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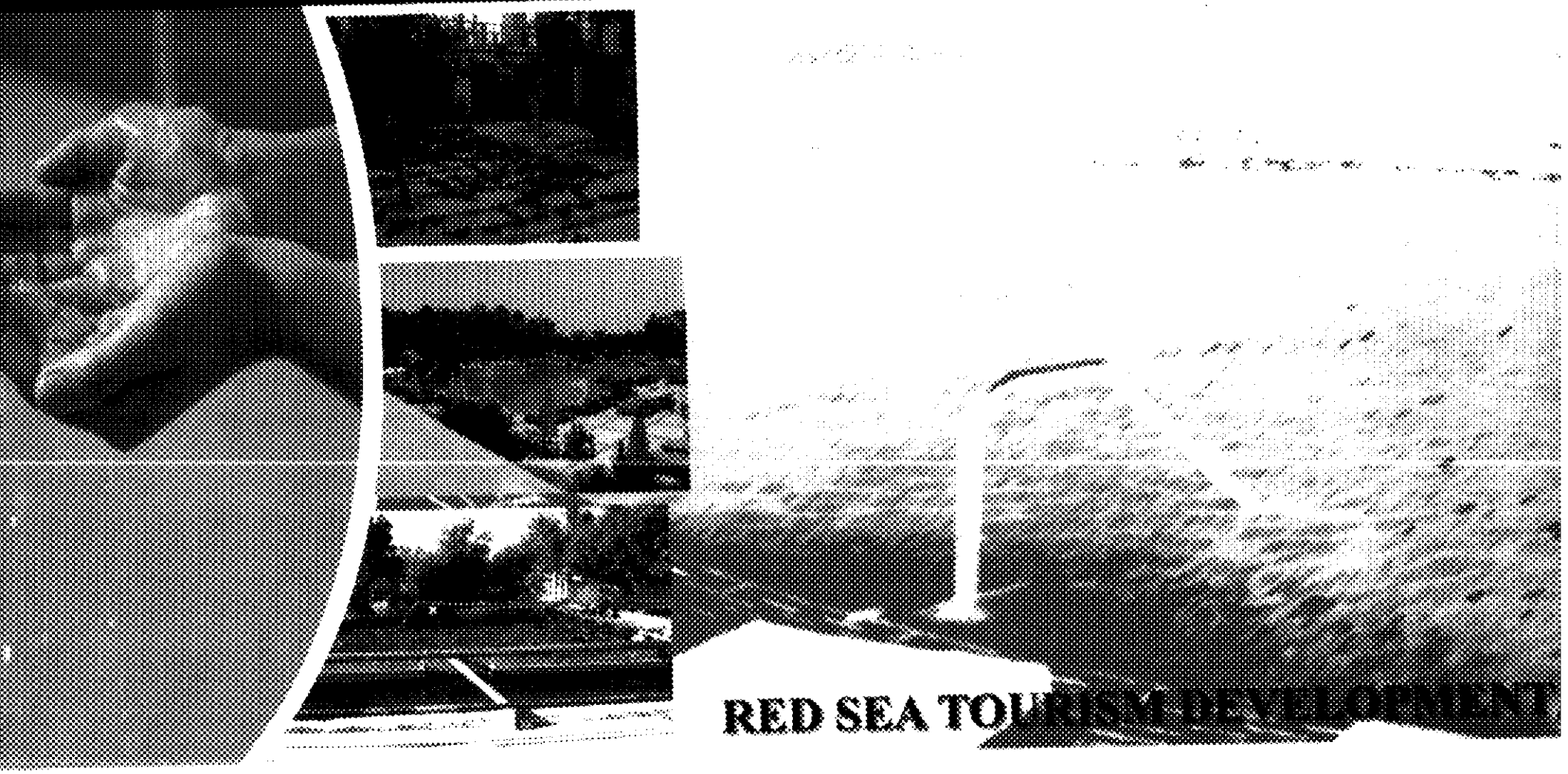
Water and Sanitation

Best Practices



RED SEA TOURISM DEVELOPMENT

BEST PRACTICES
for
WATER &
SANITATION SYSTEMS

This document was prepared under the Red Sea Sustainable Tourism Initiative, which is part of the United States Agency for International Development (USAID/Egypt)'s Egyptian Environmental Policy Program (EEPP) implemented in cooperation with the Egyptian Tourism Development Authority (TDA). The Red Sea Sustainable Tourism Initiative project is implemented by PA Government Services Inc., a wholly-owned subsidiary of PA Consulting Group under the USAID IQC # LAG-I-00-99-00019-00 Task Order 807.

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Comments and suggestions regarding this document are welcomed. Please bring any errors or omissions to the attention of the Tourism Development Authority/Red Sea Sustainable Tourism Initiative.

21/23 Giza Street,
Nile Tower, 7th Floor
Giza,
Egypt.

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Patricio Gonzalez Morel, author
Dr. Mahmoud Abdel Azim, technical review
Amy Doll, editor
Tarek Rached, Graphic Design
Ayman Mansour, formatting
And
Ihab Shaalan, coordination and supervision

From the Tourism Development Authority:

Eng. Mohamed Ali
General Manager of the Environment Department , RSSTI Project Manager

Dr. Hisham Hafez
Consultant to TDA

Wael Barakat
Planner, Planning Department

Abeer Abdel Rahman
Architect, Project Review Department

Hossam El-Din Anwar
Planner, Project Review Department

Foreword

Responding to the increasing demand for leisure tourism on the Red Sea, the Tourism Development Authority, TDA, has put into effect plans to ensure that the Red Sea region is ready to receive thousands of tourists who wish to spend their vacations in a pristine environment. While the development strategy of the Red Sea region relies on the private sector, TDA plays a vital role in guiding developers to adopt the highest quality standards in design, construction and operations.

TDA recognizes that the Red Sea natural environment is the main asset upon which all tourism activities rely. Understanding that any development or human activity may have negative impacts if not properly managed, TDA has developed regulations and legal requirements intended to prevent degradation of the natural environment. It is however TDA's policy when dealing with developers to encourage rather than discourage, provide incentives rather than penalize and guide rather than command.

In view of this policy and the advisory role we play, TDA, with funding from the US Agency for International Development (USAID) introduced the "Best Practices for Tourism Center Development along the Red Sea Coast" for the first time in 1998. That document introduced the main concepts of Best Practices in environmental planning and design of tourism destinations. It touched upon many topics of environmental concern and introduced the framework for tourism development and environmental protection.

Five years later, greater environmental awareness has emerged and more practitioners are seeking guidance. To fulfill these needs, TDA, through the Red Sea Sustainable Tourism Initiative (RSSTI), introduces the updated Best Practices Manuals.

The new Best Practices Manuals are more comprehensive in addressin key issues of environmental concern in the Red Sea region such as: Soli Waste Management, Landscape Architecture, Landscape Planting, Wate & Sanitation, Energy Efficiency and Environmental Management fc Resorts. The documents contain practical examples and information t guide developers as well as practitioners in the field of tourism developmer during the development process of a tourism center or resort from th planning phase to design, construction and operational phases. The Bc Practices Manuals are neither intended to be used as text books nor a a "How To" type of reference. Instead, they ***highlight*** for the develope and consultants, the main issues to be considered in each phase of th development. It is then left to the professionals in each field to select th design and the practice that is appropriate to their development purpose

Finally, the TDA is committed to continually update the Best Practicc Manuals periodically according to the new needs of developers and t cope with the latest innovations in the field of sustainable tourism. It hoped that by issuing and publishing these manuals, greater environment awareness will be created encouraging all of us to protect the unique Re Sea environment.

Eng. Mohamed Magdy Kobaicy
Chief Executive Officer
Tourism Development Authority

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About this Manual

This manual was prepared by the Red Sea Sustainable Tourism Initiative (RSSTI) – a project under the Egyptian Environmental Policy Program (EEPP), funded by the US Agency for International Development (USAID) and implemented by the Egyptian Tourism Development Authority (TDA). PA Government Services is providing technical assistance to TDA under USAID IQC # LAG-I-00-99-00019-00, Task Order #807. The overall objective of RSSTI is to assist in development and dissemination of environmentally sound practices for the design, construction and operation of tourism centers and resorts along the Red Sea Coast. RSSTI's core work areas are:

- Environmental Best Practices,
- Environmental Impact Assessment (EIA),
- Environmental Monitoring,
- Land Use Management and Environmental Planning, and
- Sustainable Tourism Awareness.

Best Practices for Water and Sanitation is one in a series of best practice manuals produced by RSSTI that also includes manuals on :

- Landscape architecture,
- Solid waste management,
- Energy Management , and
- Landscape planting

Although this manual discusses a specialized subject, yet a simple technical language is used so that it is understandable by readers of different disciplines and backgrounds. It specifically targets investors as well as managers of Red Sea coastal resorts. It will provide them with guidelines to evaluate the water and sanitation practices in their resorts. The guidelines can be used as a basis for discussion with the consultants, contractors, equipment suppliers, and operation and maintenance staff to improve water efficiency and reduce both water demand and costs.

The Best Practices for Water and Sanitation manual focuses on existing and future resorts on the Red Sea coast. It includes guidelines for improving the water efficiency of existing buildings through retrofits. It covers the issue of water-efficient equipment and their standards to ensure minimum water consumption and how this is cost effective.

Design and selection of wastewater treatment systems as well as efficient operation requirements are also presented and assessed.

