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IDARA (INSTITUTING WATER DEMAND MANAGEMENT IN JORDAN)

Task 1.4- Perform End Use Analysis

Deliverable 2 – End Use Analysis for Large Consumers – Governmental Office Buildings Water Audit Report.

Final Submitted – October 2011

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DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

IDARA – Water Audits for Large Consumers – Governmental Office Buildings

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1. Background

Jordan is the fourth water poorest country on earth. Demand for water already exceeds Jordan's available water resources. Annual per capita water availability has declined from 3600 cubic meters per year in 1946 to around 145 cubic meters per year in 2008. Water demand is currently estimated at around 1530 MCM versus 870 MCM of water resources. The demand is projected to increase to around 1670 MCM by 2022. The high water shortage has caused a drastic over-abstraction of the groundwater aquifers that are pumped at two folds the safe yield. On the other hand, Jordan's stability, tourism attraction, quality of business and health services make it as a prime regional hub for investment. This challenging situation provides a great opportunity for the introduction of the most effective water demand management tools.

Water Demand Management in Jordan started from the bottom of the pyramid concentrating on educating and convincing the public about the need and benefits of water efficiency, then moved up to work with the institutions to develop water demand management policies, institutionalizing WDM; developing standards, codes and regulations; introducing technologies and Best Management Practices. Water Audits are one of the tools and Best Management Practices that determine water use patterns for the various consumer categories, and identify water saving opportunities.

Within the scope of Activity 1, "Institutional Capacity for Water Demand Management", IDARA profiled large Institutional and Commercial categories in Amman (Figure 1) and recommended five of them for water audits and end use analysis. These IC categories are health facilities, government office buildings, Schools and Universities, Hotels and Mosques. This report presents end use analysis for twelve office buildings with details about the methodology and approach, assumptions, water use evaluation for each of the audited hospitals, conclusions and recommendations.

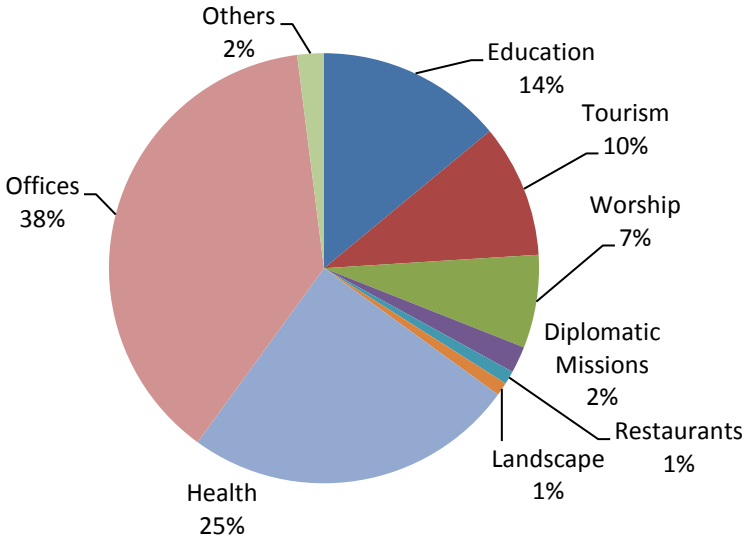

Figure 1: Institutional and commercial billed consumption by Category.

2. Objective

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The main objectives of the end use analysis are summarized below:

1. Establish water use patterns in each of the selected facilities.
2. Determine opportunities to reduce water use.
3. Quantify potential savings as a result of adoption of water use efficiency measures.
4. Establish cost and payback for potential measures.
5. Establish Water Use Baseline to obtain realistic estimates of future water demands.

3. Approach and Methodology

3.1 Overall Methodology

The types of water use in an office building generally fall in three categories, Domestic, cleaning and landscape.

The information gathered from the audited office buildings was tabulated and imputed into a "water model" developed by Water Management, Inc. The "model" is a series of excel spreadsheets that are linked together. The calculations for each facility are based on data gathered from the site audits and from engineering calculations. In very broad terms, indoor water use is based on population and flow rates of fixtures and flush volumes of toilets; and irrigation use is based on the surface area being irrigated, the evapotranspiration rate for the area, and type of plants.

Performing an audit of water use within an office building requires a number of estimates, based on the site visits and the interviews with the staff, below are the steps followed for each of the audits:

1. Complete an initial survey form prior to the site visit (See Appendix A for a copy of the audit form),
2. Conduct site visit interviews with staff to confirm the information in the survey form and to obtain additional data on levels of activity in individual departments,
3. Collect water use information from both metered use and water purchased from tank trucks, if any.
4. Make measurements and set assumptions prior to site visits.
5. Follow-up questions at the end of the site visit.
6. Input data gathered including water use information and fixture counts into the water model.

3.2 Data Collection

3.3 Flow Measurement Collection

Plumbing Fixtures: During the walkthrough, representative samples of faucets, trigger sprays, and bidets were chosen for measurement. The "Bucket and Stop Watch" method was used to gather this data. Faucet and showerhead flow rates were measured using a calibrated flow bag. Faucets flow rates were taken by turning the valve a quarter turn. The auditor collects water for five seconds and then notes the water level in the bag which corresponds to the calibration on the bag in liters per minute (lpm).

The vast majority of the toilet fixtures in the audited offices are "Turkish" style, which means they have no tank or button-actuated water delivery system. Instead, users must fill a small bucket (usually 2 liters in volume) and manually clear waste from the floor basin and drain. This water is also used for personal hygiene in place of toilet paper. As such, there is no pre-set "flush volume" related to these fixtures. In order to calculate the water consumed in toilet "flushing" the following information was required, Quantity of water required for clearing solid and liquid waste, whether the user would "flush" the toilet after every use, and how much water is used to wash the basin after evacuation. The measurement of water use in toilets was done either by using a T-5 measuring device that measures actual volume of water flushed or by examining the tank size and observing the actual flush. Where tanks were not accessible or flush valves were used, the volume was estimated based on the make and model of the toilet. Again, a representative sampling of toilets was measured.

Irrigation: - The irrigation water use estimation was based on local evapotranspiration and rainfall data, vegetation type (shrubs, grass, and trees) and planted area.

Cleaning: A conservative standard is proposed to calculate cleaning water in the audited facilities. Cleaning water was estimated at 0.125 liters per square meter per week. For Turkish toilet cleaning the same number was assumed in daily basis, and for gravity type toilets two flushes per day were allotted for cleaning.

3.4 Auditing Equipment

Following are the auditing equipment used to conduct indoor water use audits:

1. Graduated Cylinder
2. Portable timing device
3. Tape Measure
4. T-5 device to measure flush volumes
5. Other equipment as needed

Figure 2: Flow bag used for measurement

Figure 3: T-5 device to Measure the Toilet Flush Volume.

Figure 4: Graduated Cylinder

Figure 5: Ultrasonic flow meter

4. Assumptions

The following assumptions were developed to calculate the water balance for the various water uses

- A staff member/worker will use the restroom once every 3 hours.
- A visitor to the building will use the restroom once every 4 hours. The assumed length of visit for each visitor is 1 hour. Therefore, on average, one out of four visitors will use the toilet during their visit to the building.
- It is assumed that the toilet is flushed in some manner ranging from 50% to 90% of the time it is used by either staff or visitors. The percentage used depends on the number of Turkish toilets in the building, as it is most probable that Turkish Toilet users will void and leave without flushing.
- It is assumed that 33% of staff and visitors using the toilet will use an accompanying hose with an average flow rate of one liter per use.
- For those that use the toilet it is estimated that 95% of those users will use the lavatory faucet after a toilet use for hand washing at a rate of 10 seconds per use. Normally, this use is calculated at 6 seconds per toilet use; however, in this instance it is assumed that a small percentage of staff will use the lavatory faucets for ablution before prayer. This is averaged out and combined into the normal hand washing lavatory use
- Cleaning water is calculated at a rate of 0.125 liters per square meter daily or weekly (as indicated per audit site) for non-bathroom areas such as kitchens, non carpeted floors. Bathroom cleaning water is equal to 4 flushes where "Turkish" toilets with no tank are found and a greater amount of cleaning is required. In office settings with a predominance of tank and bowl fixtures or "Turkish" toilets with tanks, 2 flushes are used. This figure represents all water used to clean bathroom fixtures. Countertops and floor.
- Number of flushes for Urinals was assumed to be a certain percentage of the total number of flushes of toilets at the building. This percentage varies depending on what has been reported on site.

5. Water Use Evaluation

5.1 Audited Facilities

Facility 1

Facility Information

This facility extends over 2,500m^2 and was built in 2005. It has 200 employees and receives around 100 visitors per day.

Water Balance and End Use Types

This facility receives water from Miyahuna with no supplemental tanker water. The annual water consumption of the facility was estimated at 889 m^3.

The facility has no commercial kitchen, no water features, and no water-cooled cooling tower. The building does have an estimated 3 m^2 of xeric in planter boxes that is watered manually. This usage is calculated as little more than 1m^3 annually and therefore is not factored into the overall water balance. Water use for plumbing is around 91% of overall water use with water dedicated for cleaning purposes taking the other 9%.

Domestically, the buildings public bathrooms have "Turkish" tanks and one gravity tank toilet. "Turkish" style tanks are operational and many "Turkish" stalls are equipped with a spigot and bucket. Actual average flow rates for tanks exceed 9 lpf. However, a usage with an average flush rate of 7.0 lpf for all tank-operated fixtures is assumed to attempt to account for spigot-users. It is noticed that different flushing mechanisms exist inside the tanks, both ball float valves and tower float valves. All were adjustable, allowing for a variety of flush volumes. The men's room also had compression valve urinals that deliver 0.5 lpm at one-half turn.

The lavatory faucets at the building had an average flow rate of 6.0 lpm. Very few faucets had even strainers or flow restrictors and many faucets were unable to fit a flow restriction device.

Two flushes were allotted per fixture for bathroom cleaning, as the predominance of toilet fixtures deliver water with a tank. While the overall building space is 2,500 m^2, it is suggested that approximately 1,000m^2 is the area cleaned with a mop or hose weekly. The results of the end use water balance are illustrated in the Table below.

