

=٣ أشهر

يمكن حساب نسبة التوفير و ذلك بقسمة كمية التوفير على كمية الإستهلاك

نسبة التوفير= ٩٦٠,٢÷٢٨٠٧,١٤

=٣٤ %

APPENDIX F

List of Retrofitted Sites

Retrofitted Sites and Awarded RFPs

الرقم	الاسم	ID
١	مركز صحي الحسين الشامل	R
٢	مركز صحي سحاب	R
٣	مستشفى الفحيص	R
٤	مستشفى السلط	R
٥	الأميرة بسمة	R
٦	الأميرة بديعة	R
٧	صحة العقبة	Aw
٨	صحة العقبة	Aw
٩	مؤسسة الاقراض الزراعي	R
١٠	مديرية الحراج-وزارة الزراعة	R
١١	المركز الوطني للبحوث الزراعية	R
١٢	وزارة العدل / مبنى قصر العدل	Aw
١٣	وزارة التموين/ الجناح الاداري	R
١٤	مبنى مجلس الاعيان	R
١٥	مبنى مجلس النواب	R
١٦	وزارة المياة و الري	R
١٧	وزارة المياه - المختبرات المائية	R
١٨	إدارة مياه المفرق	R
١٩	إدارة مياه جرش	R
٢٠	إدارة مياه العقبة	R
٢١	مؤسسة الأسكان	R
٢٢	رئاسة الوزراء	R
٢٣	رئاسة الوزراء	R
٢٤	وزارة الثقافة – المركز الملكي	R
٢٥	وزارة المالية / شارع السلط	R
٢٦	مبنى هيئة الاوراق المالية	R
٢٧	البنك المركزي	R
٢٨	البنك المركزي	R
٢٩	الجمارك	R
٣٠	وزارة الداخلية/ المبنى الجديد	R
٣١	مديرية الطيران المدني	R
٣٢	سلطة الطيران المدني	R
٣٣	المطار المدني/ خزان المطار	R
٣٤	مطار العقبة	R
٣٥	مطار العقبة	R
٣٦	مطار العقبة	R
٣٧	امانة العاصمة /مكتبة الامانة	R
٣٨	امانة عمان / قاعة عمان	R
٣٩	امانة عمان الكبرى/ مبنى الموظفين	R
٤٠	امانة عمان- مركز الملك الحسين ب	R
٤١	امانة العاصمة – مديرية المنطقة أ	R
٤٢	امانة عمان دائرة الرقابة الغذائية	R
٤٣	امانة عمان / الوحدة الصحية	R

٤٤	م/ عبدالله الثاني بن الحسين	R
٤٥	مدينة العاب الترويحية	R
٤٦	وزارة التنمية الاجتماعية – الرعاية	R
٤٧	وزارة البريد و الاتصالات	R
٤٨	سلطة المصادر الطبيعية	R
٤٩	مستشفى الجامعة الاردنية	R
٥٠	العيادات الخارجية-مستشفى الجامعة	R
٥١	الجامعة الاردنية / سكن الدكاترة	R
٥٢	الجمعية العلمية الملكية	R
٥٣	وزارة التعليم العالي	R
٥٤	دائرة الاحصاءات العامة	R
٥٥	المركز الجغرافي	R
٥٦	وزارة الطاقة- الطاقة النووية	R
٥٧	مدينة الحسن الرياضية	R
٥٨	مدينة الحسن الرياضية	R
٥٩	مدرسة هيا بنت الحسين	R
٦٠	وزارة الأشغال العامة	R
٦١	التدريب المهني	R
٦٢	التدريب المهني	R
٦٣	التدريب المهني	R
٦٤	التدريب المهني	R
٦٥	التدريب المهني	R
٦٦	التدريب المهني	R
٦٧	أوقاف العقبة	R
٦٨	أوقاف العقبة	R
٦٩	أوقاف العقبة	R
٧٠	أوقاف العقبة	R
٧١	أوقاف العقبة	R
٧٢	المواني	R
٧٣	المواني	R
٧٤	التلفزيون	R
٧٥	التلفزيون	R
٧٦	أوقاف عمان	R
٧٧	أوقاف عمان	R
٧٨	أوقاف عمان	Aw
٧٩	أوقاف عمان	Aw
٨٠	أوقاف عمان	Aw
٨١	أوقاف عمان	Aw
٨٢	أوقاف عمان	Aw
٨٣	أوقاف عمان	Aw
٨٤	أوقاف عمان	Aw
٨٥	أوقاف عمان	Aw
	٣١ مدرسة	RFP