Best Practices for

Water & Sanitation Systems

in Red Sea Tourism Centers

I

Framework and requirements for the planning and implementation of water and sanitation systems for tourism centers

II

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Guidelines for the design, construction and Operation of Sanitation systems

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Water and Sanitation Systems for Coastal and desert eco-tourism properties

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I

Framework and requirements for the planning and implementation of water and sanitation systems for tourism centers

1- The Water and sanitation project requirements

1- The Water and sanitation project requirements

The water and sanitation sectors play an important role in the early stages of tourism development, constituting between 15 20 percent of a project's total estimated cost. The possibility of installing such systems will determine the very existence of a project and may be the limiting factor for a project's success This guidebook will list requirements and define needs, allowing investment parties to determine the optimum selection and application of water and sanitation systems. Experiences highlighting successes and failures will be included to allow for optimizing proposed solutions. Principles of best practice for conservation and pollution prevention will be considered. Ten years ago, the Egyptian Ministry of Housing, Utilities, and Urban Planning (MHUUP) released the Egyptian Building Code in a multi-volume publication. However, in the field of tourism there is no specific code that applies, and no enforcement of any code. Various codes are applied virtually at the whim of the investor, construction manager, or contractor.

The Egyptian code may be applied to water and sanitation networks; however, there is no current code for desalination plants or wastewater treatment plants of the size and scale used in tourism projects. Well-organized, well-managed, and integrated development projects may apply codes properly and solicit inspections. Minor projects, however, are less likely to either solicit such inspection or to be the target of attention from the overburdened bureaucracy. Unfortunately, in the case of water and sanitation systems, the majority of problems arise during the stage of operations and maintenance.

The Egyptian Tourism Development Authority requires developers to identify sources and methods of supplying potable water and ways of disposal of wastewater. In the documents submitted by the developer, technical reports and drawings should be submitted showing the water supply, sewage, irrigation and fire networks.

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I

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Water and Sanitation Systems for Coastal and desert eco-tourism properties

II

Guidelines for the design,construction and Operation of Water systems

2- Water needs of the project

3- Water conservation - equipment issues

4- Water conservation - operational issues

5- Water sources

6- Water storage tanks

7- Water pressurization system

8- Water distribution system

2- Water needs of the project

One of the first steps in the design of a tourism property's water system is evaluating its required water supply capacity, that is, the maximum volume of water the property is expected to consume when operating at full occupancy. This evaluation needs to be done with care because the property's required water supply capacity will affect many important elements in the planning and design of its water and sanitation installations, including the selection of the water source, the selection of the wastewater treatment option, and the detailed engineering design of the water supply and wastewater collection and treatment systems[1].

Estimating the required water supply capacity is unfortunately not an easy process as there are, in addition to the number of rooms or the maximum number of guests, three other key parameters that greatly affect the actual water consumption of a project:

- Star rating or classification of the hotel,
- Number of employees housed in the hotel or in adjacent staff quarters, and
- Irrigation needs of the property.

Impact of star rating on the property's water consumption - To assist project designers, the TDA has developed a list of proposed design water consumption (PDWC) indices, which can be used to obtain a preliminary estimate of a hotel's required water supply capacity (see Table 2.1).

[1] The project team should also take into account the impact of the property's future expansion plans on its long-term required water supply capacity and water and waste water infrastructure. In some cases, it may be beneficial to base the design of certain elements of the water and wastewater system on the larger expected flows.

Table 2.1. TDA's proposed design water consumption for tourism hotels

Hotel classification	Proposed design water consumption	Required water supply capacity of the hotel (m^3/day)
5-star	0.80 m^3/room.day	(number of rooms) x (1.0 m^3/room.day)
4-star	0.70 m^3/room.day	(number of rooms) x (0.70 m^3/room.day)
3-star	0.50 m^3/room.day	(number of rooms) x (0.60 m^3/room.day)

Figure 2.1 The use of water-intensive vegetation, inefficient irrigation technology, and poor irrigation practices will greatly increase the property's irrigation requirements (e.g., manually irrigating turf grass during daytime hours)

It is important to note that these indices account only for the domestic water needs of the hotel (i.e., the water consumed in guestrooms, front-of-house areas, back-of-house areas, pools and other guest facilities) and, therefore, exclude the fresh water needs of its gardens and of any on-site staff housing. In addition, these figures are intended to apply only to hotels that strive to use water efficiently -- for example, by installing water-saving plumbing fixtures throughout their facilities, providing adequate maintenance to their equipment and installations, and practicing other sound water conservation measures (see chapters 2 and 3).

Impact of on-site staff housing on water consumption - Any property that plans to house a significant number of employees on its premises must adjust its required water supply capacity to account for the water that will be consumed by the staff quarters. The proposed design water consumption for employees who are housed on-site is 0.30 m3/ employee.day[2].

Impact of irrigation on water consumption - Given Egypt's arid climate, irrigation can have a huge impact on the required water supply capacity of any property that does not have access to treated wastewater for irrigation or whose irrigation needs exceed the output of its wastewater

[2] Example - The required total water supply capacity of a 100-room, 5-star property which houses 75 employees on site is calculated as follows:
Required water supply capacity of the hotel = 50 rooms x (1.0 m3/room.day)
Required water supply capacity of the staff quarters
= 75 employees x (0.3 m3/employee.day)
Total required water supply capacity = 50 m3/day + 22.5 m3/day
= 72.5 m3/day (excluding irrigation needs

treatment system. For instance, the irrigation needs of one of the Red Sea properties assessed by RSSTI accounted for 55% of its total fresh water consumption and costs (i.e., 115,300 m3 and US$ 290,000 per year). This 310-room property was unfortunately not able to rely on wastewater irrigation because its effluent was processed in a centralized wastewater treatment plant and then used to irrigate the IDC's golf course

The total water needs of a property's gardens is largely a function of four key factors:

(a) the suitability of the vegetation to the local climate,
(b) the use of water efficient irrigation technology,
(c) the use of water-efficient irrigation and gardening practices, and
(d) the size of the irrigated areas.

The project team will need to carefully account for these factors when determining the future water needs of the gardens and the impact that irrigation will have on the property's required water supply capacity.

Table 2.2. Impact of key factors on the irrigation needs of a property

Factor	Effect on the total water needs of the gardens
Suitability of the garden's vegetation to the local climate	The use of vegetation that is not well suited to Egypt's arid climate can greatly increase the water needs of the gardens. For instance, a study conducted by RSSTI in a 240-room Red Sea hotel revealed that approximately 50% of its irrigation water was used to water the lawns that covered only 10% of its gardens. In other words, a square meter of this property's turf grass consumed nine times more water than a square meter of the drought resistant vegetation planted in the rest of the gardens.
Use of efficient irrigation technology	The average efficiency of common irrigation practices are as follows: 50% or less for flood irrigation, 70% for sprinkler irrigation, 90% for drip irrigation. A property that relies on flood or sprinkler irrigation can therefore reduce the water needs of its garden by approximately 20 to 45% by switching to drip irrigation.
Use of water -efficient irrigation & gardening practices	The use of simple water-efficient irrigation and gardening practices can have a substantial impact on a property's irrigation needs. For instance, watering the gardens during the coolest hours of the day (i.e., from sunset to sunrise) can reduce the consumption of irrigation water by more than 25%. Additional information on water-efficient irrigation and gardening practices can be found in chapter 5.7 of TDA's "Environmental Management Guidelines for Coastal Hotels and Resorts - Volume 1".
Size of the irrigated areas	In a property with uniform garden composition and irrigation practices, the total irrigation needs should vary directly with the size of the gardens. According to RSSTI's experience along the Red Sea coast, the consumption of water per square meter of irrigated land ranges from 1,000 liters/year for an efficient garden to 2,500 liters/year for a medium-efficiency garden.

3- Water conservation - equipment issues

Experience worldwide has amply demonstrated that building water-efficient hotels makes a lot of sense, and particularly so in areas where water is scarce or expensive. Water conservation can benefit a property in many ways.

1) It reduces the utility bills if the water is purchased from a local water supplier, or the operating cost of the reverse osmosis (RO) desalination plant if the property produces its own water.
2) It reduces wastewater management costs whether the property is connected to a local sewerage network or operates its own wastewater treatment and disposal system.
3) It improves the performance of the wastewater treatment system and the quality of the treated effluent and, therefore, reduces the potential health risks of treated wastewater irrigation.
4) It lowers energy consumption and costs by reducing the operation of water and wastewater pumps, and reducing the volume of hot water consumed by the property's plumbing fixtures and equipment.
5) It enhances the long-term sustainability of the property's water source.
6) It improves guest satisfaction, for example, by minimizing pressure fluctuations in the water distribution system and eliminating hot water shortages.

The planning and design phases offer a unique opportunity to include important water conservation features throughout the property, in particular in the design of the water pressurization and supply systems, the selection

Figure 3.1 Pressure reducing valve installed on a water supply line

of plumbing fixtures and appliances, the layout and composition of green areas, and the design of the irrigation system. Although many water-efficient fixtures and features can be retrofitted in inefficient properties, the cost of a water conservation retrofit is always much greater than that of a well-designed initial installation.

The main water conservation measures that should be considered during the planning and design phases of the project are summarized below.