Table 1: End uses of water for facility 1

Facility 1		
Types	**Avg. %**	**m^3/year**
Toilets	80%	709
Urinals & Bidets	4%	39
Faucets (Kit and Lav)	7%	59
Cleaning	9%	81
Total		**889**

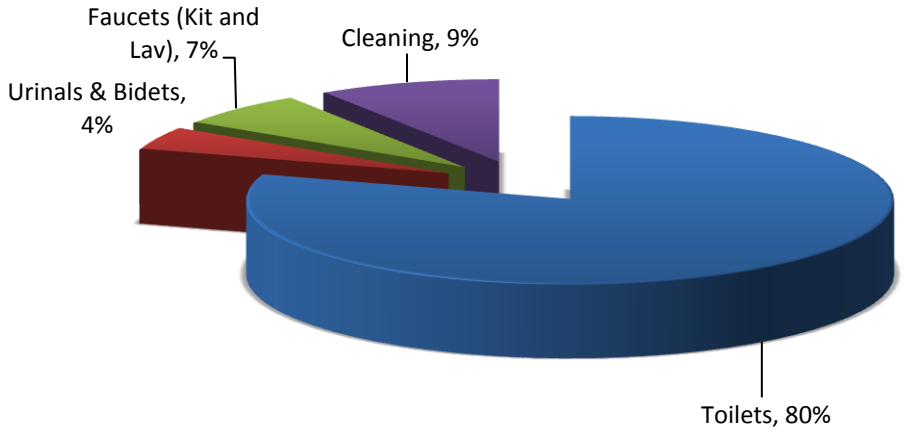

Figure 6: Water use percentages for facility 1

Recommended Measures

Toilets

Toilets consume the majority of water at the facility. The existing flush tanks with a flush volume of 9 lpf should be retrofitted with 6.0 lpf fixed-volume flush mechanisms that prevent an end-user or maintenance worker from adjusting the amount of water delivered. The facility could choose to replace the entire fixture (tank for "Turkish" or tank and bowl) or swap out the adjustable ball/tower float in the existing tank for a fixed-volume tower float. To further reduce consumption the facility manager should consider installing dual flush toilets (3l/6l) that operate at an average of 4.0 lpf.

Savings related to this measure are difficult to calculate because behavior regarding this water use is not easily identified. As stated above, the end user could opt to use part of or the entire 2 liter bucket to flush the "Turkish" toilet instead of flushing the 8-10 lpf tanks. Were all fixtures operated by tank flushing alone, savings would be much easier to calculate.

Lavatory Faucets

Faucet flow rates are higher than necessary and the facility could reap savings by retrofitting lavatory faucets with pressure-compensating flow controls of 4.5 lpm.

Urinals

The urinals on the ground floor men's room are likely not used with the same frequency as the tank-less "Turkish" fixtures. However, the possibility for leakage related to the compression nature of the valve operating the urinal makes retrofitting those fixtures a necessity. The user actuates the urinal much like a faucet, turning it on to flush for a desired length of time, then turning it off. Not closing any or all of the 8 valves could result in significant water loss over time.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	709
Bidet consumption per year	39
Lavatory consumption per year	59
TOTAL DOMESTIC CONSUMPTION	807

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	396
Bidet consumption per year	39
Lavatory consumption per year	44
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	479

Based on the above calculations, if the facility implements the recommended domestic measures it will reduce consumption by 328 m^3 per year, which is equivalent to an annual saving of 37% of the total water use.

Facility 2

Facility Information

The facility extends over 1,800 m^2 and was built in 1965. It has approximately 300 employees and receives around 80 visitors per day. In November and December the facility remains open until 11pm. One hour has been added to the average daily work shift to account for this instance.

Water Balance and End Use Types

The facility receives the majority of its water from Miyahuna and the rest (240m^3/year) in supplemental tanker. The total annual water consumption was estimated at 3,430 m^3.

The facility has no commercial kitchen, no water features, and no water-cooled cooling tower. Water use for plumbing represents 93% of total use; the remaining is used for cleaning purposes (6%) and treatment via reverse osmosis (1%). It is assumed that the RO units produce 20 liters per day of treated water and reject 60 liters per day.

The buildings public bathrooms have a mixture of "Turkish" tank and gravity tank toilets. "Turkish" style tanks are operational and many "Turkish" stalls are equipped with a spigot and bucket. Actual average flow rates for tanks exceed 9 lpf. Because nearly 70% of the building's toilets are "Turkish", usage is calculated to be of an average flush rate of 6.0 lpf for all tank-operated fixtures to account for spigot-users. There are different flushing mechanisms inside the tanks, both ball float valves and tower float valves. All were adjustable, allowing for a variety of flush volumes.

The lavatory faucets at the building had flow rates of 6.5 lpm. Many faucets had low flows, despite not having flow restriction devices. Flow rates observed were ranging from 2.8 lpm to 11.4 lpm. Disparities in building pressure likely account for this wide range. For this reason, it is important that the facility retrofits its faucets with pressure compensating faucet ends to prevent users from receiving trickling streams of water from some inadequately pressurized faucets.

Two flushes per fixture were allotted for bathroom cleaning, as the predominance of toilet fixtures deliver water with a tank, while the overall building space is 2,500 m^2. It is estimated that approximately 800 m^2 is the area cleaned with a mop or hose weekly. The results of the end use water balance are illustrated in the Table below.

Table 2: End uses of water at facility 2

Facility 2		
Types	**Avg. %**	**m^3/year**
Toilets	61%	2,095
Urinals & Bidets	5%	175
Faucets (Kit and Lav)	26%	902
Cleaning	6%	220
RO/Filtration	1%	21
Total		3,413

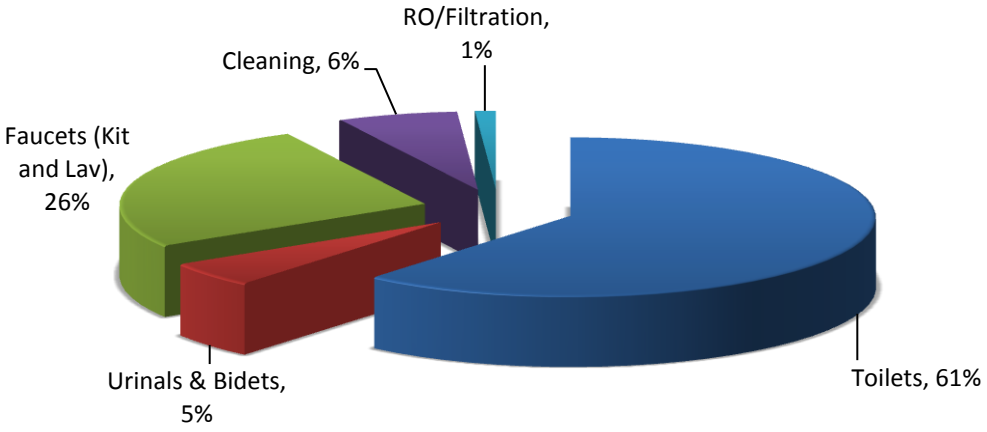

Figure 7: Water use percentages at facility 2

Recommended Measures

Toilets

Toilets consume the vast majority of water at the facility. The facility can surely improve on the average 9.5 lpf rate of tank toilet fixtures. These tanks should be retrofitted with 6.0 lpf fixed-volume flush mechanisms that prevent an end-user or maintenance worker from adjusting the amount of water delivered. The facility manager could choose to replace the entire fixture (tank for "Turkish" or tank and bowl) or swap out the adjustable ball/tower float in the existing tank for a fixed-volume tower float. To further reduce consumption the facility manager should consider installing dual flush toilets (3l/6l) that operate at an average of 4.0 lpf.

Lavatory Faucets

Faucet flow rates are higher than necessary and the facility could reap substantial savings by retrofitting lavatory faucets with pressure-compensating flow controls. Lavatory faucets should be retrofitted to 4.5 lpm or less, on average, cutting over 30% of the faucets use.

Reverse Osmosis Reject Re-Use

The existing 1:3 RO units should be replaced by 1:1 RO units where production water volume is equal to reject volume. The two units will produce 20 liters and reject 20 liters/day. This will result in saving 40 liters/day which is is equivalent to around 50% saving of total RO water use, nearly 15 m^3 a year. The reject water could be reused to water plants or clean floors/bathrooms.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	2,095
Bidet consumption per year	175
Lavatory consumption per year	902
TOTAL DOMESTIC CONSUMPTION	3,172

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	1,676
Bidet consumption per year	175
Lavatory consumption per year	624
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	2,475

Based on the above calculations, if the facility implements the recommended domestic measures it will reduce consumption by 697m^3 per year, which is equivalent to an annual saving of 20% of the total water use.

Facility 3

Facility Information

The facility extends over 2,870 m^2 and was built in 1970. Approximately 160 employees and receives around 250 visitors per day.

Water Balance and End Use Types

The facility receives water from Miyahuna and "occasionally" buys between 7-12 m^3 of tanker water. Using the information obtained during the audit, if it is assumed that the facility receives 10 m^3 from tankers every other week, this additional 260 m^3 of tanker water brings the total water use to 1,328 m^3. Water is stored in a 24 m^3 underground tank and eight 2 m^3 rooftop tanks.
The building has no commercial kitchen, no water features, and no water-cooled cooling tower. Water use for plumbing is 92% of overall water use. The rest of the water (8%) is dedicated for cleaning.

The building's public bathrooms have a mixture of "Turkish" tank and gravity tank toilets. "Turkish" style tanks are operational and many "Turkish" stalls are equipped with a spigot and bucket. Actual average flow rates for tanks exceed 7.5 lpf. However, the usage rate is calculated with an average flush rate of 7.0 lpf for all tank-operated fixtures to account for spigot-users. Different flushing mechanisms inside the tanks were noticed; both ball float valves and tower float valves. All were adjustable, allowing for a variety of flush volumes.

The lavatory faucets at the building had flow rates of 8.8 lpm. This average flow rate far surpasses recommended rates of 4.5 lpm. While many units had aerator, the internal restriction or filtration components were missing contributing to higher per unit flow rates. The building also had one shower stall that used 5 lpm. No water usage is attributed to this fixture as staff reported only sporadic use.

Two flushes per fixture were allotted for bathroom cleaning. While the overall building space is 2,870 m^2, it is suggested that approximately 1,000 m^2 is the area cleaned with a mop or hose weekly. The results of the end use water balance are illustrated in the Table below.

