PN ADC-291

Training Course On

Conducting Water Audits for Large Consumers

Technical Summary Report

Submitted To:

Water Efficiency and Public Information for Action
(WEPIA)

Prepared By:

International Research Corporation
April, 2001

Amman-Jordan

TABLE OF CONTENTS

INTRODUCTION 1

METHODOLOGY 5

AUDIT RESULTS 8

WATER SAVING CALCULATIONS 16

APPENDIX 30

LIST OF TABLE

Title	Page
Table 1. Sinks/Faucets at the Philadelphia Hotel	8
Table 2. Toilets at the Philadelphia Hotel	8
Table 3. Showers at the Philadelphia Hotel	9
Table 4. Sinks/Faucets at the RACJ	9
Table 5. Toilets at the RACJ	10
Table 6. Showers at the RACJ	10
Table 7. Urinals at the RACJ	10
Table 8. Sinks/Faucets at the NRA	11
Table 9. Toilets at the NRA	12
Table 10. Urinals at the NRA	12
Table 11. Faucet Usage Behavioral Assumptions at the Philadelphia Hospital	17
Table 12. Toilet Usage Behavioral Assumptions at the Philadelphia Hospital	19
Table 13. Shower Usage Behavioral Assumptions at the Philadelphia Hospital	20
Table 14. Behavioral Assumptions at the RACJ Main Buildings	22
Table 15. Behavioral Assumptions at the RACJ Driver Training Center	24
Table 16. Behavioral Assumptions at the NRA	25
Table 17. Cash Flow Analysis for the Philadelphia Hospital	27
Table 18. Cash Flow Analysis for the RACJ	28
Table 19. Cash Flow Analysis for the NRA	29

Chapter 1

INTRODUCTION

1.1 OVERVIEW:

One of WEPIA's missions in Jordan is to promote awareness among Jordanians as to the scarcity of water resources and to familiarize them with the Best Management Practices in water conservation. One of the BMP's recommended by WEPIA is the utilization of Water Saving Devices (WSD's) by homeowners and large water consumers. Previous studies have proven "Water Audits" to be one of the most effective tools in promoting the use of WSD's. As a result, WEPIA has conducted a series of training courses to familiarize Jordanians with "Water Audits". Throughout its efforts, WEPIA has been very successful in training individuals from different sectors and different age groups.

1.2 WATER AUDITS:

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 flowrates. Once a complete inventory of the water fixtures is obtained, and all the leakage locations (if any) are identified, 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). Having conducted 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 are converted into their equivalent monetary value according to the local water tariff. Simple cash flow analysis can 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.

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, in order to promote WSD's to the highest levels possible, it is necessary to train as many individuals as possible to conduct water audits. The report at hand summarizes the results for a training course administerd by WEPIA and conducted by the International Research Corporation, a multidiciplinary Jordanian consulting firm with advanced expertise in the area of water resources and conservation. The target group for this particular training course was governmental employees from the Ministries of Water and Irrigation, Education, and Health. The participants were from various governerates and were all involved in water consumption at their respective places of work. The

course was held at the Royal Automobile Club of Jordan in Amman during the period of April 16th to 19th, 2001.

1.3 OBJECTIVE:

The main objective of the training course was to promote the use of WSD's by large consumers through the training of 20+ individuals to conduct water audits and perform all the necessary water consumptions/savings calculations Specific objectives for the training course included

1. Conducting detailed water audits for three large water consumers in the Greater Amman Municipality.

2. Introduce 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. Give 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.

1.4 STUDY SITES

As part of the course's curriculum, detailed water audits were conducted for the following buildings:

1. The Royal Automobile Club of Jordan

2. The Philadelphia Hospital

3. The Natural Resources Authority

The three sites were thought to give the trainees the needed exposure to the various audit scenarios they might be faced with once their training was complete and they were ready to perform audits on their own.

1.5 REPORT OUTLINE:

The report is composed of four chapters and an appendix. The first chapter gives an overview of the nature of the training course. Chapter Two describes the methodology followed by the study team in the conduct of the course and the field data collection. Chapter Three summarizes the raw data resulting from the water audits conducted at the study sites. Chapter Four presents water saving calculations as a result of the implementation of water saving technology, the cash flow calculations for the investment, and the conclusions and recommendations. Finally, the attached appendix includes the trainees evaluation of the course, and information about the trainees

Chapter 2

METHODOLOGY

Three audits were conducted of the study sites over a period of two days The trainees were divided into three groups, each group was supervised by a trainer and the groups were assigend to different parts of the study sites. Data were collected by the trainees using data collection sheets specifically designed for water audits The following sections describe the time schedule and the work mechanism followed by the trainers to accomplish the desired objectives of the training course.