- Design the water pressurization and distribution system to provide a reasonably low water pressure throughout the property. Most hotels can operate normally with a water pressure of 2 to 4 bars (30 to 60 psi).
- Install pressure reducing valves in areas of the property that are subjected to excessively high water pressure.
- Use a primary water meter to monitor the property's total water consumption.
- Use sub-meters to monitor water consumption in high-use areas of the property, such as staff living quarters, large guestroom blocks, back-of-house facilities, swimming pools, and irrigation systems.
- Install isolation valves in key points of the water distribution system to facilitate the maintenance of the property's water supply lines and plumbing fixtures.
- Use effective low-flow showerheads, which consume less than 9.5 liters/minute, in all areas of the property.
- Install self-closing valves to control the operation of pool or beach showers and foot-wash taps. These valves have a spring-loaded mechanism that shuts off the flow a short time after the valve's lever, push-button or chain is released

- Consider installing only showers in guest bathrooms instead of the standard shower and tub combination. Filling a typical bathtub can consume up to 150 liters of water, or about 60% more than a 10-minute shower taken with a low-flow showerhead.
- Carefully evaluate the total impact that whirlpool tubs (jacuzzis) can have on the property's utility costs and maintenance requirements before deciding to install them in guestrooms. Depending on their size, whirlpool tubs can consume from 150 to 450 liters per use, or a volume of water equivalent to a 15 to 50-minute shower. They will also increase the workload on the maintenance staff by adding a motor, a pump, a set of controls and, possibly, an electric water heater in each guestroom that is equipped with a whirlpool tub.
- When selecting sinks or tubs that are equipped with "pop-up" stoppers, ensure that the stoppers operate effectively or, at least, can be easily repaired or replaced.
- Use faucets that produce a flow of 6 liters/minute or less in guestrooms, public restrooms, staff changing rooms, and staff bathrooms.

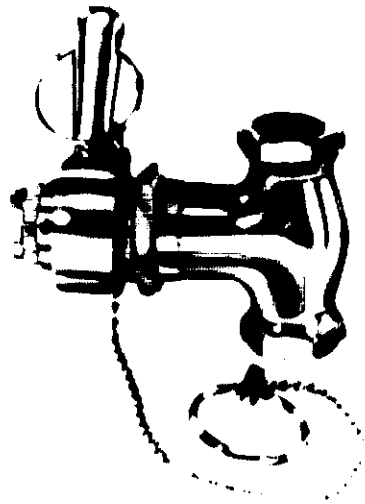


Figure 3.2 Self-closing shower valve

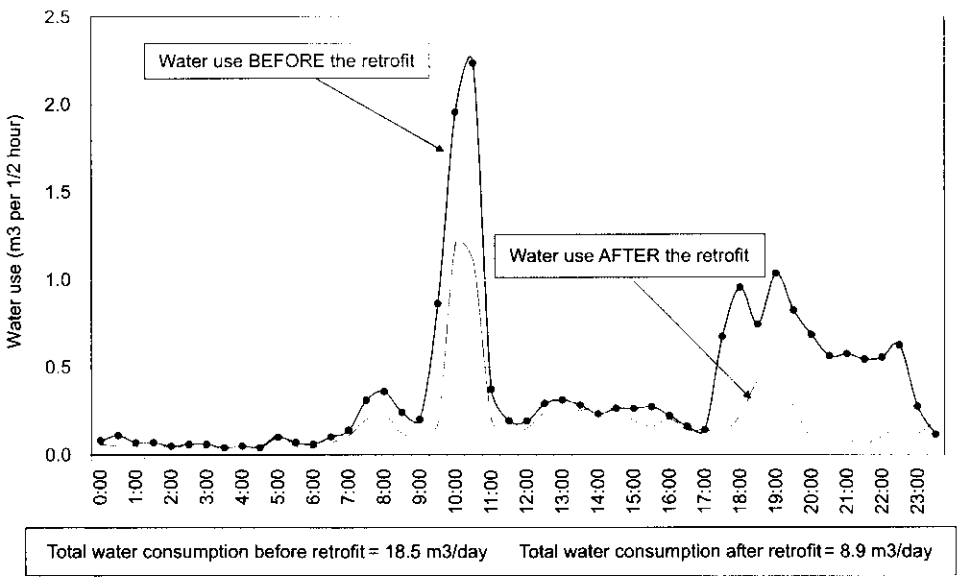


Figure 3.3 water use profile of a guestroom block (14 rooms, 25 guests) before and after the water conservation retrofit

"This data was collected over two consecutive days, during which the same 25 guests occupied the same 14 rooms "

Case study -
Impact of using water efficient plumbing fixtures and implementing simple water conservation measures in hotel guestrooms

The figure below shows the daily water consumption curve of a guestroom block in a Red Sea coast hotel before and after the guestrooms were given a water conservation retrofit. This water conservation retrofit consisted of:

- Installing flow restrictors in the existing inefficient hand-held showerheads to reduce their flow output to less than 9 liters/minute;
- Replacing the existing inefficient faucet aerators with new aerators to reduce the maximum faucet output to less than 6 liters/minute;
- Repairing toilet leaks; and
- Adjusting the water level in the toilet water tanks to the recommended height.

The water conservation retrofit carried out in the 14 rooms of this guestroom block required only a total of two man-hours of labor and US$ 62 worth of materials (that is, one US$ 3.50 aerator and one US$ 0.90 flow restrictor in each guestroom). In return, this retrofit reduced the guestrooms' water consumption by 52% or 384 liters per guest-night. Since this 150-room hotel had an average occupancy of 68,900 guest-night/year and a water cost of US$ 2.92/m3, it was estimated that giving a similar water conservation retrofit to all guestrooms could have reduced water consumption by 26,400 m3/year and saved US$ 77,000/year.

- Use faucets that produce a flow of 9.5 liters/minute or less in work areas such as kitchens, bars, food outlets, laundry rooms, and linen rooms.
- Consider installing metering faucets in staff and public restrooms. Metering faucets are equipped with a mechanism that either limits the duration of the flow or activates the flow only when the user's hand is under the faucet.
  Consider installing pedal or knee valves to control the operation of frequently used kitchen and bar faucets
- Consider installing self-closing spray valves in kitchen pot sinks or in the dishwasher's pre-rinse station.
- Use water-saving toilets that consume no more than 6 liters/flush in all guest, staff and public bathrooms.
- Use water-saving urinals that consume no more than 4 liters/flush in staff and public bathrooms. Several manufacturers produce urinals that consume as little as 2 liters/flush.
- Ensure that the water-efficient fixtures selected for the project (water-saving toilets and low-flow showerheads in particular) perform as expected and have a proven track record.
- Take water-efficiency into consideration when selecting appliances such as laundry washers and dishwashers. Efficient appliances have a higher initial cost than their standard-efficiency counterparts, but this cost difference is generally small compared to the water and

Typical Costs of Water-efficient Plumbing Fixtures

Low-flow showerheads: The cost typically ranges from US$ 10 to 30 per guestroom low-flow showerheads, and US$ 5 to 20 for tamper-proof low-flow showerheads suitable for public areas (e.g., beach and pool showers) or staff changing rooms.

Water-saving toilets : The cost of a basic 6-liter/flush toilet typically ranges from US$ 100 to 200. More stylish models can cost more than US$ 400, however, the main difference between the luxury and basic toilet models is aesthetics rather than performance.

Faucet aerators: In the US, the cost ranges from US$ 1 to 2 for standard aerators, US$ 2 to 4 for tamper-proof aerators, and US$ 4 to 10 for dual-spray aerators for kitchen and bar faucets.

Metering faucets: The cost of metering faucets varies widely depending on type, brand, style, quality and features. In the US, the cost ranges from US$ 300 to 400 for electronic metering faucets, and from US$ 75 to 150 for mechanical (spring-loaded) metering faucets.

Pedal valves : The cost of pedal valves for kitchen and bar faucets ranges from US$ 100 to 500

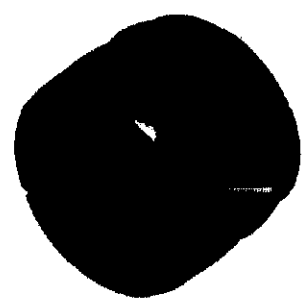


Figure 3.4 An aerator can be used to limit the maximum output of a faucet to 9.5 liters/minute, 6 liters/minute or less (Neoperl, www.Neoperl.com)

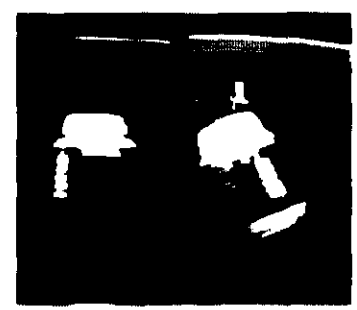
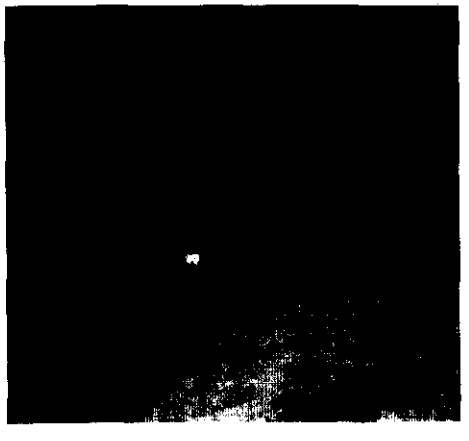


Figure 3.5 Dual-spray aerator for kitchen and bar faucets (www.amconservationgroup.com)

Figure 3.6 Mechanical metering faucet (Chicago Faucet, www.chicagofaucet.com)

Figure 3.7 Pedal valves installed under a kitchen sink
(Pedal Valves Inc.,www.pedalvalve.com)



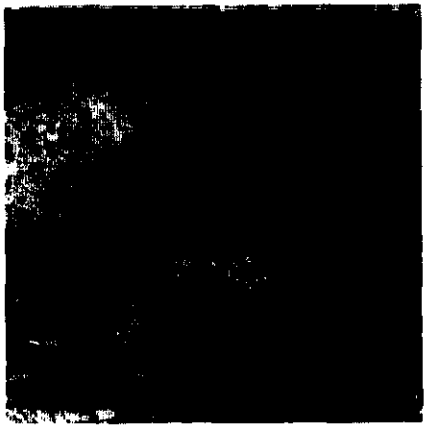


Figure 3.8 and 3.9 Drip irrigation systems commonly used in Red Sea hotels

energy savings achieved by the higher-efficiency appliances.