Table 3: End uses of water at facility 3

Facility 3		
Types	**Avg. %**	**m^3/year**
Toilets	71%	943
Urinals & Bidets	4%	57
Faucets (Kit and Lav)	17%	223
Cleaning	8%	105
Total		**1,328**

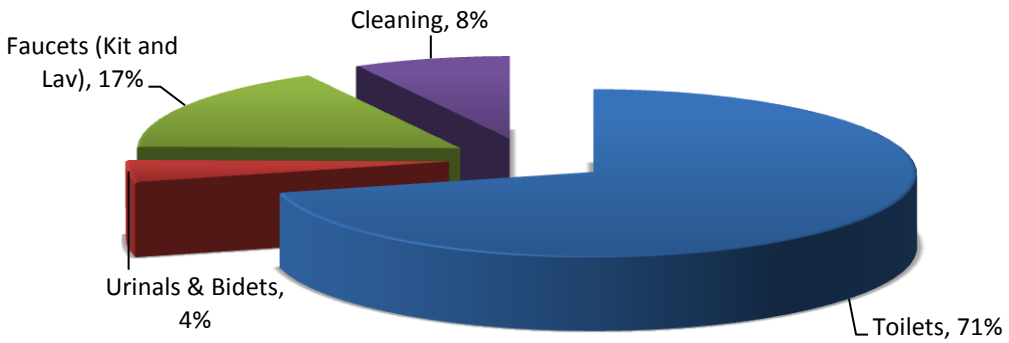

Figure 8: Water use percentages at Facility 3

Recommended Measures

Toilets

Toilets consume the vast majority of water at this facility. The existing flush tanks should be retrofitted with 6.0 lpf fixed-volume flush mechanisms that prevent an end-user or maintenance worker from adjusting the amount of water delivered. The manager could choose to replace the entire fixture (tank for "Turkish" or tank and bowl) depending on the designed flush volume of the bowl, or swap out the adjustable ball/tower float in the existing tank for a fixed-volume tower float. Savings related to this measure are difficult to calculate because behavior regarding this water use is not easily identified. As stated above, the end user could opt to use part of or the entire 2 liter bucket to flush the "Turkish" toilet instead of flushing its tank. Were all fixtures operated by tank flushing alone, savings would be much easier to calculate. To further reduce consumption the facility manager should consider installing dual flush toilets (3/6) lpf that operate at an average of 4.0 lpf.

Lavatory Faucets

Faucet flow rates are higher than necessary and the facility could reap substantial savings by retrofitting lavatory faucets with pressure-compensating flow controls. Lavatory faucets should be retrofitted to 4.5lpm on average, cutting lavatory water consumption by nearly 50%.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	943
Bidet consumption per year	57
Lavatory consumption per year	223
TOTAL DOMESTIC CONSUMPTION	1,223

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	628
Bidet consumption per year	57
Lavatory consumption per year	113
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	798

Based on the above calculations, if the facility implements the recommended domestic measures it will reduce consumption by 425 m^3 per year, which is equivalent to an annual saving of 32% of the total water use.

Facility 4

Facility Information

This facility was built in the year 2000 and extends over 7 floors each has an area of 1000 m^2. The facility has 900 employees and receives 60 visitors per day.

Water Balance and End Use Types

The facility average annual water consumption was estimated at 9,609 m^3. The building has no commercial kitchen, no water features, and no water- cooling tower. Water use for plumbing is around 93% of overall water consumption and the remaining 7% is dedicated for cleaning.

The building's public bathrooms have a mixture of "Turkish" tank and gravity tank toilets. "Turkish" style tanks are operational and many "Turkish" stall is equipped with a spigot and bucket. Actual average flow rate for tanks exceeds 7.5 lpf. However, the usage rate is calculated with an average flush rate of 7.0 lpf for all tank-operated fixtures to account for spigot-users. Around 60% of measured toilet fixtures used more than 6 lpf. Some were measured using as much as 12 lpf.

Figure 9: Flushing Mechanism for Gravity Tank Toilets

Different flushing mechanisms inside the tanks, both ball float valves and tower float valves. All were adjustable, allowing for a variety of flush volumes. Three of the toilet fixtures surveyed were found leaking.

The lavatory faucets had an average flow rate of 8.9 lpm. This average flow rate surpasses by far the recommended rate of 4.5 lpm. Many units had aerator, the internal restriction or filtration components were missing contributing to higher per unit flow rate, while others had no faucet end at all.

Some units without restrictors on the lower floors of the building were measured using 17.2 lpm (maintenance lockers), 15.1 lpm (ground floor), 12.6 lpm (4th floor men's), and 15.2 lpm (4^{th} floor women's). Several leaking faucets were observed. The faucet in the maintenance area of the building was leaking hot water at 65^oC. This is a waste of energy and a serious scalding risk for employees.

The building also has a few showers in office suites that used less than 5 lpm. Since the water use is minimal, no water usage is attributed to these fixtures. Two flushes per fixture were allotted for bathroom cleaning. While the overall building floor space is unknown, It is suggested that approximately 20,000m^2 is the area cleaned with a mop or hose weekly. The results of the end use water balance are illustrated in the Table below.

Table 4: End uses of water at facility 4

Facility 4		
Types	**Avg. %**	**m³/year**
Toilets	66%	6,347
Urinals & Bidets	3%	326
Faucets (Kit and Lav)	24%	2,291
Cleaning	7%	645
Total		**9,609**

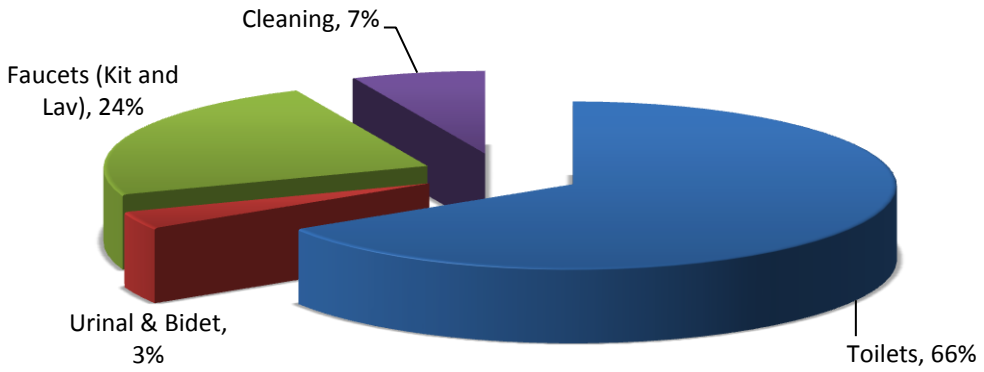

Figure 10: Water uses percentages at the facility 4

Recommended Measures

Toilets

The greatest opportunity for savings at the facility is toilet retrofit/maintenance. The facility can surely improve on the average 7.0 lpf rate of tank toilet fixtures. These tanks should be retrofitted with 6.0 lpf fixed-volume flush mechanisms that prevent an end-user or maintenance worker from adjusting the amount of water delivered. To further reduce consumption the facility manager should consider installing dual flush toilets (3/6) lpf that operate at an average of 4.0 lpf.

Furthermore, the facility needs to be under periodic preventative maintenance and leak repair. Compared to the other office buildings in the audit scope, this facility had the most audited inefficiencies. Until substantial retrofits can be performed, vigilant maintenance reducing tank volumes by manipulating float valves, faucet repair/replacement, and toilet leak repair will reduce consumption and eliminate waste.

Lavatory Faucets

Lavatory faucets should be retrofitted with 4.5 lpm or less flow controls, cutting lavatory water consumption by nearly 50%.

It is also recommended that the hot water at lavatories stays within a safe temperature range (below 50°C) to save energy and prevent injuries.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	6,347
Bidet consumption per year	326
Lavatory consumption per year	2,291
TOTAL DOMESTIC CONSUMPTION	8,964

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	3,627
Bidet consumption per year	326
Lavatory consumption per year	1,158
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	5,111

Based on the above calculations, if the facility implements the recommended domestic measures it will reduce consumption by 3,853 m^3 per year, which is equivalent to an annual saving of 40% of the total water use.

Facility 5

Facility Information

This facility consists of two buildings (10,000 m^2 per building). There are 307 employees and receives around 180 visitors per day. Because this building is new and employees were just moving in at the time of the audit there was no historical water consumption data available. Therefore projected water use estimates were made based on building census and fixture flow rates.

Water Balance and End Use Types

The average domestic water usage for this building was estimated at 3,129 m^3 annually. The building does not have a commercial kitchen, or any water features. The building has a water softener and a closed loop for heating and cooling. There are six public bathrooms on each floor, two toilets and three sinks in both men and women's rest-rooms, and two toilets and two lavatories in the handicaps rest-room. The men's rest-rooms also have two urinals each.

A majority of the projected water use (53%) will go to flushing the toilets. The toilets that were measured at the time of the audit were single flush 6 liter wash down toilets that were out of adjustment and were flushing an average of 7.8 liters per flush.

The lavatory faucets at this building had a wide range of flow rates which is partially the result of different flow controls that were installed at the time of construction, and partially due to the difference in water pressure on each of the floors. On the ground floor the faucet lavatory in one of the handicaps bathrooms measured 5.8 lpm, and in the men's room measured 8.2 lpm. The average flow rate on the first floor was 7.5 lpm, while the flow rate on the third floor was 2 lpm. Showers at the building were found to flow at an average of 7.2 lpm.

One flush per fixture for bathroom cleaning was allotted. The overall floor space is 10,000 m2 per building. It is estimated that 2,000 m^2 for each building is the area that gets cleaned with a mop or hose weekly. The results of the end use water balance are illustrated in the Table below.