Day One:

During the first day, the trainees were introduced to the water problem in Jordan They were provided with igeneral nformation 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 flowrates for water fixtures

12. Water audit planning

13. Conducting water audits; measuring flow rates and detecting leaks

14. Compilng water audit data

15. Behavioral assumptions pertaining to water consumption

16. Water saving calculations

Day 2:

In the second day, the trainees were assigned to the different locations and successfully completed audits for the RACJ and the Philadelphia Hospital. The trainees were taugh 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

Day 3:

In the third day, the audit of the Natural Resources Authority was completed The trainees were then 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 presentation on the results of the water audit conducted for the Jordan University Hospital. Finally, the trainees were briefly introduced to the concept of energy savings as a results of utilising WSD's

Day 4:

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

Chapter 3

AUDIT RESULTS

As mentioned before, three audits were conducted of the study sites over a period of two days. The trainees were divided into three groups, each group was supervised by a trainer and the groups were assigend to different parts of the study sites. Data were collected by the trainees using data collection sheets specifically designed for water audits. Table 1 through Table 3 summarize the audit data for the Philadelphia Hospital, Table 4 through Table 7 summarize the audit data for the RACJ, and Table 8 through Table 10 summarize the audit data for the Natural Resources Authority

Table 1.
Sinks/Faucets
Philadelphia Hospital

Type	Location	Total	No. Leaking	Flow Rate L/min	Notes
Manual	Patients	20	0	6	Patients Rooms
Manual	Staff	1	0	6	Surgery
Manual	Staff	5	0	10	Kitchen
Manual	Staff	3	0	25	Kitchen
Manual	Staff	1	0	10	Contamination
Manual	General	8	0	12	Clinics/Cafeteria
Total Faucets		**38**	**Avg Flow Rate**	**9.39**	

Table 2. Toilets
Philadelphia Hospital

Type	Tank Handle	Location	Total in W.C.	No. Leaking	Tank Capacity Liters	Notes
Gravity	Top	P/S/V	24	0	7	Ground to 2nd Floors
Gravity			3	0	7	Kitchen
Gravity			1	0	7	Basement
Total Toilets			**28**	**Avg. Tank Capacity**	**7**	

Table 3. Showers

Philadelphia Hospital

Type	Location	Total	No. Leaking	Flow Rate L/min	Notes
Wall	Staff/Pat.	3	0	15	Ground Floor
Wall	Patients	28	0	11	1st to 2nd Floor
Total Showers		**28**	**Avg. Flow Rate**	**11.39**	

Table 4. Sinks/Faucets

RACJ

Type	Location	Total	No. Leaking	Flow Rate L/min	Notes
Manual	General	4	1	28.8	Training Center
Manual	General	1	0	14.4	Training Center
Manual	General	4	0	20	Training Center
Manual	Staff	1	0	20	Kitchen Training Center
Manual	Staff	1	0	28.8	Kitchen Training Center
Total Faucets		**11**	**Avg Flow Rate**	**23.5**	
Manual	General	3	0	8	Pool/Calcified
Manual	General	3	0	8	Pool/Calcified
Manual	Staff	1	0	15	Kiosk
Manual	General	2	0	8	Pool/Calcified
Manual	General	2	0	8	Pool/Calcified
Manual	General	6	0	8	Main Building
Manual	General	1	0	20	Main Building
Manual	Staff	1	0	7	Tennis Courts Buffet
Manual	General	2	0	12	Tennis Courts
Manual	General	2	0	8	Tennis Courts
Manual	General	4	0	6	French Restaurant
Manual	Staff	2	0	15	Ballroom
Manual	Staff	3	0	8	Kitchen
Manual	Staff	2	0	9	Kitchen
Manual	Staff	2	0	8	Kitchen
Manual	Staff	1	0	60	Administration
Manual	Staff	2	0	10	Administration
Manual	Staff	1	0	9	Cafeteria
Manual	General	4	0	8	Bowling
Total Faucets		**44**	**Avg Flow Rate**	**10.06**	