- Select ice making machines that are equipped with air-cooled rather than water-cooled condensers. Water-cooled ice making machines consume 10 to 25 liters of water per kg of ice produced, or approximately 10 times more water than air-cooled machines.
- Consider using a sea water swimming pool. Given the weather conditions along the Red Sea coast, swimming pools consume a large volume of fresh water to compensate for evaporation losses.
- Carefully consider the water needs of plants before they are widely introduced into the gardens, and avoid or minimize the use of species that are poorly suited to the local climate (e.g., turf grass).
- Install an efficient irrigation system that can be easily controlled to facilitate the irrigation of the grounds during the night and early morning hours when evaporation losses are low.[3]
- Properties that do not have access to treated wastewater should ensure that their gardens are water-efficient and consider collecting and using their graywater for irrigation.

Additional information on many of these water conservation measures can be found in Chapter 5 of TDA's "Environmental Management Guidelines for Coastal Hotels and Resorts - Volume 1".

[3] The impact of proper plant selection, irrigation technology, and irrigation practices on the amount of irrigation water consumed by Red Sea hotels is discussed in greater detail in chapter 12 of this document

4- Water conservation - operational issues

As discussed in the preceding chapter, the proper design of the water supply system, layout and composition of the landscaped areas, and selection of plumbing fixtures, equipment and irrigation technology can greatly reduce a property's water needs. However, these water-efficient features can be effective in the long run only if they are properly operated and maintained. As such, the property should give as much attention to operational and maintenance issues as to the technical details of its water conservation features.

The principal operational and maintenance issues that should be implemented by the property are summarized below. It is important to note that many of these issues should be addressed during the design phase of the project and are not, as is often assumed, the sole responsibility of the hotel's operator.

- Devise an effective preventative maintenance program for the property's water supply system, plumbing fixtures, and water-using equipment. The design team and the equipment suppliers should provide most of the information that is needed to develop this program and draft the preventative maintenance manual
- Reduce the property's future maintenance load by taking into account maintenance concerns in the detailed design of the water system. The selection, configuration and layout of the equipment and installations should be done in a way to minimize maintenance needs and facilitate the expected maintenance operations.

Impact of Poor Maintenance on Water Consumption in a Red Sea Hotel

It is well known that the lack of an effective maintenance program affects the water and energy efficiency of hotels, but many hoteliers fail to realize the magnitude of the impact it can actually have on their utility consumption and costs. Unfortunately, the potential impact can be enormous.

The figure below shows the distribution of water consumption at a 150-room, 5-star hotel located on the Red Sea coast. This property had an excellent preventative maintenance program for its guestrooms and public areas, but largely overlooked the maintenance needs of the back-of-house areas and, in particular, of the staff quarters, which were plagued with leaks and malfunctioning plumbing fixtures. As a result, the staff quarters ended up consuming three times more water than the 150 guestrooms, the two main kitchens, and all front-of-house areas. The volume of water consumed by the modest staff bathrooms amounted to 24,800 m3/year and cost the hotel US$ 47,000/year.

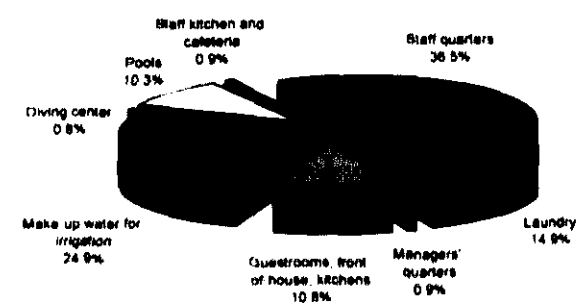


Figure 4.1 Distribution of water consumption at a 150-room, 5-star Red Sea hotel

Effect of a Towel Reuse Program on Laundry Operations

The impact of implementing an effective towel reuse program in a "typical" 150-room hotel is as follows:

- reduction in amount of laundry processed = 49,500 kg/year
- reduction in number of washer and dryer loads = 3,960 full loads/year in a 25-kg washer and 25-kg dryer
- reduction in water use = 1,040 m3/year
- reduction in electricity use = 15,900 kWh/year
- reduction in detergent use = 370 kg/year
- reduction in bleach use = 140 kg/year

In addition, the adoption of a towel reuse program increases the service life of the laundry's washers and dryers, reduces the maintenance requirement of the laundry's equipment, minimizes the wear and tear on the towels, and reduces the labor requirements in the laundry.

Note : The savings shown above are based on the following assumptions: the hotel has a 60% average occupancy rate; there are on average 2 guests per occupied room; the towel reuse program reduces the total weight of towels processed by the laundry by 40%; and the laundry is equipped with an electric water heater and dryer

- Devise a water monitoring program to track the property's water consumption and detect leaks.
- Draft standard operating procedures (SOPs) for all activities that have or can potentially have a large impact on the property's water consumption. Examples of such activities include:
  - Operation and supervision of the water supply and pressurization system,
  - Operation of the irrigation system,
  - Pool maintenance (e.g., backwashing of sand filters),
  - Upkeep of decorative fountains, and
  - Operation of laundry washers and kitchen dishwashers.

The design team and equipment suppliers should provide most of the information that is needed to draft these SOPs.

- Adopt strategies to reduce the volume of dirty laundry that must be processed by the property. Laundry operations typically account for 10 to 20% of indoor water use and thus have a large impact on the property's water efficiency.
  - Put in place a towel reuse program to invite the guests to use their bath towels for more than a day. Ensure that the guest bathrooms are equipped with racks or hooks where the towels can be conveniently left to dry, and that the housekeepers are trained to respect the decision of the guests who choose to reuse their towels
  - Devise a similar reuse program for beach or pool towels. In many beach hotels, the total weight of beach/pool towels that is laundered on a daily basis is greater than that of guestroom towels.

- Put in place a bed linen reuse program. This program can be either voluntary or the property can simply implement a policy of changing bed linens every two or three days.
- Avoid using excessively heavy blankets and bedspreads. The weight of blankets and bedspreads should be suited to the local climate.
- Avoid triple-sheeting the beds.
- Consider making beds without a blanket during the hottest months of the year (the blankets could be stored in the guestroom closet).
- Consider using hard-top place mats instead of tablecloths in restaurants

• Include water conservation issues in the staff training activities and ensure that employees practice water conservation in their daily activities.
• Inform the guests and invite them to participate in the hotel's water conservation efforts.

Additional information on these water conservation issues can be found in Chapter 5 of TDA's "Environmental Management Guidelines for Coastal Hotels and Resorts - Volume 1".

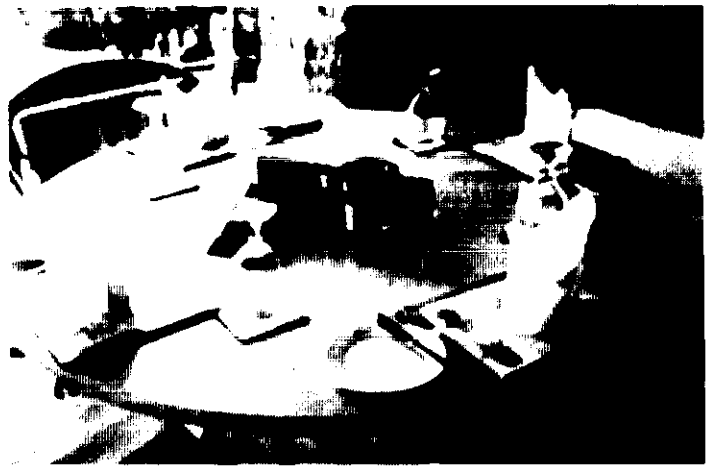


Figure 4.2 Table set with hardtop place mats and coasters rather than a table cloth

" Experience in hotels has shown that these relatively simple measures can cut the laundry load by more than 50%. In addition to saving water, reducing the volume of items processed through the laundry will also significantly reduce the laundry's labor requirements, its energy and chemical consumption, and the wear and tear on the washers and dryers."

5- Water sources

The water source options available to coastal and desert tourism hotels typically fall into one of the following categories.
1) A direct connection via a pipeline to an existing water system (e.g., a municipal water distribution system) or a desalination plant operated by an independent water supplier.
2) An indirect connection via tanker trucks to an existing water system.
3) The operation of a desalination plant by an individual property.
4) The operation of a desalination plant by a group of neighbouring properties within the context of an IDC.

Project planners should carefully evaluate the applicability, benefits and drawbacks of each of these options before deciding on the water source that best fits the needs and limitations of the property. The final choice of water source will largely depend on the factors that are discussed below.