Table 5: End uses of water at facility 5

Facility 5		
Types	**Avg. %**	**m^3/year**
Toilets	53%	1,656
Urinals & Bidets	14%	451
Faucets (Kit and Lav)	12%	384
Showers	11%	333
Cleaning	6%	176
Others	4%	129
Total		**3,129**

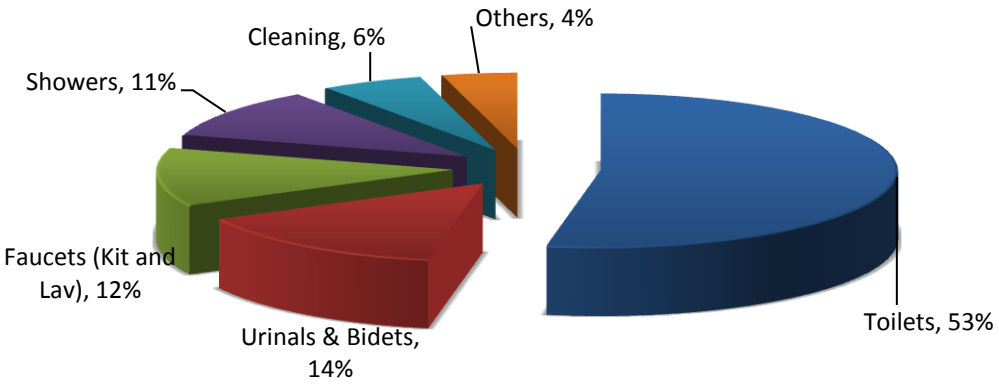

Figure 11: Water use percentages at the facility 5

Recommended Measures

Toilets

The greatest opportunity for savings at the facility is toilet retrofit/maintenance. The facility can surely improve on the average 7.8 lpf rate of tank toilet fixtures. The toilet tanks should be retrofitted with dual flush (3/6 lpf) tanks. This would reduce toilets water consumption by around 50%.

Lavatory Faucets

Lavatory faucets should be retrofitted with 4.5 lpm pressure-compensating flow controls.

It is also recommended that the management at this facility ensures that hot water at lavatories stays within a safe temperature range (below 50°C) to save energy and prevent injuries.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	1,656
Bidet consumption per year	315
Lavatory consumption per year	384
Shower consumption per year	333
TOTAL DOMESTIC CONSUMPTION	2,688

Building Domestic Subtotals - Consumption m^3/year (Post-Program)	
Toilet consumption per year	849
Bidet consumption per year	315
Lavatory consumption per year	240
Shower consumption per year	333
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	1,737

Based on the above calculations, if the facility implements the recommended domestic measures it will reduce consumption by 951 m^3 per year, which is equivalent to an annual saving of 30% of the total water use.

Facility 6

Background Information

This facility was built in 1996 on a total surface area of 5,500 m^2. It has 149 employees and receives around 250 visitors a day.

Water Balance and End Use Types

The water consumption data provided by the Aqaba Water shows an annual consumption of 1,266 m^3.
The building's bathrooms have 3 western type toilets that flush at 4.7 liters per flush (lpf), three "Turkish" style toilets with tanks having an average flow rate of 6 lpf. There are 5 lavatories that operate at 5.4 lpm.

There are no aerators on any of the faucets. In addition, it is important to note that roughly 65% of the employees practice ablution and the visitors to the building do not have access to the restrooms.

The building has a kitchen that is used to make coffee and tea. Dishes are done daily by office staff. The building is air conditioned by a 24 ton unit.

The landscape consists of turf and beds on the grounds and is manually irrigated. The flow rate of the hose used is 13 lpm.

The results of the end use water balance are illustrated in the Table below.

Figure 12: Flush valve toilet at facility 6

Table 6: End uses of water at facility 6

Facility 6		
Types	**Avg. %**	**m^3/year**
Toilets	62%	790
Faucets (Kit and Lav)	14%	171
Cleaning	12%	147
Landscape	10%	124
Unaccounted	3%	34
Total		**1,266**

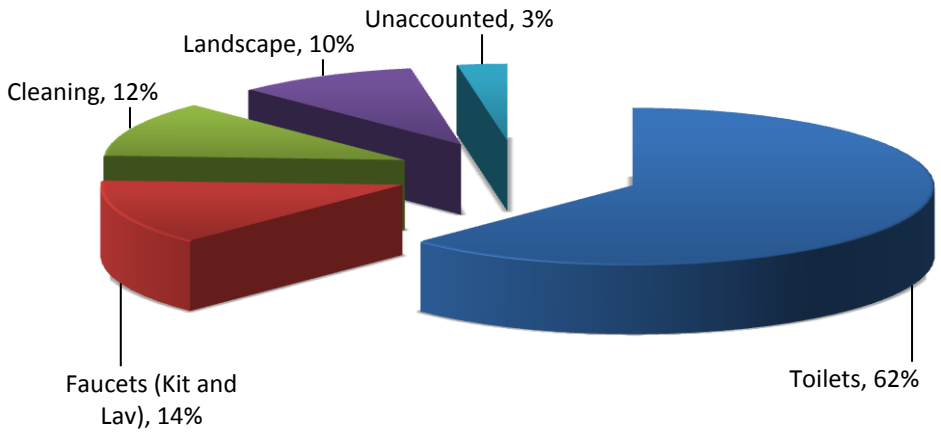

Figure 13: Water use percentages at facility 6

Proposed Measures

Toilets

Toilet tanks should be retrofitted with 6.0 lpf or less fixed-volume flush mechanisms that prevent an end-user or maintenance worker to adjust the amount of water delivered. The facility can choose to replace the entire fixture, or swap out the adjustable ball/tower float in the existing tank for a fixed-volume tower float.

To further reduce consumption, the facility should consider installing dual-flush toilets. While 3L/6L dual-flush models exist, it is recommended that the facility ensure its drainage plumbing infrastructure will operate adequately with such a flow reduction.

Lavatory & Kitchen Faucets

Faucet flow rates are slightly high compared to Jordanian standards. By retrofitting lavatory faucets with pressure-compensating 4.5 lpm flow controls, the facility could save approximately 17% of lavatory water consumption in addition to energy saving associated with hot water production and boiler operation.

Irrigation

The facility managers should consider the use of water wise landscape best management practices to retrofit all the landscape areas. This would result in tremendous saving of water without losing the attractiveness of the landscape scenery.

Potential Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	790
Lavatory consumption per year	171
TOTAL DOMESTIC CONSUMPTION	961

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	596
Lavatory consumption per year	142
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	738

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 223 m^3 per year, which is equivalent to 18% of the total water use.

Facility 7

Background Information

The facility was built in 1996. The surface area of the building property is 5,500 m^2. It has 50 employees.

Water Balance and End Use Types

The building receives its water from Aqaba Water Company. The annual water consumption was estimated at 374 m^3.

The facility's bathrooms have 4 Turkish-style tank toilets that flush at 6 lpf, and one Western-style toilet that flushes on 8.3 lpf. This location is not equipped with urinals, bidets, or showers. There are 3 lavatory faucets that operate at 3.7 lpm, though there are no aerators currently installed.

The facility is equipped with a single kitchenette, primarily used for the preparation of coffee and tea. There is no dishwasher in the kitchenette, and all glassware is hand washed daily. There is one sink present, and its faucet runs at 4.7 liters per minute. The facility is equipped with multiple single-room air-conditioning units, all of which are air-cooled. The results of the end use water balance are illustrated in the Table below.

Table 7: End uses of water at facility 7

Facility 7		
Types	**Avg. %**	**m^3/year**
Toilets	77%	288
Faucets (Kit and Lav)	11%	42
Cleaning	8%	29
Unaccounted	4%	15
Total		**374**

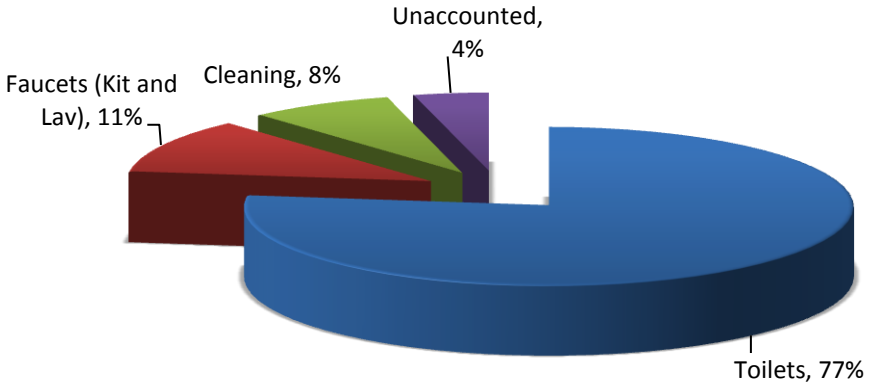

Figure 14: Water use percentages at facility 7

Proposed Measures

Toilets

Since the existing flush mechanisms flush at an average of 6 lpf the facility managers should consider installing dual flush toilets (3L/6L) that flush at an average of 4 lpf.

Potential Domestic Water Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	288
Lavatory consumption per year	42
TOTAL DOMESTIC CONSUMPTION	330

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	192
Lavatory consumption per year	42
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	234

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 96 m^3 per year, which is equivalent to 26% of the total water consumption.

Facility 8

Background Information

This facility is located in the city of Aqaba and was built in the early nineties and upgraded in 2001. The surface area of the building is 3,000 m^2 and the total area of the property is 7,762 m^2. The facility has 170 employees.

Water Balance and End Use Types:

This building receives its water from the Aqaba Water Company. The annual water consumption was estimated at 2,874 m^3.

The facility's bathrooms have 1 Turkish-style tank toilets that operates at 6 lpf, and 11 Western-style toilets that operate at an average of 5.5 lpf. This facility is not equipped with bidets, or showers. There are 11 urinals in the building that operate at an average rate of 1.5 lpf. There are 13 lavatory faucets that flow at 5.6 lpm, though there are no aerators currently installed.

The facility is equipped with three kitchenettes, primarily used for the preparation of coffee and tea. There is no dishwasher in the kitchenette, and all glassware is hand washed daily. The average flow rate of the kitchen faucets is 4.6 liters per minute. The facility is equipped with multiple single-room air-conditioning units, all of which are air-cooled. The results of the end use water balance are illustrated in the Table below.