Table 5. Toilets

RACJ

Type	Tank Handle	Location	Total in W.C.	No. Leaking	Tank Capacity Liters	Notes
Gravity	Top	General	8	4	12	Training Center
Turkish		General	1	0	12	Training Center
Total Toilets			**9**	**Avg Tank Capacity**	**12**	
Gravity	Calibrated	Staff	1	0	6	Main Building
Turkish	Calibrated	Staff	1	0	4	Main Building
Gravity	Calibrated	General	2	0	5	French Restaurant
Gravity	Calibrated	General	4	0	5	Bowling
Gravity	Calibrated	Staff	1	0	5	Bowling
Gravity	Calibrated	General	15	0	6	Pool
Gravity	Calibrated	Staff	2	0	7	Administration
Gravity	Calibrated	General	7	0	4	Main Building
Gravity	Manual	General	4	0	12	Tennis Courts
Total Toilets			**37**	**Avg. Tank Capacity**	**6.08**	

Table 6. Showers

RACJ

Type	Location	Total	No. Leaking	Flow Rate l/min	Notes
Wall	General	7	0	11	Pools
Wall	General	4	0	10	Tennis Courts
Wall	Staff	2	0	20	Kitchen
Total Showers		**13**	**Avg. Flow Rate**	**12.07**	

Table 7. Urinals

RACJ

Type	Location	Total	No. Leaking	Flow Rate l/min or flush	Notes
Manual	General	2	0	14.4	Ground Floor Training Center
Manual	General	2	0	10	1st Floor Training Center
Total Urinals		**4**	**Average Flow Rate**	**12.2**	
Calibrated	General	9	0	4	Main Building
Calibrated		2	0	6	Pools
Calibrated		2	0	4	Bowling
Calibrated		3	0	4	Pools
Total Urinals		**16**	**Avg. Flow Rate**	**4.25**	

Table 8. Sinks/Faucets

NRA

Type	Location	Total	No. Leaking	Flow Rate L/min	Notes
Manual	General	3	0	5	Restrictor Installed
Manual	General	2	0	20	
Manual	General	1	0	20	
Manual	General	5	0	5	Restrictor Installed
Manual	General	3	0	10	
Manual	General	2	0	5	Restrictor Installed
Manual	General	1	0	28	
Manual	General	4	0	5	Restrictor Installed
Manual	General	4	0	10	
Manual	General	13	0	4	Restrictor Installed
Manual	General	1	0	15	
Manual	General	5	0	5	Restrictor Installed
Manual	General	3	0	10	
Manual	General	2	0	5	Restrictor Installed
Manual	General	5	0	5.5	Restrictor Installed
Manual	General	5	0	6	Restrictor Installed
Manual	General	2	0	15	
Manual	General	1	0	20	
Manual	General	3	0	8	Restrictor Installed
Manual	General	2	0	5	Restrictor Installed
Manual	General	2	0	20	
Manual	General	3	0	6	Restrictor Installed
Manual	General	2	0	10	
Manual	General	1	0	6	Restrictor Installed
Manual	General	1	0	5.5	Restrictor Installed
Manual	General	4	0	12	
Manual	General	3	0	10	
Manual	General	7	0	15	
Manual	General	6	0	4	Restrictor Installed
Manual	General	7	0	15	
Manual	General	6	0	4	Restrictor Installed
Manual	General	4	0	20	
Manual	General	1	0	15	
Manual	General	1	0	20	
Manual	General	1	0	7.5	Restrictor Installed
Manual	General	3	0	20	

Total Faucets **119** **Avg Flow Rate*** **14.90**

*** Average Flow Rate Calculated Using Non-Restricted Flows Only**

Table 9. Toilets

NRA

Type	Tank Handle	Location	Total in W.C.	No. Leaking	Tank Capacity Liters	Notes
Gravity	Top	General	1	0	12	
Turkish		General	2	0	9	
Turkish		General	1	0	9	
Gravity		General	1		12	
Gravity	top	General	2	1	12	
Turkish		General	1		9	
Turkish		General	6	3	9	
Gravity		General	6	3	9	
Gravity		General	3	0	15	
Turkish		General	1	0	9	
Gravity		General	2	0	9	
Turkish		General	8	0	9	
Turkish		General	8		6	
Gravity		General	3	0	6	
Turkish		General	4		6	
Gravity		General	7		6	
Total Toilets			**56**	**Avg. Tank Capacity**	**8.35**	

Table 10. Urinals

NRA

Type	Location	Total	No. Leaking	Flow Rate l/min or flush	Notes
Manual	General	14	2	4	
Manual	General	4	0	8	
Manual	General	1	0	12	
Total Urinals		**19**	**Avg. Flow Rate**	**5.25**	

3.1 DISCUSSION OF AUDIT RESULTS:

Generally, the faucet and shower flow rates and the toilet tanks' capacities at the study sites were higher than the recommended international standards. Some of the water fixtures at the study sites, however, were acceptable, according to the same standards

Therefore, comprehensive retrofits were not deemed necessary at those locations The recommended flow rates were as follows:

1. Faucets: 6 liters per minute

2. Shower heads: 9liters per minute

3. Toilet tanks: 6 liters per flush

The following setions discuss the main findings of the water audits, and presents the recommended retrofits for each site.