APPENDIX G

Modified Audit Form

وزارة المياه و الري

مشروع الكفاءة المائية و التوعية

WEPIA

تدقيق مائي للمدارس

معلومات الموقع

مدرسة---------- عمر البناء----------

العنوان---------- عدد الطوابق----------

المنطقة---------- عدد الطلاب----------

المحافظة---------- عدد المعلمين----------

هاتف---------- عدد العمال----------

المدير---------- عدد الزوار----------

ضابط الاتصال---------- عدد ايام الاستخدام السنوي----------

الاستهلاكات و الخزانات

كمية المياه المستهلكة في الدوره---------- م^3 عدد خزانات المياه----------

مجموع الاستهلاك السنوي---------- م^3 سعة خزان المياه---------- م^3

الاستهلاك السنوي بواسطة الصهاريج---------- م^3 مجموع سعة الخزانات---------- م^3

بئر ماء -------- عدد الأبار -------- سعة بئر الماء---------- م^3 مجموع سعة الأبار---------- م^3

الري

ما هو مصدر مياه الري؟---------- ما هي طريقة الري؟---------- مساحة الحديقة المروية---------- م^2

الفصول التي يتم فيها ري الحديقة؟----------

كم مرة يتم ري الحديقة في الاسبوع؟---------- ولكم ساعة يتم ري الحديقة في كل مرة؟----------

كمية المياه المستعملة في كل سقاية---------- م^3 هل يوجد نظام حصاد مائي أو تدوير مياه في الموقع؟----------

معلومات المدقق

اسم المدقق---------- المؤسسة----------

العنوان---------- هاتف/فاكس----------

التاريخ---------- رقم التدقيق----------

الأعداد و الاستخدامات

حنفيات
عدد مستخدمين الحنفيات----------
معدل مرات الاستخدام اليومي للفرد----------
معدل فترة الاستخدام لكل مرة (دقيقة)----------
معدل التدفق (لتر/دقيقة)----------
دورات المياه
عدد مستخدمين المراحيض----------
معدل مرات الاستخدام اليومي للفرد---------
معدل سعة خزان المرحاض (لتر)---------
الدوشات
عدد مستخدمين الدوشات----------
معدل مرات الاستخدام اليومي للفرد----------
معدل فترة الاستخدام لكل مرة (دقيقة)----------
معدل التدفق (لتر/دقيقة)----------
المختبرات
عدد المختبرات----------
عدد الحصص لكل مختبر يوميا----------
عدد مستخدمين المختبر لكل حصة---------
معدل مرات الاستخدام في الحصة للفرد---
معدل فترة الاستخدام لكل مرة (دقيقة)-----
معدل التدفق (لتر/دقيقة)----------
المصلين
عدد المتوضئين----------
معدل مرات الوضوء اليومي خلال الدوام للفرد----------
معدل الفترة التي تستخدم فيها الحنفية لكل وضوء (دقيقة)----------

الأعداد

عدد الحنفيات غير المسننة----------
عدد الحنفيات المسننة----------
عدد الحنفيت المسننة داخليا----------
عدد الحنفيات كاملة----------
عدد المراحيض مع خزان كاملة----------
عدد الدوشات كاملة----------
عدد حنفيات المختبرات كاملة----------