Table 8: End uses of water for facility 8

Facility 8		
Types	**Avg %**	**m^3/year**
Toilets	48%	1,371
Faucets (Kit and Lav)	34%	969
Cleaning	18%	518
Urinals	1%	16
Total	100%	2,874

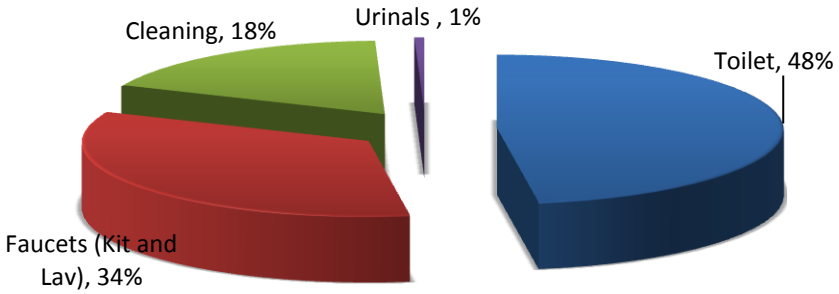

Figure 15: Water use percentages at facility 8

Proposed Measures

Toilets
Since the existing flush mechanisms operate at an average of 6.0 lpf the facility managers should consider installing dual flush toilets (3/6L) that consume an average of 4lpf.

Lavatory Faucets
Faucet flow rates are higher than the recommended standards. By retrofitting lavatory faucets with pressure-compensating 4.5l pm flow controls, the facility could save approximately 20% of the lavatory water consumption, in addition to energy saving associated with hot water production and boiler operation. The results of the end use water balance are illustrated in the Table below.

Urinals
Urinals flow rates were higher than what is recommended, therefore it is recommended to either adjust the flushing mechanisms or replace the existing ones with those flushing at the recommended flow rate.

Potential Domestic Water Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	1,371
Urinal consumption per year	16
Lavatory consumption per year	831
Kitchen faucet consumption per year	138
TOTAL DOMESTIC CONSUMPTION	2,3572,356

Building Domestic Subtotals - Consumption m^3/year (Post-Program)	
Toilet consumption per year	999
Urinal consumption per year	10
Lavatory consumption per year	669
Kitchen faucet consumption per year	138
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	1,816

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 540 m^3 per year, which is equivalent to around 19% of the total facility water consumption.

Facility 9

Background Information

This facility is composed of one building with a total surface area of 6,425 m^2. The structure was built in 1980 and underwent an expansion to increase floor space in 1992. The building has 256 employees and receives around 250 visitors per a day.

Water Balance and End Use Types

The building receives water once or two times a week. The annual water consumption was estimated at 2,364 m^3.

The building's bathrooms have 1 western type toilet that is currently not functioning In addition to 13 "Turkish" style toilets with an average flow rate of 9 lpf. There are 12 hand washing lavatories that operate at 6.5 lpm. There are no aerators on any of the faucets. In addition, it is important to note that roughly 65% of the employees practice ablution. The building has a kitchen that is used to make coffee and tea. Dishes are done daily by office staff. The kitchen sink's faucet has a flow rate of 9lpm. The building is air conditioned by a split unit. The results of the end use water balance are illustrated in the Table below.

Figure 16: Facility 9

Table 9: End uses of water facility 9

Facility 9		
Types	**Avg. %**	**m^3/year**
Toilets	81%	1,921
Faucets (Kit and Lav)	10%	226
Cleaning	9%	217
Total		**2,364**

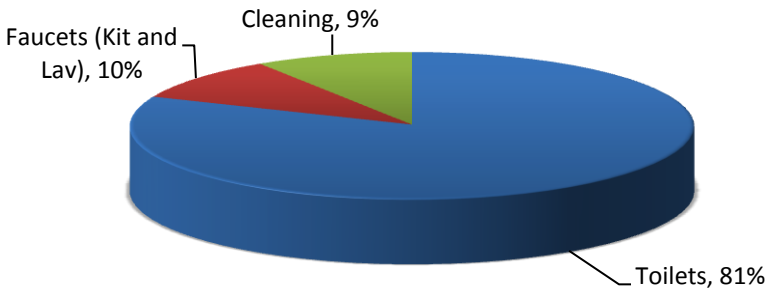

Figure 17: water uses percentages at facility 9

Proposed Measures

Toilets

Toilet tanks should be retrofitted with 6.0 lpf or less fixed-volume flush mechanisms that prevent an end-user or maintenance worker to adjust the amount of water delivered. This would lead to 33% savings of the tank toilets water use. The facility can choose to replace the entire fixture (depending on the designed flush volume of the bowl), or swap out the adjustable ball/tower float in the existing tank for a fixed-volume tower float.

To further reduce consumption, the facility should consider installing dual-flush toilets. While 3L/6L dual-flush models exist, it is recommended that the facility ensure its drainage plumbing infrastructure will operate adequately with such a flow reduction. Installing dual flush toilets will result in 55% savings of tank toilets water use.

Lavatory & Kitchen Faucets

Faucet flow rates are high compared to Jordanian standards. By retrofitting lavatory faucets with pressure-compensating 4.5 lpm flow controls, the facility could save approximately 31% of lavatory water consumption in addition to energy saving associated with hot water production and boiler operation. Appropriate kitchen area faucets should also be retrofitted to a range of 8.3 lpm.

Potential Domestic Water Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	1,921
Lavatory consumption per year	226
TOTAL DOMESTIC CONSUMPTION	2,147

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	853
Lavatory consumption per year	156
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	1,009

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 1,138 m^3 per year, which is equivalent to 48% of the total water use.

Facility 10

Background Information

This Facility was built in 1982 and went through extensive remodeling in 1985 and 1989 when additional floors were added to the structure. The surface area of each of the four floors is 600 m^2. The facility has 78 employees and receives around 200 visitors per day.

Water Balance and End Use Types

The building receives water once or twice a week. The annual water consumption was estimated at 750 m^3.

The facility's bathrooms have 8 Turkish-style tank toilets that flush at 6.5 lpf. There are also 8 lavatory faucets that operate at 4.5 lpm. The facility is equipped with a single kitchenette. There is one kitchen sink with a flow of 8 liters per minute. According to staff interviewed during the survey, facility uses approximately 312 m^3 of water a year in the daily cleaning of 1682 m^2 of floor surface.

The results of the end use water balance are illustrated in the Table below.

Figure 18: Restrooms condition at facility 10

Table 10: End uses of water at facility 10

Facility 10		
Types	**Avg %**	**m^3/year**
Toilet	52%	391
Faucets (Kit and Lav)	6%	47
Cleaning	42%	312
Total		**750**

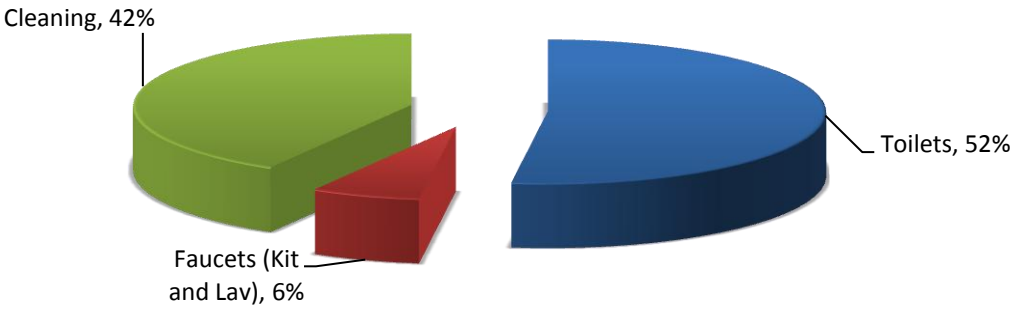

Figure 19: Water use percentages at facility 10

Proposed Measures

Toilets

The facility should consider installing 3L/6L dual-flush. However, it is recommended that the facility ensures its drainage plumbing infrastructure will operate adequately with such a flow reduction. Installing dual flush toilets will result in 33% savings of toilets water use.

Potential Domestic Water Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	391
Lavatory consumption per year	47
TOTAL DOMESTIC CONSUMPTION	438

Building Domestic Subtotals - Consumption m3/year (Post-Program)	
Toilet consumption per year	261
Lavatory consumption per year	47
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	308

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 130 m^3 per year, which is equivalent to 17% of the total water use.

Facility 11

Background Information

This office facility was built in 1988, and is comprised of two buildings. It has 152 employees and receives around 100 visitors per day.

Water Balance and End Use Types

The facility receives water once a week. The annual water consumption was estimated at 1,295 m^3. The facility's bathrooms have 9 Turkish-style toilets that operate at 4.9 lpf. There are 13 lavatory faucets that operate at 5.2 lpm.

The facility has approximately 1,000 m^2 of landscaping, but according to the staff it is not irrigated. An estimated 483 liters of water per day are used for cleaning.

The results of the end use water balance are illustrated in the Table below.

Table 11: End uses of water at facility 11

Facility 11		
Types	**Avg %**	**m3**
Toilet	48%	622
Faucets (Kit and Lav)	15%	190
Cleaning	37%	483
Total		1,295

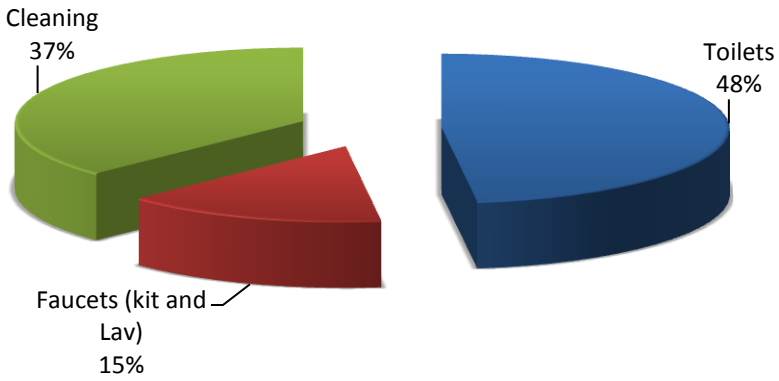

Figure 20: Water use percentages at facility 11

Proposed Measures

Toilets

To reduce consumption at the facility, the toilets should be retrofitted with 3L/6L dual-flush toilets. However, it is recommended that the facility ensures its drainage plumbing infrastructure will operate adequately with such a flow reduction. Installing dual flush toilets will result in around 32% savings of toilets water use.

Lavatory & Kitchen Faucets

Faucet flow rates are high compared to Jordanian standards. By retrofitting lavatory faucets with pressure-compensating 4.5 lpm flow controls, the facility could save approximately 13% of lavatory water consumption in addition to energy saving associated with hot water production and boiler operation. Appropriate kitchen area faucets should also be retrofitted to a range of 8.3 liters per minute.