3.1.1 Philadelphia Hospital:

The average faucet flow rate at the hospital was 9.39 liters per minute The majority of the faucets, however, had flow rates as low as 6 liters per minute which falls within the recommended values. Such low flow rates are belived to be due to calcification rather than the use of water saving technology. Therefore, it is recommended that all the faucets at the hospital be retrofited. The shower heads also demonstrated high flow rates with an average flow rate of 11.39 liters per minute. Such high flow rates warrant the installation of water saving technology to reduce the flow in those shower heads to the recommended flow rate of 9 liters per minute. Finally, the toillet tanks had an average capacity of 7 liters per flush. Although within the acceptable range for toilet tank capacity, it is recommended that all the toilets be equipped with water saving technology to reduce the amount of water per flush. Replacement of the toilet tanks, however, is not recommended.

3.1.2 Royal Automobile Club of Jordan:

The RACJ site was divided into two separate parts; the Driving Training Center, and the Club Main Buldings. The reason for doing so was the high variablity in flow rates between the two parts. The Training Center had extremely high flow rates and toilet tank capacities. The average faucet flow rate, urnial flow rate, and toilet tank capacity were 23.5 liters per minute, 12.2 liters per second, 12 liters per flush, respectively. Those values warrant comprehensive retrofitting of water fixtures at the RACJ Driving Center

The main buildings, on the other hand, had an average faucet flow rate of 10.06 liters per minute, and an average shower flow rate of 12.07 liters per minute. The toilets and urinals were calibrated with flow rates of 6.08 liters per flush and 4.25 liters per flush, respectively. The flow rates for faucets and shower heads warrant the utilization of water saving technology, while those for toilets and urinals are within the recommended international standards. Therefore, retrofitting is only recommended for the faucets and showerheads at the RACJ's main buildings

3.1.3 Natural Resources Authority:

The average faucet flow rate at this facility was found to be 14.9 liters per minute. Several faucets at the facility has flow rates within the recommended international standards. Such low flow rates, however, is attributed to the use of restrictors. Due to the limited durability of such devices, it is recommended that they be replaced with aerators. The average toilet tank capacity was found to be 8.35 liters per flush. Water saving technology to reduce the flow rate to 6 liters per flush is recommended. Finally, the urinals had an average flow rate of 5.25 liters per flush which was believed to be

within the range of acceptable international standards. Therefore, only retrofitting of faucets and toilet tanks is recommended at the facility.

Chapter 4

WATER SAVINGS CALCULATIONS

In order to conduct water savings calculations as a result of installing water saving devices at the study sites, certain behavioral assumptions have to be made Reviews of previous studies were conducted to arrive at the most accurate assumptions describing people's behavior at the study sites. The following sections summarize the behavioral assumptions and water saving calculations for the three study sites

4.1 PHILADELPHIA HOSPITAL

Generally, there are three categories of people that use water facilities at the Hospital Those are:

1. Staff
2. Patients
3. Visitors

There are a total of 65 employees at the Hospital The "staff" was further sub-divided into three groups resulting in a total of five different groups among the hospital population. The three staff sub-groups were

- Nurses (40)
- Surgeons (5)
- Other (20)

The maximum patient capacity of the Hospital is 31. The total number of patients at any given time was approximately 65 percent of the maximum capacity which results in an average occupancy of 21 patients at any given time during the year. In addition, Hospital statistics revealed that the daily number of vistors is 5 visitors per bed, and the total number of visitors to the Out-Patient Clinics is 15 visitors per day, resulting in a total of 20 visitors per day.

Each of the groups has different water consumption behaviors according to the nature of their duties. The water saving calculations were preformed for faucets, toilets, and showers. The results are summarized below.

4.1.1 Faucets:

As mentioned before, the Hospital population was divided into five groups. Table 11 summarizes the behavioral assumptions pertaining to each group.