Water needs of the property - The water needs of the property can often preclude some of the possible water source options. For instance:

- Because of cost and logistical considerations, the option of trucking water from an existing desalination plant is typically suited only to small properties that have an average water need of 50 m3/day or less.
- A property with medium to large water needs (250 m3/day or greater) will in most cases be unable to find an existing water source that is able to meet this demand.
- A property with small water needs (50 m3/day or less) should consider installing its own desalination plant only if there are no other alternatives,

Figure 5.1 Mechanical vapor compression distillation units used in a large IDC-operated desalination plant

or it can guarantee that the plant will be properly operated either by its own well-trained engineering staff or by a competent outside contractor.

The possibility to form an IDC or locate the property in an existing IDC - Establishing or joining an IDC with centralized utility services is generally the best alternative for tourism projects, and should be particularly attractive to properties, large or small, that do not have access to an existing water source. Although forming or joining an IDC will require some effort on the part of the owners, this option offers many advantages

- The IDC structure allows properties to pool their technical and financial resources to design, build and operate an effective centralized desalination plant.
- An IDC-operated desalination plant relieves the individual properties from the need to maintain, operate and monitor their own plants. It also shifts to the IDC the responsibility for the proper disposal of the brine produced by the desalination plant.
- A large centralized desalination plant produces water at a lower unit cost than a smaller system

Proximity and capacity of existing systems - Obtaining water from an existing system should be an ideal solution for any property that is unable to participate in an IDC. Unfortunately, the applicability of this option is often restricted by the lack of utility infrastructure in many tourism development areas, and by the limited surplus capacity of the existing desalination plants.

Acceptability and reliability of the water source - The TDA will not approve a project unless it has access to a reliable and adequate source

of water. The TDA's requirements are as follows:

- Any property that plans to obtain its water from an existing source must have a suitable long-term supply contract with the system's operator.
- Any property or IDC that plans to build a desalination plant must conduct a hydrological study to evaluate the possibility of supplying the plant with groundwater, and, if applicable, to determine the location of the groundwater extraction well(s) and brine injection well(s). The results of this study must be presented to both the TDA and the Egyptian Environmental Affairs Agency (EEAA).
- Regardless of its source and form of treatment, the water used for human consumption must meet the chemical and biological quality criteria that required by the TDA (see Table 5.1 and table 5.2) .

Suitability of the RO plant's brine disposal system - The brine produced by desalination plants must be disposed of in a manner that minimizes the potential for environmental damage. Any property or IDC that plans to build a desalination plant will need to comply with this requirement, and prove the suitability of its brine disposal system in the Environmental Impact Assessment (EIA) it presents to the EEAA.

Quality and skills of the future system operators - The operation, monitoring and upkeep of a desalination plant requires specific technical skills and training. Poor operation practices can result in the production of water that is unfit for human use, increase the system's operating costs, and greatly reduce the service life of its components. No property should therefore consider building an on-site desalination plant unless it can guarantee that it will have the required in-house expertise or access to a competent outside contractor

Table 5.1 Chemical quality requirements for potable water

PH	7.0 - 8.5
Color "Degree" not to exceed	5.0
Taste	Not objectionable
Odor	Not objectionable
JTU not to exceed	5 .0
Total absorbed materials not to exceed	500 mg/liter
Total hardness not to exceed	100 mg/liter
Calcium not to exceed	75 mg/liter
Magnesium not to exceed	50 mg/liter
Chlorides not to exceed	200 mg/liter
Sulfates not to exceed	200 mg/liter
Iron not to exceed	0.10 mg/liter
Magnetite not to exceed	0.05 mg/liter
Copper not to exceed	0.05 mg/liter
Zinc not to exceed	0.05 mg/liter
Phenol not to exceed	0.001 mg/liter

Table 5.2 Biological quality requirements for potable water

1. 95% of samples taken in one year must not include any Colonic Bacteria
2. Any sample must never include E-Coli
3. Any sample must never include more than 10 Colonic Bacteria
4. There must not be Colonic Bacteria in two successive samples.

Disposal of the reject brine produced by reverse osmosis (RO) desalination

The desalination of brackish groundwater or sea water produces two separate flows: the product water, which consists of the potable water that is extracted from the feed water, and the reject brine, which contains most of the undesirable salts originally present in the feed water. The reject brine also contains part of the chemicals that are used in the RO desalination process, namely the feed water pre-treatment chemicals (e.g., sulfuric acid, anti-scaling chemicals) and the chemicals that are periodically used to clean the membranes (e.g., citric acid, EDTA, sodium hydroxide).

The efficiency with which a desalination plant transforms feed water into product water is defined by its recovery rate, which is equal to the ratio of the volume of product water generated to the volume of feed water processed through the system.[4] The magnitude of the recovery rate depends mainly on the quality of the feed water and the type of desalination technology used; it can vary from 15 to 95% depending of the particular characteristics of the plant and of its water source. In the case of the RO systems commonly used in hotel and IDC desalination plants, the recovery rate typically

[4] Recovery rate = $\frac{\text{(volume of product water generated)}}{\text{(volume of feed water processed)}}$

For example, a recovery rate of 40% means that 40% of the feed water processed by the plant is converted into potable water, while the remaining 60% is discharged as a reject brine. Thus, if a desalination plant with a 40% recovery rate processes 200 m3/day of feed water, it produces 80 m3/day of product water and 120 m3/day of reject brine.

ranges from a high of 80% for systems that have access to low-salinity brackish groundwater (TDS ~2,000 to 3,000 mg/liter) to a low of 25% for systems that process sea water (TDS ~45,000 mg/liter). The reject brine must be disposed of in a manner that minimizes the potential for environmental damage and, as such, the design of the desalination plant must include an effective brine disposal system. Improper disposal of reject brine can have serious environmental consequences.

- The discharge of brine on the ground or in absorption ponds (i.e., ponds that do not have an impermeable liner) will saturate the soil with salts and increase the salinity of the underlying aquifer. If the desalination plant's feed water is drawn from this aquifer, the increased salinity of the groundwater will reduce the efficiency and increase the cost of the desalination process. Facilities that adopt this inadequate practice are in fact gradually destroying their own water source.
- The discharge of brine in shallow, poorly designed, or improperly located injection wells can also contaminate the aquifer, with the same consequences mentioned in the preceding paragraph.
- The discharge of brine into the sea can affect the salinity of the sea water and harm the marine environment near the point of discharge. The magnitude of the impact on sea water quality and the marine environment depends on several factors, including the volume and composition of the brine, the location and the dilution achieved by the marine outfall structure, and the hydrographic currents in the area where the brine is discharged.

Figure 5.2 Improper disposal of reject brine in an absorption pond

The possible brine disposal options for hotel and IDC desalination plants include evaporation ponds, marine outfalls, and deep injection wells.

1) Discharge to evaporation ponds: An evaporation pond system generally consists of two or more shallow basins that are equipped with a resistant impermeable liner (the water depth in the ponds typically ranges from 25 to 45 cm). The water contained in the brine evaporates while the solids (salt) precipitate and accumulate on the bottom of the ponds. The deposited salt is typically removed every one to two years and is sold or given away to an interested party, or discarded as solid waste in an approved waste disposal site.

   The principal benefits of using evaporation ponds for brine disposal are summarized below.

   - The construction of evaporation ponds is relatively easy and straightforward.
   - Properly constructed evaporation ponds require low maintenance and operator attention.
   - The only mechanical equipment required consists of the pump that conveys the brine to the evaporation ponds. The salt that accumulates in small evaporation pond systems is generally harvested manually.
   - A properly constructed evaporation pond does not release any contaminants into the surrounding soil or groundwater and is, therefore, an environmentally sound brine disposal option.
   - In areas with high evaporation rates and low land costs, the use of evaporation ponds is often more cost effective than brine disposal by deep well injection. According to the Middle East Desalination Research Center, the construction cost of evaporation ponds in the

Sultanate of Oman ranges from US$ 7 to US$ 55/m2, with an average of US$ 19/m2 (source: Mushtaque Ahmed, 2000, Investigation of the Use of Evaporation Ponds for Brine Disposal in Inland Desalination Plants, Middle East Desalination Research Center project report 97-AS-007).

In some cases, evaporation ponds can be put to productive use and act as more than mere brine disposal systems. Some of the potential alternative uses for evaporation ponds include:

- Finfish production - Depending on the quality of the brine discharge, evaporation ponds can double up as aquaculture ponds. For example, tilapia have a salinity tolerance ranging from 25,000 to more than 40,000 mg/liter and can thus be grown in the concentration basins of the evaporation pond system.[5]
- Brine shrimp production - Brine shrimp, which are used as fish feed, can be raised even in saturated brines.
- Beta-carotene algae production - Dunaliella salina algae, a source of beta-carotene, can also be grown in highly concentrated brines.
- Salt production - The salt harvested from the evaporation ponds can be reprocessed into industrial or, possibly, food quality salt.
- Bittern production - The bittern consists of the bitter liquid that remains after the crystallization of salt from brine and typically contains more than 40% magnesium chloride. Bittern-based products can be used as stabilizers for earth-based roads and as dust suppressants.

[5] The concentration basins are the ponds that receive and concentrate the reject brine of the desalination plant before it is discharged into the crystallization pond, where salt deposition finally takes place.

2) Marine disposal: The nature and the proportional concentration of the salts contained in the reject brine are nearly identical to those of the salts contained in the feed water. Apart from the minimal amount of process-added chemicals contained in the RO brine (i.e., pre-treatment and membrane cleaning chemicals), the chemical composition of the reject brine is basically the same as that of the feed water, but with higher concentrations. RO plants that draw their feed water from brackish coastal wells may in some cases produce a reject brine whose salinity and composition is very similar to sea water and can, therefore, be safely disposed of into the sea. The discharge of desalination brines that are considerably less or more saline than sea water may have a detrimental impact on the marine environment, however, the magnitude of this impact can be greatly reduced if the design and location of the marine outfall is able to achieve a rapid dispersion and dilution of the brine.