Proposed Domestic Savings

Building Domestic Subtotals - Consumption m^3/year (Pre Program)	
Toilet consumption per year	622
Lavatory consumption per year	190
TOTAL DOMESTIC CONSUMPTION	812

Building Domestic Subtotals - Consumption m^3/year (Post-Program)	
Toilet consumption per year	513
Lavatory consumption per year	164
TOTAL DOMESTIC CONSUMPTION POST-PROGRAM	677

Based on the above calculations, if the facility implements the recommended measures it will reduce consumption by 135 m^3 per year, which is equivalent to around 10% of the total water use.

Facility 12

Background Information

This office building was built in 1994, with an area of 1000m². The facility has 80 employees and receives around 1000 visitors per day, though only an estimated 300 use restroom.

Water Balance and End Use Types

The facility receives water twice a week. The annual water consumption was estimated at 270 m³.The facility's bathrooms have 9 Turkish-style toilets that are being flushed using 2 liter buckets and 1 Western-style toilet that is broken and not in use. There are 12 lavatory faucets that operate at 3.6 liters per minute. According to staff interviewed during the survey the facility uses an estimated 40 liters of water per day to clean both bathrooms and floors.

Table 12: End uses of water at facility 12

Facility 12		
Types	**Avg %**	**m³/year**
Toilet	68%	183
Faucets (Kit and Lav)	20%	53
Cleaning	11%	29
Unaccounted	2%	5
Total		**270**

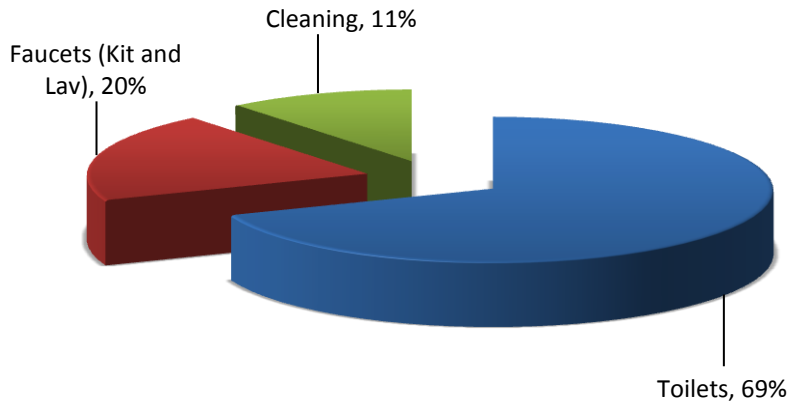

Figure 21: Wate use percentages at facility 12

Since the flows measured for the lavatory faucets and toilets at the facility are less than what is recommended, no savings are expected by retrofitting this facility.

5.2 Water Use Baseline

The two pie charts below illustrate the water use in a typical office building in the city of San Jose – US and the current baseline water use pattern in the audited office buildings in Jordan. Jordan data show that toilets (64%) account for the largest water use, followed by faucets (16%), cleaning (14%), and bidets (3%). Landscape water use is only around 1% of the total water consumption. In San Jose, toilets (40%) account also for the largest water use; however, cooling-heating (28%) and landscape (22%) are respectively, the second and third largest water users.

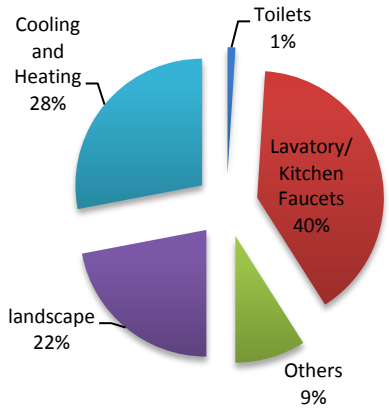

Figure 22:Water usage at office building - city of San Jose

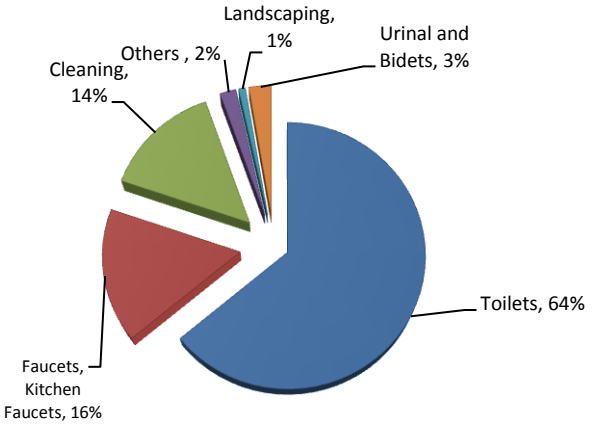

Figure 23: Baseline water use for the audited office buildings in Jordan

Table 13 indicates that water use at the audited office buildings in Jordan varies between 15 and 67 liters/per employee/ per day. Nine out the twelve facilities have a water use ranging between 30 and 50 liters/per employee/ per day. The average use for the twelve facilities is close to 36.6 liters/per employee/ per day.

Table 13: Baseline water use for Office buildings in Jordan

Facility Number	Annual Water Use (m^3)	Number of People	Liters Per employee Per day
1	889	200	18.6
2	3430	300	47.8
3	1328	160	30.3
4	9609	900	44.7
5	3129	307	42.5
6	1266	149	34.0
7	374	50	31.2
8	2874	170	67.6
9	2364	256	36.9
10	750	78	40.1
11	1295	152	32.8
12	270	80	13.0

5.3 Cost effectiveness calculations

Cost effectiveness was conducted for the audited facilities based on the potential savings resulting from the adoption of the recommended measures, and the cost of water and wastewater based on the commercial tariff (JD 1.56 /m^3). Water tanker cost was estimated at JD2.18/ m^3 in addition to JD0.56/ m^3 for sewage treatment. The interest rate used for the calculation is 7% and the present value of the water saved was calculated based on the initial cost and the life time of the fixture. Cost of energy, which is embedded in the cost of water, was estimated at around JD 4.25/m^3.

The savings (JD/Year) was calculated as follows = Number of uses per day (for example, number of flushes per day) x amount of saving per use (m^3) x number of days facility occupied per year x cost of water per m^3.

Cost of Retrofit = Number of fixtures at the facility x Cost of replacing existing fixture.

Cost effectiveness calculations for retrofit of toilets and faucets for the audited office buildings, which have water saving potential, are presented in Table 14. The cost of the fixture and its installation was estimated at JD150, JD25, and JD4 for toilet, toilet trim, and faucet aerator; respectively. The life time is 20 years for the toilet and 5 years for the faucet aerator and toilet trim. The toilet trim replacement is given as an option for users in case the toilet replacement is not cost-effective. Cost analysis for fixtures without installation, assuming that it is done by the facility staff, is also presented.

Table 14 shows that the faucets retrofit is the most cost effective with a payback period, with installation, ranging from approximately 6 days for facility four to 22 months for facility one. Without installation, the payback period drops to 2 days for facility four and 4.5 month for facility one.

Toilets replacement is cost effective for most of the facilities due to high water consumption in toilets for all the audited offices.. The payback period with installation ranges from approximately 11 months for facility four to around 8 years for facility eleven. Seven facilities have a toilet replacement payback period of less than two years. Replacement of the toilet trim is much more feasible with a payback period with installation varying from approximately 1.4 month for facility four to around five years for facility eleven.