Table 11. Faucet Usage Behavioral Assumptions

Group	Total	Frequency of Faucet Use per Day	Duration per Use (sec)
Nurses	40	10	30
Surgeons	5	12	30
Staff	20	3	30
Patients	21	3	120
Visitors*	6	1	30

* only 30% of the total visitors were assumed to use a faucet once during their visit

Using the numbers above, the weighted average frequency of daily faucet use per employee is 8 times with a duration of 30 seconds each time the faucet is used. The frequency of daily faucet use per patient is 3 times with a frequency of 2 minutes. Finally, the frequency of daily faucet use per visitor is once with a frequency of 30 seconds. Since the average flow per faucet is 9.39 liters per minute, the installation of an aerator that reduces flow to 6 liters per minute is expected to save the following amounts of water:

$$\text{Staff} = \frac{65 \text{ employees} \times (9.39 - 6 \text{ liters/minute}) \times (365 \text{ days/year}) \times (8 \text{ uses/day}) \times (0.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 321.7 \text{ m}^3$ of water saved per year

$$\text{Patients} = \frac{21 \text{ patients} \times (9.39 - 6 \text{ liters/minute}) \times (365 \text{ days/year}) \times (3 \text{ uses/day}) \times (2 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 155.9 \text{ m}^3$ of water saved per year

$$\text{Visitors} = \frac{6 \text{ visitors} \times (9.39 - 6 \text{ liters/minute}) \times (365 \text{ days/year}) \times (1 \text{ use/day}) \times (0.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 3.71 \text{ m}^3$ of water saved per year

Therefore, the total water savings anticipated from installing faucet aerators is

$= 321.7 + 155.9 + 3.71 \qquad = 481.31 \text{ m}^3$ of water saved per year

4.1.2 Toilets

As mentioned before, the Hospital population was divided into five groups. Table 12 summarizes the toilet usage behavioral assumptions pertaining to each group.

Table 12. Toilet Usage Behavioral Assumptions

Group	Total	Frequency of Toilet Use per Day
Nurses	40	1
Surgeons	5	1
Staff	20	1
Patients	21	3
Visitors*	6	1

* only 20% of the total visitors were assumed to use a faucet once during their visit

Using the numbers above, the weighted average frequency of daily toilet use per employee is one time for nurses, surgeons, staff, and visitors. The frequency of daily toilet use per patient is 3 times. Since the average flow per flush is 7 liters, the installation of water saving technology reduces flow to 6 liters per flush which is expected to save the following amounts of water:

$$\text{Staff} = \frac{65 \text{ employees} \times (7 - 6 \text{ liters/flush}) \times (365 \text{ days/year}) \times (1 \text{ use/day})}{1000 \text{ liters/m}^3}$$

$$= 23.73 \text{ m}^3 \text{ of water saved per year}$$

$$\text{Patients} = \frac{21 \text{ patients} \times (7 - 6 \text{ liters/flush}) \times (365 \text{ days/year}) \times (3 \text{ uses/day})}{1000 \text{ liters/m}^3}$$

$= 23 \text{ m}^3$ of water saved per year

$$\text{Visitors} = \frac{6 \text{ visitors} \times (7 - 6 \text{ liters/flush}) \times (365 \text{ days/year}) \times (1 \text{ use/day})}{1000 \text{ liters/m}^3}$$

$= 2.19 \text{ m}^3$ of water saved per year

Therefore, the total water savings anticipated from installing new water saving toilets is

$= 23.73 + 23.00 + 2.19 \qquad = 48.92 \text{ m}^3$ of water saved per year

4.1.3 Showers:

Table 13 summarizes the shower usage behavioral assumptions pertaining to each group in the Hospital population.

Table 13. Shower Usage Behavioral Assumptions

Group	Total	Frequency of Shower Use per Day	Duration per Use (min)
Nurses	40	1	7
Surgeons	0	0	0
Staff	0	0	0
Patients	21	0.2	8.5
Visitors	0	0	0

The analysis indicated that the average flow per showerhead is 11.39 liters per minute, with daily usage frequencies of 1 time per day for nurses, and 1 time every five days for each patient, with durations of 7 minutes and 8.5 minutes, respectively. The installation of a water saving shower head that reduces flow to 9 liters per minute is expected to save the following amounts of water:

$$\text{Staff} = \frac{40 \text{ employees} \times (11.39 - 9 \text{ liters/minute}) \times (365 \text{ days/year}) \times (1 \text{ use/day}) \times (7 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 244.2 \text{ m}^3$ of water saved per year

$$\text{Patients} = \frac{21 \text{ patients} \times (11.39 - 9 \text{ liters/minute}) \times (365 \text{ days/year}) \times (0.2 \text{ use/day}) \times (8.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 155.7 \text{ m}^3$ of water saved per year

Therefore, the total water savings anticipated from installing new showerheads is

$= 244.2 + 155.7 \qquad = 399.9 \text{ m}^3$ of water saved per year

As a result of the proceeding calculations, the total anticipated water savings as a result of retrofitting faucets, toilets, and showerheads at the Hospital is estimated at 930 m^3 of water per year. Considering the Hospital's annual water consumption of approximately (2,300 m^3), such savings account for approximately 40%. According to the Ministry of Water and Irrigation's tariff, such savings are estimated at JOD 1,395 per year.