3) Discharge to deep injection wells: This disposal method consists of using deep wells, which typically range from 300 to more than 2,000 meters in depth, to inject the reject brine into a porous subsurface rock formation, thereby creating an underground storage site for this waste flow. The disposal of brine by deep injection must be done in a way that prevents the movement of the brine into aquifers that are used to supply water for domestic, industrial or agricultural purposes. Proper site selection, which is dependent on geological and hydrogeological conditions, is therefore of crucial importance in the design of injection wells and may, in certain cases, limit the viability of this brine disposal option.

6- Water storage tanks

The primary purpose of these tanks is to ensure that an adequate volume of water is available at all times to meet the property's water needs, and thus allow for the normal operation of the property in the event of an interruption of its water supply (e.g., breakdown of the RO plant). These storage tanks must be able not only to meet the normal water needs of guests, staff and back-of-house operations, but also hold a sufficient water reserve to meet the property's fire protection needs.

The principal issues that must be evaluated during the planning and design stages of a property's water storage tanks are discussed below.

Type of storage tanks - Water can be stored in underground, ground-level or elevated storage. The choice between these three options is typically driven by operational requirements and aesthetic concerns. Elevated storage tanks (and underground or ground-level tanks located at sufficiently high elevations) are used both to store water and to distribute it to the property by gravity flow. The use of elevated storage tanks can greatly simplify the property's water pumping and pressurization system, but will not be approved by TDA if it negatively affects the aesthetics of the property. As such, a property that plans to operate a gravity pressure water distribution system will have to integrate the elevated storage tank(s) in its architecture or, if possible, build a ground-level or underground tank on a nearby hill

Non-gravity water supply systems rely on either underground or ground-level tanks, which simply receive the water supplied by the source and hold it until is pumped into the water distribution system. These tanks

Figure 6.1 Some architectural features, such as this tower of an El Gouna hotel, can double up as water towers

can be easily blended into the property's landscape or buildings and thus pose no aesthetic concerns .

Storage volume for domestic water - TDA requires that the capacity of the domestic water storage tank(s) should be sufficient to meet the property's maximum water needs for a period of at least one day. Project designers should, however, take into consideration the expected frequency and duration of water supply interruptions, and the availability of emergency water supplies (e.g., trucked water) when defining the storage volume that best suits the project's needs. Properties that can foresee long interruptions in water supply and do not have convenient access to an emergency source of water should be more cautious and conservative when sizing their domestic water storage tanks.

Storage needs for fire protection - In addition to the domestic water storage requirements, the property must also have a 120 m3 water reserve to meet its fire protection needs. This fire protection reserve can either be separate from or combined with the property's domestic water storage. In the case of combined storage, the system must be designed to ensure that the fire protection reserve is used only during fire emergencies. Access to this fire protection reserve is typically restricted by equipping the pumps with special controls or, preferably, by installing two outlets at different levels in the tank for the separate withdrawal of domestic and fire protection water.

Location of the storage tanks - The location of the water storage tanks should be carefully selected. They should ideally be located as close as possible to the property's main water distribution network to minimize pressure losses during times of peak water demand. However, in gravity pressure systems that use underground or ground-level tanks built at

a sufficient elevation, the position of the storage tanks will largely be defined by the site's topography.

Tank configuration - The domestic water should ideally be stored either in two (or more) separate tanks, or in a single tank that is divided into two separate compartments. This storage configuration will allow one of the tanks or compartments to be taken out of service for cleaning or repairs without interrupting the supply of water to the property.

Water quality protection - The domestic water tanks must be properly designed to protect the quality of the water during storage. In order to achieve this essential requirement, the tank's design should include the following features.

- The tank must be completely covered.
- The tank's hatchway and its cover must be designed to prevent the ingress of surface runoff, rainwater, insects, windborne dust, and other foreign matter. The hatchway cover must also be equipped with a lock to prevent tampering.
- The tank vents and/or overflow pipes must be designed to prevent the ingress of outside water and other foreign matter, and fitted with a fine mesh to prevent the entry of insects.
- The shape of the tank and the position of the inlet and outlet pipes should ideally be designed to avoid creating pockets of stagnant water in the tank.
- The tank should be equipped with a water level indicator to avoid the use of dip-sticks, which are a potential source of water contamination.
- There should be no cross-connections between the domestic water storage tanks and any tank or distribution system which carries non-potable water.

7- Water pressurization system

The design of a pressurization system is dependent on many factors -- such as site topography, peak and average water demand, pressure and fire protection requirements -- and can thus vary widely from one property to the next. In its simplest and ideal form, the pressurization system consists of a single elevated storage tank that is fed directly from the water source and operates without pumps or special controls. Unfortunately, and typically due to site constraints, most systems are more complex and include water supply pumps, fire protection pumps, and hydropneumatic pressure tanks or variable frequency pump controllers.

The water pressurization systems that are typically used in hotels fall in one of the following three categories: gravity, pneumatic or direct pressure systems.

1) A gravity pressure system relies on an elevated storage tank to maintain the required pressure and introduce water into the distribution network. Water is supplied to the elevated storage tank either directly from the source (if the pressure in the supply line is sufficient to raise the water to the elevated storage tank) or via an intermediate storage tank equipped with pumps.
2) A hydropneumatic pressure system relies on pressure tanks to sustain the pressure generated by the pump that draws water from the storage tank and introduces it into the distribution network. Since the pressure tanks are partially filled with compressed air, they are able to store and release a certain volume of pressurized water, and allow the pump to cycle on and off instead of operating continuously.
3) In a direct pressure system, the required pressure is maintained only

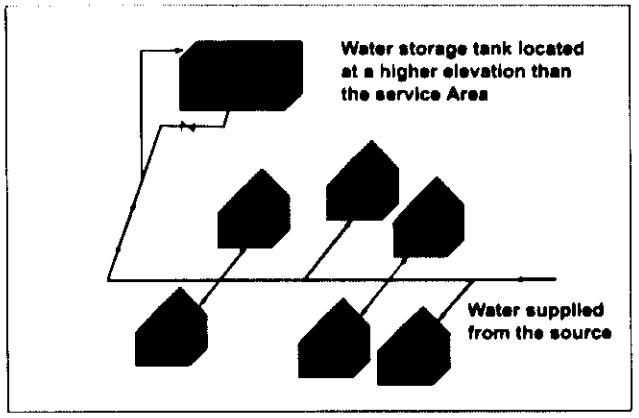


Figure 7.1 Typical configuration of a gravity pressure system

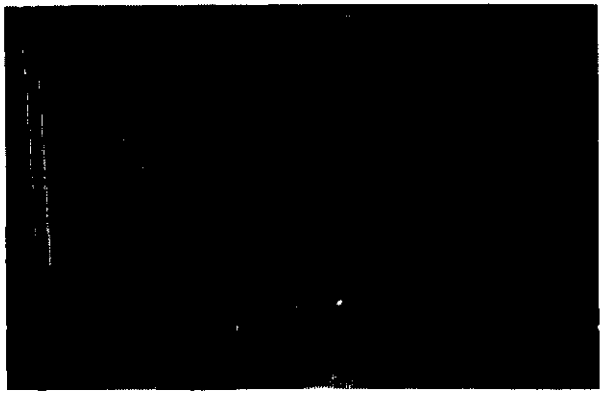


Figure 7.2 Typical configuration of a hydropneumatic or direct pressure system

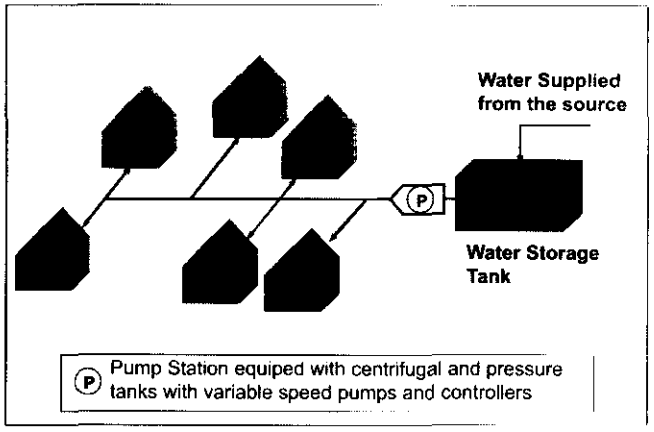


Figure 7.3 Centrifugal pump and hydropneumatic tank

by the pump that draws water from the storage tank and introduces it into the distribution network. This pump is controlled by an electronic system that automatically adjusts the speed of the pump to the property's instantaneous water demand.

The principal issues that should be considered when selecting and designing a property's water pressurization system are discussed below.

If possible, take advantage of gravity - Properties that have favorable site topography or can effectively integrate an elevated water storage tank into their architecture should give preference to gravity pressure systems. Gravity pressure systems typically have lower operating costs and are easier to maintain and operate than other water pressurization systems.

Use the water pressure provided by the source - If the property is supplied by a municipal or IDC main that carries enough pressure, it should take advantage of this pressure either to avoid the need to purchase and install water supply pumps or to reduce the time of operation of its existing water supply pumps. For example:

- If the elevated storage tank of a gravity pressure system can be supplied with water directly from the source, the system may be able to operate without the need for any pumps.
- A property that operates a pneumatic or direct pressure system should use whenever possible the pressure provided by the source, rather than its own pumps, to pressurize its water distribution network. However, even if sufficient pressure is always available from the source, the property will still need to periodically run its own pumps to consume and thereby refresh the water contained in its storage tank.