Table 14: Cost effectiveness calculations for office buildings

		Quantity of Equpment in Facility	Efficient Use Rate		Existing Average Use Rate	Unit of Use Per day	No of Days Equipment Used per Year	Life of Equipment (years)	Incremental Cost for Efficient Equipment (JD)	Total Incremental Cost for Efficient Equipment (JD)	Unit Cost of Replacing Existing Equipment (JD)	Total Cost of Replacing Existing Equipment	Estimated Water Savings per Day (liters)	Water Savings per Year (cubic meters)	Perecnt Hotwater	Weighted Price of Water	Value of Water and Wastewater Savings per Year (JD) Incl. Energy	Present Value of Water Saving Over Life of Measure (JD) (Incl. Energy)	Payback for Replacing Inefficient Equipment without installation (Months)	Payback for Replacing an Existing Equipment with installation (Months)
Facility 1	Toilet (3l/6l)	10	4.0	lpf	7	436	239	20	100	1,000	150	1,500	1,308	313	0%	1.77	554	11,081	21.7	32.5
	Toilet Trim	10	4.0	lpf	7	436	239	5	20	200	25	250	1,308	313	0%	1.77	554	2,770	4.3	5.4
	Faucet Aerators	31	4.5	lpm	6	41	239	5	0.5	16	2.5	78	62	15	30%	2.84	42	208	4.5	22.3
	Total for All Equipment									1,216		1,828						208.35		
Facility 2	Toilet (3l/6l)	10	4.0	lpf	5	1753	239	20	100	1,000	150	1,500	1,753	419	0%	1.77	743	14,852	16.2	24.2
	Toilet Trim	10	4.0	lpf	5	1753	239	5	20	200	25	250	1,753	419	0%	1.77	743	3,713	3.2	4.0
	Faucet Aerators	34	4.5	lpm	6.5	581	239	5	0.5	17	2.5	85	1,162	278	30%	2.84	787	3,937	0.3	1.3
	Total for All Equipment									1,217		1,835						22,501		
Facility 3	Toilet (3l/6l)	11	4.0	lpf	6	574	274	20	100	1,100	150	1,650	1,148	315	0%	1.56	491	9,814	26.9	40.4
	Toilet Trim	11	4.0	lpf	6	574	274	5	20	220	25	275	1,148	315	0%	1.56	491	2,454	5.4	6.7
	Faucet Aerators	18	4.5	lpm	8.8	93	274	5	0.5	9	2.5	45	400	110	30%	2.84	311	1,553	0.3	1.7
	Total for All Equipment									1,329		1,970						13,821		
Facility 4	Toilet (3l/6l)	25	4.0	ave. liters per flush	7	3794	239	20	100	2,500	150	3,750	11,382	2,720	0	1.56	4,244	84,873	7.1	10.6
	Toilet Trim	25	4.0	ave. liters per flush	7	3794	239	5	20	500	25	625	11,382	2,720	0	1.56	4,244	21,218	1.4	1.8
	Faucet Aerators	25	4.5	lpm	9	1077	239	5	0.5	13	2.5	63	4,739	1,133	30%	2.84	3,211	16,054	0.0	0.2
	Total for All Equipment									3,013		4,438						122,146	0.3	0.4
Facility 5	Toilet (3l/6l)	25	4	lpf	7.8	885	240	20	100	2,500	150	3,750	3,363	807	0%	1.56	1,259	25,182	23.8	35.7
	Toilet Trim	25	4	lpf	7.8	885	240	5	20	500	25	625	3,363	807	0%	1.56	1,259	6,296	4.8	6.0
	Faucet Aerators	25	4.5	lpm	7.2	222	240	5	0.5	13	2.5	63	599	144	30%	2.84	408	2,039	0.4	1.8
	Total for All Equipment									3,013		4,438						33,517		
Facility 6	Toilet (3l/6l)	3	4.0	ave. liters per flush	5.3	596	250	20	100	300	150	450	775	194	0%	1.56	302	6,043	11.9	17.9
	Toilet Trim	3	4.0	ave. liters per flush	5.3	596	250	5	20	60	25	75	775	194	0%	1.56	302	1,511	2.4	3.0
	Faucet Aerators	5	4.5	lpm	5.2	127	250	5	0.5	3	2.5	13	89	29	30%	2.84	81	405	0.4	1.9
	Total for All Equipment									363		538						7,959		
Facility 7	Toilet Trim	6	4.0	lpm	6	200	240	5	20	120	25	150	400	96	0%	1.56	150	749	9.6	12.0
	Total for All Equipment									120		150						749		
Faaclity 8	Toilet (3l/6l)	6	4.0	lpm	5.5	991	250	20	100	600	150	900	1,487	372	0%	1.56	580	11,595	12.4	18.6
	Toilet Trim	11	4.0	ave. liters per flush	5.5	991	250	5	20	220	25	275	1,487	372	0	1.56	580	2,899	4.6	5.7
	Faucet Aerators	13	4.5	lpm	5.6	590	250	5	0.5	6.5	2.5	33	649	162	30%	2.84	460	2,300	0.2	0.8
	Urinals	4	1	lpm	1.5	45	250	20	80	320	120	480	23	6	0%	1.56	9	176	437.6	656.4
	Total for All Equipment									827		1,208						16,793		
Facility 9	Toilet (3l/6l)	13	4.0	ave. liters per flush	9	854	250	20	100	1,300	150	1,950	4,270	1,068	0	1.56	1,665	33,306	9.4	14.1
	Toilet Trim	13	4.0	ave. liters per flush	9	854	250	5	20	260	25	325	4,270	1,068	0	1.56	1,665	8,327	1.9	2.3
	Faucet Aerators	12	5	lpm	6.5	139	250	5	0.5	6	2.5	30	278	70	30%	2.84	197	985	0.4	1.8
	Total for All Equipment									1,566		2,305						42,618		
Facility 10	Toilet (3l/6l)	9	4.0	lpm	6	271	240	20	100	900	150	1,350	542	130	0%	1.56	202.92	4,058	53.2	79.8
	Toilet Trim	9	4.0	lpm	6	271	240	5	20	180	25	225	542	130	0%	1.56	202.92	1,015	10.6	13.3
	Total for All Equipment									1,080		1,575						5,073		
Facility 11	Toilet (3l/6l)	9	4.0	ave. liters per flush	4.85	493	260	20	100	900	150	1,350	419	109	0	2	170	3,399	63.5	95.3
	Toilet Trim	9	4.0	ave. liters per flush	4.85	493	260	5	20	180	25	225	419	109	0	2	170	850	12.7	15.9
	Faucet Aerators	13	4.5	lpm	5	141	260	5	0.5	7	2.5	33	99	26	30%	3	73	364	1.1	5.4
	Total for All Equipment									1,087		1,608						4,613		

6. Conclusions

Following are the main conclusions of the End Use report for office buildings in Jordan:

1. Offices water use occurs essentially at the toilets (64%) followed by Lavatory and kitchen faucets (16%), Cleaning (14%) Urinals and Bidets (3%) and landscaping (1%).
2. The average water use is estimated at around 36.6 liters/employee/day.
3. Only one out of the twelve audited office buildings use water efficiently and do not currently require retrofitting. The remaining eleven facilities have potential saving from domestic water use ranging between 10% and 48% of the total annual water use.
4. Tanker water is used by a limited number of facilities; it does not exceed 20% of their total water consumption.
5. Most of the office buildings had little or no landscaping.
6. Retrofitting faucets is proven to be economically feasible, the payback period in most cases is less than three months
7. Generally Turkish toilets consume less water than the proposed gravity tank toilets, thus retrofit of Turkish toilets is not economically feasible.
8. Retrofitting of tank toilets is generally cost effective given that toilets account for the majority of the offices water use. However, replacement of the toilet trim is much more economically feasible.

7. Recommendations

Based on the End Use Analysis study, following are the recommendations for the governmental office buildings in Jordan,

1. Install WSD for all faucets that use more than 4.5 lpm, Pressure Compensating flow controls should be considered
2. In office buildings that have many visitors, water saving devises (WSDs) on faucets are usually removed for a satisfying flow rate, it is therefore recommended to install tamper proof WSDs in these buildings.
3. Retrofitting toilets is only recommended when economically feasible; otherwise retrofitting toilet trims should be practiced.
4. Provide regular maintenance and repair for all plumbing fixtures including toilet flushing valves and faucets, leak detection via dye testing.
5. In office buildings where there is an intensive use of RO systems, it is recommended to use systems that have a 1:1 product to reject ratio.
6. High water consumption landscapes, especially grass areas, need to be replaced by water-wise vegetation applying xeriscaping principles.
7. Conduct awareness programs targeting employees to increase their knowledge of how to use water more efficiently in their office facilities.
8. Conduct water audits at office buildings to identify areas of water saving, and develop and implement water efficiency programs.

3 Appendices

5.4 8.1 Appendix A

Office Building Survey Form:

Audit Survey Form

Date: _____:التاريخ Auditor: _____:المحقق/ المدقق

Name of facility: _____:إسم المنشأ
Operational Company Name:_____إسم الشركة التشغيلية
Address: _____ :العنوان
Manager name: _____إسم مدير المنشأ Telephone: _____ الهاتف
FAX: _____الفاكس
e-mail address: _____البريد الإلكتروني
Date facility built: _____تاريخ بناء المنشأ

Census and occupancy data based on daily averages for year (answer where applicable):

Number of buildings the facility is composed of_____عدد المباني التي يتكون منها المنشأ
Total area of each building:_____ _____المساحة الإجمالية لكل مبنى

Number of staff :_____عدد الموظفين; % Male _____نسبة الذكور
Average number visitors per day: _____ متوسط عدد الزائرين في اليوم
Number of days per year operational: _____عدد أيام الإشغال سنوياً

يرجى الحصول على المخططات التالية:

1. **التمديدات الصحية ومخططات الطوابق المختلفة**

Engineering drawings (Plumbing drawings and floor plans)

2. **مخططات المساحة الخارجية المزروعة**

Irrigation drawings (irrigation engineering drawings, if available, otherwise site maps including general landscaping information

ACTIVITY AND EQUIPMENT CHECKLIST (check or fill in all that are applicable)

Main Kitchen Operations **عمليات المطبخ الرئيسية**

عَدَد (أدرج) الوجبات المقدمة في اليوم الفطور _____ الغداء _____ العشاء _____غير ذلك _____
No. of meals/day served Breakfast: ____, Lunch: ____ Dinner: _____ Other: _____
عَدَد (أدرج) الوجبات المقدمة في الصحون _____ عَدَد (أدرج) الوجبات المقدمة في الصحون1 القابلة للإتلاف_____

[1] صحون إستعمال مرة واحدة

Number of meals served on china_____ Number served on disposable ware_____

FOOD SERVICE ITEMS **بنود خدمات الطعام**

Water cooled refrigeration equipment معدات التبريد التي تعمل بإستخدام المياه المبردة
Water cooled ice makers معدات صنع الثلج التي تعمل بإستخدام المياه المبردة
Air cooled ice makers (Including remote head units) معدات صنع الثلج التي تعمل بإستخدام الهواء المبرد (وتشمل وحدة التحكم عن بعد)
Freezers الفريزرات
Steam tables طاولات بخار
Boilerless Steamer مبخرة بدون مرجل لتوليد البخار
Boiler type Steamer مولدات بخار بإستخدام المراجل
Combination ovens الأفران التجميعية
Steam kettles غلايات البخار
Garbage grinders (disposers) مطاحن القمامة (والتخلص منها)
Dish Washer/Ware-washer غسالات أطباق
Three compartment sinks مجلى بثلاثة مصارف
Pot soaker مجلى لنقع الطناجر
Pulper مستأصل اللب
Sluice trough to garbage grinder (disposal) حوض صغير لطحن القمامة
Pre-rinse spray with shutoff رشاش ما قبل الشطف مع قاطع للتيار الكهربائي أتوماتيكي
Confectionary faucet – (ice cream scoop sink & faucet) صنبور حلويات – (صنبور و حوض للمثلجات)
Faucets drip حنفيات تنقيط
Thaw meat in sink إذابة اللحوم المجمدة في أحواض الجلي
Water left running الصب المتواصل للمياه
Kitchen floors hosed down at end of day ترك خرطوم المياه على أرضية المطبخ عند الشطف
Other غيرها

_____

WATER TREATMENT **معالجة المياه**

Water Softener جهاز تنقية المياه من الشوائب
Reverse Osmosis جهاز تنقية المياه من الأملاح باستخدام التناضح العكسي
Water Stills أجهزة تقطير المياه
Ultra-pure Water System نظام للتنقية القصوى للمياه
Other غيرها

_____

LABORATORY EQUIPMENT **أدوات المختبر**

Vacuum autoclaves without water tempering device
Vacuum autoclaves with water tempering device
Gravity autoclaves without water tempering device
Gravity autoclaves with water tempering device
Air cooled compressors (no water use)
Water cooled and sealed air compressors

_____

MECHANICAL EQUIPMENT **المعدات الميكانيكية**

Air conditioned facility – tons _____ مكيفات الهواء – السعة بالطن

Cooling towers – tons_____ أبراج تبريد –السعة بالطن
Contract for cooling water treatment إتفاقية لمعالجة المياه المستخدمة في التبريد
Contract specifies cycles of concentration for cooling tower إتفاقية تحدد دوائر التركيز لبرج التبريد