4.2 RACJ

As mentioned before, the RACJ was divided into two parts due to the high variability in flow rates and the nature of the services between the Driving Training Center and the

remaining parts of the Club. Generally, there are two categories of people that use water facilities at the both parts of the club, staff and visitors. Therefore, water saving calculations were conducted for each part separately.

4.2.1 Club Main Buildings

Two groups of people using water fixtures were identified, staff, and club members/visitors. The number of employees varies throughout the year, however, there are a total of 80 permanent and 50 temporary employees at the Club. The additional temporary help is utilized during the summer season for a period of four months. The resulting average daily number of employees on any given day is 95 employees. Assuming an employee attendance rate of 90%, this would result in nearly 85 employees. Similarly, the average number of daily visitors varies throughout the year and is estimated at 1000 visitors per day during the summer season, and 200 visitors per day throughout the remainder of the year. The resulting average daily number of visitors on any given day is 460 visitors. According to the audit results, retrofitting was only recommended for faucets and showerheads. Table 14 summarizes the behavioral assumptions pertaining to the use of those fixtures throughout the year by the entire club population.

Table 14. Behavioral Assumptions for the RACJ Main Buildings

Fixture	Frequency of Use per Day	Duration per Use (sec)
Faucets	3	30
Showerheads	0.2	210

The installation of water saving technologies is expected to reduce the flow rates from 10.06 liters per minute to 6 liters per minute for faucets, and from 12.07 liters per minute to 9 liters per flush for showerheads. The total savings can be calculated as follows

$$\text{Faucets} = \frac{554 \text{ people} \times (10.06 - 6 \text{ liters/minute}) \times (365 \text{ days/year}) \times (3 \text{ uses/day}) \times (0.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 1{,}231.5 \text{ m}^3$ of water saved per year

$$\text{Showerheads} = \frac{554 \text{ people} \times (12.07 - 9 \text{ liters/minute}) \times (365 \text{ days/year}) \times (0.2 \text{ uses/day}) \times (7 \text{ minutes/use})}{1000 \text{ liters/m}^3}$$

$= 869.1 \text{ m}^3$ of water saved per year

Thus, the anticipated water savings as a result of retrofitting faucets and showerheads at the RACJ main buildings is estimated at nearly 2100 m^3 of water per year

4.2.2 Driving Training Center

Two groups of people using water fixtures were identified, staff and visitors. The number of employees is 20, while the average number of visitors is 120 visitors per day. Assuming an employee attendance rate of 90%, a total nearly 18 employees per day are expected to be present at the facility. According to the audit results, retrofitting was recommended for faucets, urinals, and toilet tanks. It is assumed that 30% of the visitors use the water fixtures. Table 15 summarizes the behavioral assumptions pertaining to the use of those fixtures throughout the year by visitors and employees

Table 15. Behavioral Assumptions for the RACJ Driving Training Center

Fixture	Frequency of Use per Day	Duration per Use (sec)
Faucets	0.7	30
Urinals	0.4	10
Toilets	0.5	N/A

The installation of water saving technologies is expected to reduce the flow rates from 23.5 liters per minute to 6 liters per minute for faucets, and from 12.2 liters per minute to 6 liters per minute for urinals, and from 12 liters per flush to 6 liters per flush for toilets. The total savings can be calculated as follows

$$\text{Faucets} = \frac{138 \text{ people} \times (23.5 - 6 \text{ liters/minute}) \times (260 \text{ days/year}) \times (0.7 \text{ uses/day}) \times (0.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 219.7 \text{ m}^3$ of water saved per year

$$\text{Urinals} = \frac{138 \text{ people} \times (12.2 - 6 \text{ liters/minute}) \times (260 \text{ days/year}) \times (0.4 \text{ uses/day}) \times (0.16 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$= 151.5 \text{ m}^3$ of water saved per year

$$\text{Toilets} = \frac{138 \text{ people} \times (12 - 6 \text{ liters/flush}) \times (260 \text{ days/year}) \times (0.5 \text{ uses/day})}{1000 \text{ liters/m}^3}$$

$= 107.64 \text{ m}^3$ of water saved per year

As a result of the proceeding calculations, the anticipated water savings as a result of retrofitting faucets, urinals, and toilets at the training center is estimated at nearly 478 m^3

of water per year. The total anticipated savings at the club are estimated at nearly 2,580 m^3 per year. According to the Ministry of Water and Irrigation's tariff, such savings are estimated at JOD 3,870 per year.