Base the system design and equipment selection on sound engineering analysis The pressurization and pumping system should be designed to run efficiently under the expected average operating conditions,

effectively meet the property's peak water demand, and minimize the wear and tear on its components. These objectives can be achieved only if the system design and equipment selection is entrusted to an experienced engineer.

Use energy efficient equipment - All pumps, and especially those that have a heavy workload, should be equipped with high efficiency motors.

Provide backup pumping capacity - Each pumping station should be equipped with a standby pump (or pumps) of sufficient capacity to ensure the proper operation of the water supply system in the case of pump breakdown or maintenance.

Provide adequate pumping capacity for fire protection - The pumps that supply water to hydrants and other fire protection systems should have the capacity to generate the required fire flows. In addition, since the fire protection needs must be covered at all times, the property should either be equipped with a diesel backup pump, or connect its electric fire pumps to a backup generator, or adopt another strategy that ensures the proper performance of the fire protection system in case of a power failure.

Operate the water distribution system at a reasonably low pressure - Most hotels can operate normally with a pressure of 2 to 4 bars. Higher water pressures are wasteful in terms of the extra costs of the equipment and energy required to produce them, and the increased volume of water consumed by fixtures and lost through leaks. However, properties that plan to operate at a pressure of less than 1.5 bar should make sure that their plumbing fixtures and water using equipment will perform well inthese low pressure conditions. According to TDA recommendations, the water pressure at any point of the water distribution system should never fall below 1 bar.

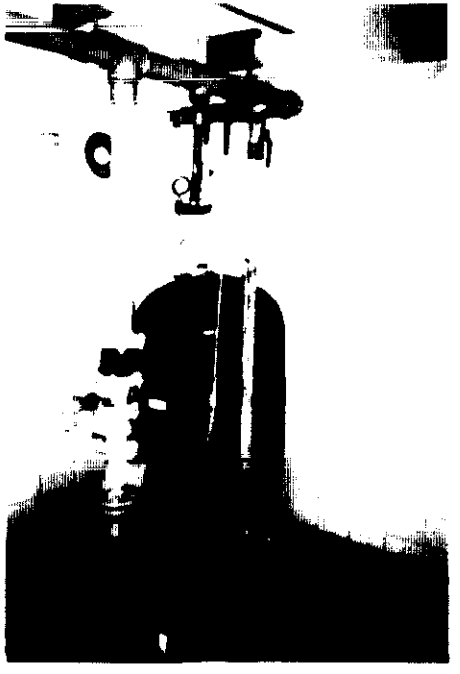


Figure 7.4 Electric and backup diesel fire pumps at a 310-room, 5-star Red Sea hotel

8- Water distribution system

The purpose of a water distribution system is to deliver water to all points of use in an adequate amount and at a satisfactory pressure, under both normal and exceptional operating conditions (e.g., the superposition of normal flows and fire flows). The basic components of a water distribution system include the feeder mains that are the principal arteries of the system, the service lines that connect the buildings to the feeder mains, and the flow control valves. To ensure the adequacy and integrity of the water distribution system, the project team should give appropriate consideration to the following guidelines and issues.

Detailed design of the water distribution system - Flow and pressure conditions in a water distribution system are affected by a large number of parameters including the lengths, diameters and material of the water supply pipes; the pressure provided by the water source or by the pumps; the topography of the site; the height of the buildings; and the number, type and distribution of plumbing fixtures that are connected to the water supply system. Given this level of complexity, the design of the water distribution system must be based on sound analysis and entrusted to an experienced engineer. The proper design and construction of a water distribution system is particularly important because upgrading a defective system can be both costly and disruptive.

Layout of the feeder mains - The layout of a property's feeder mains should ideally be looped rather than branched. Although the construction of a looped feeder main requires additional materials and incurs higher costs, this configuration can greatly improve the performance of the water

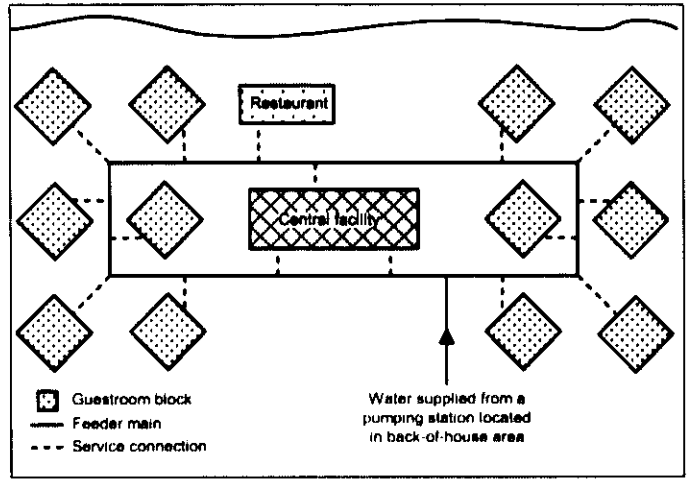


Figure 8.1 Typical layout of a looped feeder main

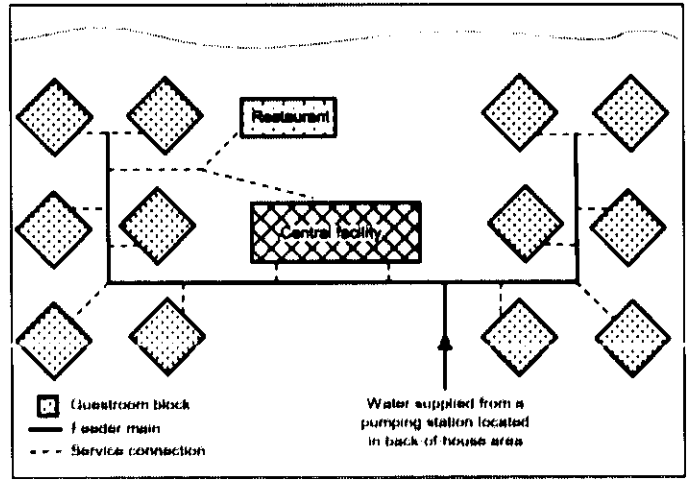


Figure 8.2 Typical layout of a branched feeder main

Table 8.1 Typical water valves and applications

Valve type	Application
Isolating valves	Used to cut off the flow of water through a pipe and thus isolate a section of the distribution system for repair or maintenance. They are typically installed at all pipe intersections and on all pipe branches.
Flushing (or blowoff) valves	Installed at the end of branched mains and used to periodically flush the sediments that typically accumulate at dead ends.
Air relief valves	Used to vent off the air that may accumulate in the pipelines. They are typically installed at all high points in long water lines.
Vacuum relief valves	Allow air to enter the water distribution system when it is being emptied or subjected to a vacuum, thereby preventing the possible backflow of contaminated water into the distribution system.
Pressure reducing valves	Used to reduce the pressure in sections of the water distribution system that are subjected to excessively high pressures (e.g., in low-lying

distribution system.

- A looped feeder main reduces pressure losses in the principal water supply lines and thereby achieves more uniform pressure conditions throughout the water distribution system.
- Since the service lines that feed water to the buildings can be supplied from more than one direction, a section of a looped feeder main can be taken out of service for repairs without disrupting the water supply to large sections of the property.
- A looped feeder main avoids the creation of undesirable dead ends in the principal water supply lines of the distribution system.

Location and position of water supply lines - All standard precautions must be respected when defining the location and position of water supply lines. In particular, the property should:

- Avoid laying water lines under paved areas to facilitate leak detection and repairs,
- Maintain an adequate horizontal separation between water and sewer lines,
- Maintain an adequate vertical separation and respect the required safety precautions at water and sewer line crossings, and
- Avoid cross-connection between the water supply system and pipelines that carry non-potable water.

Valve selection and location - Several different types of valves are typically needed to ensure the proper operation and maintenance of a water distribution system. Since each type of valve has specific application requirements and limitations, the selection and placement of valves in the water distribution system must be based on sound engineering analysis.

Selection of pipe material - Water distribution systems in hotels typically use pipes that are made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polypropylene (PP), polyethylene (PE), galvanized steel, copper, and/or ductile cast iron (DCI). The principal factors that must be taken into account when selecting the type of pipe for a specific application include its ability to withstand the maximum anticipated internal and external pressures; its resistance to external and internal corrosion; and, if applicable, its resistance to high water temperatures and UV radiation. Although pipe selection should always be based on sound engineering practice, properties should be particularly cautious when considering the following possible applications:

- Use of galvanized steel, copper or ductile cast iron pipes in aggressive soils;
- Use of galvanized steel, copper or ductile cast iron pipes to convey desalinated water;[6]
- Use of plastic pipes, other than CPVC and polypropylene pipes, in hot water distribution systems; and
- Use of plastic pipes in areas exposed to direct sunlight.

Installation precautions - The property must ensure that all due precautions are taken during the construction of its water distributions systems. In particular, the construction practices must ensure that

- Pipes laid in trenches are properly bedded and provided with uniform longitudinal support,

[6] RO water that does not receive an adequate post treatment (i.e., stabilization and addition of a corrosion inhibitor) is extremely aggressive and can rapidly corrode metal pipes.