أنظمة التبريد والتدفئة بإستخدام وحدة تبريد وتدفئة مركزي مغلقة
Closed loop chilled/hot water system for heating and cooling

جمع وإعادة استخدام مبردات الهواء بأبراج التبريد لأغراض الري
Collect and reuse air conditioner condensate for irrigation of cooling towers

أبراج تحتوي على عداد لقياس كميات المياه المضخوخة لبرج التبريد بهدف تعويض الفاقد
Towers equipped with a makeup meter

Towers equipped with bleed off or blowdown meters
Towers equipped with conductivity controllers

RESTROOM ROOMS **الحمامات**

Number of toilets _____ عدد المراحيض
التدفق (لتر بالدفقة) (إختر واحدة مما يلي) 6 13.25 13.25أعلى من
Litters per flush (circle one) 6.0 lpf 13.25 lpf Over 13.25 lpf
Number of urinals _____ عدد المبولات
Litters per flush (circle one) 3.8 lpf 7.6 lpf Over 7.6 lpf لتر بالدفقة (إختر واحدة مما يلي)
Number of showers _____ عدد الدوشات
Shower flow rate _____ lpm معدل تدفق الدوش _____ لتر/ دقيقة
Number of hand washing lavatories عدد المغاسل (لغسل اليدين)
Flow rate of aerators _____ lpm معدل تدفق أجهزة الإشباع بالهواء (لتر/ دقيقة)
Other water using fixtures or appliances أي تركيبات أو قطع أخرى تستخدم للمياه

LOCKER ROOMS (if you have)

Number of toilets _____ عدد المراحيض
Litters per flush (circle one) 6.0 lpf 13.25 lpf Over 13.25 lpf لتر بالفورة (إختر واحدة مما يلي)
Number of urinals _____ عدد المبولات
Litters per flush (circle one) 3.8 lpf 7.6 lpf Over 7.6 lpf لتر بالفورة (إختر واحدة مما يلي)
Number of showers _____ عدد الدوشات
Shower flow rate _____ lpm معدل تدفق الدوش _____ لتر/ دقيقة
Number of hand washing lavatories عدد المغاسل (لغسل اليدين)
Flow rate of aerators _____ lpm معدل تدفق أجهزة الإشباع بالهواء (لتر/ دقيقة)
Clothes washer غسالات الملابس
Hot tub or Jacuzzi أحواض ساخنة أو جاكوزي
Other water using fixtures or appliances أي تركيبات أو قطع أخرى تستخدم للمياه

LANDSCAPE **المساحات الخارجية**

Landscape irrigation ري الحدائق(غير المساحات المخصصة للرياضة)

جدول الري – عدد المرات بالأسبوع _____ عددالدقائق لكل منطقة _____

Irrigation schedule – use per week _____ minutes per zone _____

مساحة المرج (متر مربع):_____مساحة الأحواض (مثل أحواض الزهور) - متر مربع _____
Square meters of turf: _____ Square meters of beds: _____

Type of turf: _____ نوع المرج
Installed sprinkler system (Yes) (No) نظام ري بالرشاشات؟ (نعم) (لا)
Managed by landscape company (Yes) (No) تديرهُ شركة مختصة؟ (نعم) (لا)
Condition of irrigation system :_____ وضع نظام الري
Type of plant material: _____ نوع النباتات المزروعة
Soil depth: _____ عمق التربة
Opportunity for rainwater harvesting: _____ هل هناك فرصة لتخزين مياه الأمطار

هل هناك إستخدام للمياه غير الصالحة للشرب لري المزروعات _____
Opportunity for non-potable sources of irrigation water _____
_____

SWIMMING POOLS, THERAPY POOLS AND SPAS برك سباحة، برك علاج، ومنتجعات إسترخاء علاجية

Water meter on makeup هل يوجد عداد لقياس المياه المفقودة من البركة
Total volume _____ الحجم الكلي, Surface area:_____ مساحة السطح
Heated pool; temperature_____ درجة حرارة البرك المدفأة

__ما هي ميكانيكية سحب المياه من البركة لتنظيف الفلاتر؟ هل يتم تفعيلها عند إنخفاض الضغط أي بدون استخدام المؤقت؟
Backwash set by pressure drop and not timer _____
_____هل يتم إعادة استخدام هذه المياه لري المزروعات
Backwash water reused for irrigation_____
_____هل يتم تغطية البرك الساخنة عندما لا تكون مستخدمة منعاً للتبخر
Hot tubs covered when not in use to prevent evaporation _____

DECORATIVE FOUNTAINS AND WATER FEATURES ديكورات النوافير ومعالم مائية اخرى مع التصوير

Describe decorative fountains _____ وصف موجز للنوافير إن وجدت
Describe ponds, streams, etc. _____... وصف للجداول ، برك تجمع المياه وما الى ذلك
Describe other features _____ وصف المعالم الاخرى

المصارف الخارجية و التنظيف (مواقف سيارات، مباني، مناطق القمامة والنفايات، وما الى ذلك)
OUTSIDE WASHDOWN AND CLEANING (parking lot, building, dumpster area, etc.)

Pressure washer used (Yes) (No) هل يتم استخدام آلة غسيل تعمل بالضغط (نعم) (لا)
Garden hose used (Yes) (No) هل يتم استخدام خرطوم مياه حديقة (نعم) (لا)

) (نعم) (لا)nozzlesإذا كان الجواب على البند السابق نعم، هل الخرطوم معد بفوهة إغلاق (
Shut-off nozzles on hose, if hose used (Yes) (No)

هل يمكن استبدال أعمال التنظيف الخارجية التي تستخدم المياه بأدوات التكنبس أو النفخ (للاوراق مثلاً) (نعم) (لا)
Can sweeping & blowing substitute for outdoor cleaning? (Yes) (No)

هل يوجد لديكم معدات لغسل السيارات أو المركبات (نعم) (لا)
Car or vehicle washing equipment? (Yes) (No)

Other outdoor uses: _____ غيرها من الاستخدامات الخارجية
_____

LAUNDRY FACILITIES **منشآت الغسيل**

Number washers available for use _____ عددالغسالات المتوفرة للاستعمال
Number of loads washed per month _____ ما هو عدد الأحمال في الشهر
On Premise Commercial Laundry Equipment هل يتم استخدام معدات غسيل لأغراض تجارية في الموقع
Capacity (Kilo) for each _____ القدرة الاستيعابية للغسالة (كيلو)

عدد الأحمال للملابس ذات الأوساخ الخفيفة لكل يوم _____
Number of loads per day for lightly soiled items _____

عدد الاحمال ذات الأوساخ الثقيلة لكل يوم _____
Number of loads per day for heavily soiled items _____

يوجد إعادة تدوير للمياه أو هل يتم استخدام معدات للمعالجة بالأوزون (نعم) (لا)
Water recycle or ozone equipment used (yes) (No)
_____

CLEANING AND OTHER INDOOR USES **التنظيف والإستخدامات الداخلية الأخرى**

نظافة الخزائن التي يحتفظ فيها بمواد وأدوات التنظيف ووضع أحواض الغسيل من حيث النظافة_____ _____
Janitorial closet or sink condition:_____ _____

عدد المرات التي يتم فيها المسح في اليوم _____ مصدر المياه الخاصة بالمسح_____ إستخدام الخرطوم العادي للشطف _____
Moping/Day: _____ Source of mop water:_____ Hose down: _____

إذا كان الخرطوم هو المستعمل ، هل يوجد عليه فوهة رشاش (نعم) (لا) وما هو مقدار التدفق _____ لتر / دقيقة
Does hose have spray nozzle (yes) (no) – what is flow rate _____ litter per minute

هل هو من النوع الذي يستخدم أنبوب معقم مائي (نعم) (لا)
Floor cleaning machine (wet vacuum type) (yes) (no)
Water broom (yes) (no) هل يوجد مكنسة تستخدم المياه (نعم) (لا)

TOTAL WATER USAGE

Total Metered Water Use:

Main Meter Units (thousands of liters, cubic meters, etc.) _____
وحدات العداد الرئيسي (الاف الليترات، مترات مكعبة، إلخ)_____

Amount for last year: الكمية للسنة الماضية

January كانون الثاني	February شباط	March اذار	Q1 (total)
April نيسان	May أيار	June حزيران	Q2 (total)
July تموز	August اب	September أيلول	Q3 (total)
October تشرين الأول	November تشرين الثاني	December كانون الأول	Q4 (total)

Water purchased from private sources المياه التي تم شراؤها من مصادر خاصة

Main Meter Units (thousands of liters, cubic meters, etc.) _____
وحدات العداد الرئيسي (الاف الليترات، مترات مكعبة، إلخ) _____

Amount for last year: الكمية للسنة الماضية

January كانون الثاني	February شباط	March اذار	Q1 (total)
April نيسان	May أيار	June حزيران	Q2 (total)
July تموز	August اب	September أيلول	Q3 (total)
October تشرين الأول	November تشرين الثاني	December كانون الأول	Q4 (total)

Other water sources مصادر المياه الأخرى

Main Meter Units (thousands of liters, cubic meters, etc.) _____
وحدات العداد الرئيسي (الاف الليترات، مترات مكعبة، إلخ)_____

Amount for last year: الكمية للسنة الماضية

January كانون الثاني	February شباط	March اذار	Q1 (total)
April نيسان	May أيار	June حزيران	Q2 (total)
July تموز	August اب	September أيلول	Q3 (total)
October تشرين الأول	November تشرين الثاني	December كانون الأول	Q4 (total)

List Sources: _____عدد المصادر

5.5 8.2 Appendix B

List of organizations and firms that participated in the audits:

- Water Demand Management Unit (WDMU) of the Ministry of Water and Irrigation (MWI)
- Water Authority of Jordan (WAJ)
- Northern Governorates Administration (NGWA)
- Miyahuna
- Aqaba Water Company (AWC)
- Royal Scientific Society (RSS)
- National Energy Research Center (NERC)
- JUST University
- Consolidated Consultants (CC)
- Center for Engineering Consultancy (CEC)
- ME POWER
- Orient for Engineering Consultancy and Design
- ECO Consult
- Energy Management Services (EMS)
- Green Tech for Sustainable Environment
- Inter-Disciplinary Research Consultant (IDRC)
- Total H2O
- Engicon