4.3 NATURAL RESOURCES AUTHORITY

Here, only two types of water fixtures are recommended for retrofitting, faucets and toilet tanks. Due to the nature of services offered by the Authority, visitors' use of water fixtures was considered negligible and was therefore dropped from the analysis. As a result, only the 993 employees were considered to use water fixtures at the Authority. The frequencies for daily usage are summarized in Table 16 below. Employee attendance rate on any given day was considered to be 90% (i.e., 894 employees).

Table 16. Behavioral Assumptions For the Natural Resources Authority

Fixture	Frequency of Use per Day	Duration per Use (sec)
Faucets	3	30
Toilets	1.5	N/A

The installation of water saving technologies is expected to reduce the flow rates from 14.9 liters per minute to 6 liters per minute for faucets, and from 8.35 liters per flush to 6 liters per flush for toilets. The total savings can be calculated as follows:

$$\text{Faucets} = \frac{894 \text{ employees} \times (14.9 - 6 \text{ liters/minute}) \times (260 \text{ days/year}) \times (3 \text{ uses/day}) \times (0.5 \text{ minute/use})}{1000 \text{ liters/m}^3}$$

$$= 1{,}034 \text{ m}^3 \text{ of water saved per year}$$

$$\text{Toilets} = \frac{894 \text{ employees} \times (8.35 - 6 \text{ liters/flush}) \times (260 \text{ days/year}) \times (1.5 \text{ uses/day})}{1000 \text{ liters/m}^3}$$

$= 819.35 \text{ m}^3$ of water saved per year

As a result of the proceeding calculations, the total anticipated water savings as a result of retrofitting faucets and toilets at the Authority is estimated at nearly 1830 m^3 of water per year. Considering the Authority's annual water consumption of approximately (4,880 m^3), such savings account for approximately 38%. According to the Ministry of Water and Irrigation's tariff, such savings are estimated at JOD 2,745 per year.

4.4 CASH FLOW ANALYSIS

4.4.1 Philadelphia Hospital

Table 17 summarizes the cash flow analysis over a period of 5 years for investing in retrofitting the water fixtures at the Hospital. The following summarizes the cost of equipment:

38 faucet aerators @ JOD 2.5 Ea.	=	JOD 95
28 toilet attachments @ JOD 18 Ea.	=	JOD 504
28 new shower heads @ JOD 9 Ea.	=	JOD 252
Total equipment cost	=	*JOD 851*
Installation (10% of equipment cost)	=	JOD 85
Maintenance (5% of initial cost)	=	JOD 42
Total Annual Expenditures	=	*JOD 42*
Anticipated Savings	=	JOD 1,395

Table 17. Cash Flow Analysis for the Philadelphia Hospital

Beginning of Year	Expenditures (JOD)			Total Expenditures JOD	Saving JOD
	Equipment	Installation	O+M		
1	851	85	0	936	0
2	0	0	42	42	1,395
3	0	0	42	42	1,395
4	0	0	42	42	1,395
5	0	0	42	42	1,395
6	0	0	42	42	1,395

Using an annual interest rate of 7%, the cash flow analysis of the above amounts reveal that the Net Present Value of the investment (NPV) is approximately JOD 4,300 with a payback period of approximately 8 months, thus, indicating the feasibility of the investment.

4.4.2 RACJ

Table 18 summarizes the cash flow analysis over a period of 5 years for investing in retrofitting the water fixtures at the RACJ. The following summarizes the cost of equipment:

55 faucet aerators @ JOD 2.5 Ea	=	JOD 138
9 toilet attachments @ JOD 18 Ea =		JOD 162
13 new showerheads @ JOD 9 Ea	=	JOD 117
4 urinal attachements @ JOD 2.5 Ea	=	JOD 10
Total equipment cost	=	*JOD 527*
Installation (10% of equipment cost)	=	JOD 53
Maintenance (5% of initial cost)	=	JOD 27
Total Annual Expenditures	=	*JOD 27*
Anticipated Savings	=	JOD 3,870

Table 18. Cash Flow Analysis for the RACJ

Beginning of Year	Expenditures (JOD)			Total Expenditures JOD	Saving JOD
	Equipment	Installation	O+M		
1	527	80	0	607	0
2	0	0	27	27	3,870
3	0	0	27	27	3,870
4	0	0	27	27	3,870
5	0	0	27	27	3,870
6	0	0	27	27	3,870

Using an annual interest rate of 7%, the cash flow analysis of the above amounts reveal that the Net Present Value of the investment (NPV) is approximately JOD 14,000 with a payback period of approximately 2 months, thus, indicating the feasibility of the investment.

4.4.3 Natural Resources Authority

Table 19 summarizes the cash flow analysis over a period of 5 years for investing in retrofitting the water fixtures at the NRA. The following summarizes the cost of equipment:

119 faucet aerators @ JOD 2.5 Ea.	=	JOD 298
56 toilet attachments @ JOD 18 Ea =		JOD 1008
Total equipment cost	=	*JOD 1,306*
Installation (10% of equipment cost)	=	JOD 130
Maintenance (5% of initial cost)	=	JOD 65
Total Annual Expenditures	=	*JOD 65*
Anticipated Savings	=	JOD 2,745

Table 19. Cash Flow Analysis for the NRA

Beginning of Year	Expenditures (JOD)			Total Expenditures JOD	Saving JOD
	Equipment	Installation	O+M		
1	1,306	130	0	1436	0
2	0	0	65	65	2,745
3	0	0	65	65	2,745
4	0	0	65	65	2,745
5	0	0	65	65	2,745
6	0	0	65	65	2,745

Using an annual interest rate of 7%, the cash flow analysis of the above amounts reveal that the Net Present Value of the investment (NPV) is approximately JOD 8,900 with a payback period of approximately 6 months, thus, indicating the feasibility of the investment.

4.5 CONCLUSIONS AND RECOMMENDATIONS

As can be seen in the previous section, the investment in retrofitting the various water fixtures at all the study sites is very feasible The investment payback period is estimated at less that one year for the three sites The study team highly recommends that the sites' administrations seriously consider the retrofitting process Additional recommendations include conducting detailed behavioral observational studies to validate the behavioral assumptions made in this study, and conduct further analysis on the anticipated energy savings as a result of the retrofitting process

APPENDIX

PARTICIPANT FEEDBACK AND EVALUATION:

The general feedback from the participants was very positive in terms of them comprehending and absorbing principles of "Water Audits" and all the necessary water consumption/saving calculations and measuring the financial feasibility of WSD's as a result of the retrofitting process. Additional feedback from the participants included

1. Recommendations to expand in the sections of the training course pertaining to energy savings calculations as a result of the retrofitting process

2. Holding courses closer to their employment locations

3. Conducting similar workshops for a wider variety of governmental agencies

4. Making arrangements for transportation to and from the course location

5. Arranging site visits for the largest consumers identified by the WEPIA study team.

6. Training on the installation of WSD's, and involvement in retrofitting projects

7. Further utilization of the media to convey the message.

PARTICIPANTS:

Name	Affiliation	Address	Telephone
Bilal Abdul Qader	MOH	Ramtha	02 7383089
Atef Ali Abassi	MOH	North Shuna Manshya	02 6587319
Sultan Ali Abdullah	MOH	Ibn Obayda Hospital Mashare'	02 6563120
Rafee' Musa	MOH	Princess Raya Hospital Deir Abi Saeed	02 6521666
Hayel Hussein Sgoor	MOH	Math Ibn Jabal Hospital Mashare'	02 6587911
Mohammed Barakat	MOH	Princess Badeea Hospital Husn	02 7101662
Khlaif Al-Tal	MOH	Princess Rahama Hospital Irbid	02 701985
Abdul Majeed Shbool	MOH	Ramtha	02 7383114
Bilal Shannaa'	MOH	Ramtha Hospital Ramtha	02 7383458
Ibraheem Alqam	MOWI	WAJ Amman	06 5680100
Jihad Al-Shareef	MOWI	WAJ Amman	06 5680100
Tawfiq Manaseer	MOWI	WAJ Amman	06 5680100
Shibli Abdullah Mustafa	MOH	Bani Kinanah Health Directorate Irbid	079 937382
Ali Arabiyat	MOWI	Balqa Water Diretorate Balqa	05 3551448
Walid Wishah	MOWI	Balqa Water Diretorate Balqa	05 3551448
Issa Abu Zir	MOWI	WAJ Amman	05 3244268
Ahmed Kharabsheh	MOEd	Amman	06 5607181
Faris Francais	NRA	Natural Resources Authority Amman	06 5825519
Sameh Al-Naber	MOEd	Amman	06 5607181
Fathi Abdul Qader	MOWI	WAJ Zarqa	03 3986499
Issam Hamarsheh	MOWI	WAJ Zarqa	03 3986499