Figure 8.3 and 8.4 Galvanized steel pipes removed from a Red Sea hotel after only 10 years of service because the corrosive RO water used by the hotel shortened the service life of these pipes by more than 75%

- Pipes and connections are not damaged during laying and construction,
- Pipe joints and connections are correctly assembled,
- Pipeline thrust blocking is provided where needed to prevent pipe movement,
- Water lines are pressure-tested for leakage before the trenches are backfilled,
- Trenches are properly backfilled, and
- Water distribution system is properly disinfected before it is placed in service.

Fire protection - A property can operate either separate or combined fire protection and domestic water supply systems; the choice between these two options is largely guided by economic considerations. However, regardless the type of fire protection system used by the property, it must comply with the following requirements.

- The system must be able maintain a pressure of at least 1 bar (15 psi) at the fire hydrants while delivering the required flows. In a separate fire and domestic water supply system, the required flow is equal to the fire flow, while in a combined system, the required flow is equal to the sum of the fire flow and the maximum daily demand.
- The diameter of the pipes that carry the fire protection water must be greater or equal to 100 mm.
- The distance between adjacent fire hydrants cannot exceed 60 meters.

Best Practices for

Water & Sanitation Systems

in Red Sea Tourism Centers

I

Framework and requirements for the planning and implementation of water and sanitation systems for tourism centers

II

Guidelines for the design, construction and Operation of Water systems

III

Guidelines for the design, construction and Operation of Sanitation systems

IV

Water and Sanitation Systems for Coastal and desert eco-tourism properties

III

Guidelines for the design,construction and Operation of Sanitation systems

9- Wastewater collection system

10- Wastewater treatment

11- Wastewater modification - volume and pollutant load reduction

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13- Graywater irrigation

9- Wastewater collection system

The purpose of a wastewater collection system is to convey wastes from the point of generation to the point of treatment (or to the collection tanks for properties that transport their wastewater by truck to an off-site treatment plant). The wastewater collection system serving a property may consist of only a conventional gravity sewer or, as is often the case in coastal hotels, of a combined gravity and pressure sewer.

- Conventional gravity sewers transport wastewater by gravity along a downward-sloping pipe gradient. They are reliable and consume no power, but are mainly suited for sites with consistently sloping ground and where the discharge point is located at a lower elevation than the service area. The use of gravity sewers in sites with unfavorable topography or subsurface conditions (e.g., high water table or hard bedrock close to the ground surface) typically requires deep and/or expensive trench excavation and wastewater lift stations, which significantly increase the system's construction and operating costs.

General considerations for the planning and design of wastewater collection systems -

- Take future development plans into account when designing the layout and capacity of the wastewater collection system to ensure it will be able to accommodate the new wastewater loads resulting from the property's expansion.
- Avoid discharging stormwater flows into the sewer system. The hydraulic surge generated during rain events can overload the sewers and the wastewater treatment plant. Stormwater flows from roofs and paved

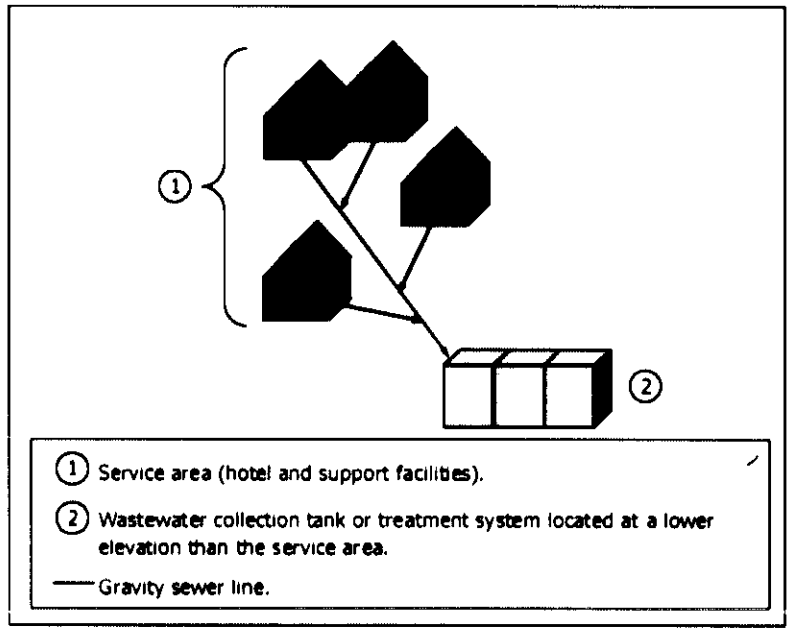


Figure 9.1 Schematic representation of a conventional gravity sewe

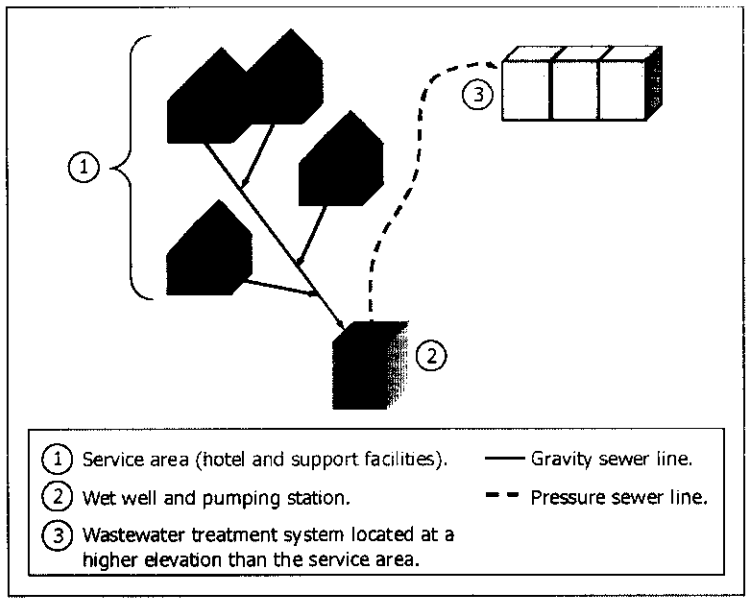


Figure 9.2 Schematic representation of a combined gravity and pressure sewer system with a single wet well and pumping station

surfaces should ideally be discharged to the surrounding gardens or grounds. However, the disposal of stormwater flows should be carefully distributed on the available land in order to prevent soil erosion, flooding and other problems that could result if a large volume of stormwater is concentrated in a single point of discharge.

- Avoid placing sewer lines in areas that will be subjected to large surface loads (e.g., road traffic), or take the necessary precautions to ensure the sewer line is able to support the loads without suffering structural damage.
- Make sure there are no cross-connections between the water supply lines and the wastewater collection system, the treated wastewater irrigation system, or any other system that carries non-potable water.
- Maintain an adequate separation between sewer and water lines to minimize the risk of contaminating the property's water supply.
- Ensure the materials used for the construction of sewer lines and appurtenances are adequate to the soil conditions. PVC pipes are not affected by corrosion and are therefore commonly used for the construction of gravity and pressure sewers.

Special considerations for the design of gravity sewers -

- The pipes used for sewer lines and for building connections must have a diameter of at least 200 mm and 150 mm, respectively.
- Manholes must be installed at junctions of gravity sewers, and at each change in pipe direction, size or slope. Sewer sections between manholes should be straight.
- All sewer building connections must be provided with cleanouts to allow the insertion of cleaning rods into the underground pipes.
- The diameter and slope of the sewer lines must be designed to respect

the minimum and maximum acceptable flow velocities: excessively low flow velocities allow solids deposition in the sewer and result in clogging problems, while high flow velocities erode the sewer pipes and damage manholes.

Special considerations for the design of pressure sewers -

- The number, capacity and mode of operation of the pumps will largely depend on the quantity and variation in the wastewater flow handled by the pumping station.
- Small stations should ideally be equipped with two identical pumps (one in operation and one in standby), each having the capacity to handle the peak wastewater flow rate discharged into the wet well. Float switches placed in the wet well should be used to control the operation of the pumps.
- Larger pumping stations, with a peak output of 2,500 liters/minute or more, should ideally be designed to operate in a continuous manner. This can be achieved by using more sophisticated flow control systems, such as variable speed pumps or a multiple-pump array that operate in cascade, to match the output of the pumps to the incoming wastewater flows.
- Each pumping station should be equipped with a standby pump (or pumps) of sufficient capacity to ensure the proper operation of the system in case of a pump breakdown or maintenance.
- The wastewater pumps must be able to handle the solids and grit contained in raw wastewater. If the system uses centrifugal pumps, the wet well should be equipped with a bar rack or screen to remove the rags and the trash contained in the incoming wastewater .

- The storage volume of the wet well must be large enough to prevent short cycling of the pump motor. The minimum required duration of a pumping cycle (i.e., the time between successive pump starts) varies according to the size of the pump, but should typically be longer than 10 to 15 minutes.
- The system should ideally equipped with alarms to signal excessively high and low liquid levels in the wet well or pump failure.

10- Wastewater treatment

Hotels are required to treat their wastewater and to reuse or dispose of the treated effluent in an environmentally acceptable manner. All hotels must therefore have access to a suitable treatment system that is able to purify their wastewater to a level that allows for its reuse in irrigation or proper disposal. The wastewater treatment options that are used by coastal and desert tourism hotels typically fall in one of the following categories.

1) A direct connection through a sewer line to an existing wastewater treatment plant that is operated by a municipality or a nearby tourism complex.
2) Wastewater collection in watertight holding tanks and off-site transport by tanker trucks to an existing wastewater treatment plant.
3) The operation of a wastewater treatment plant by an individual property.
4) The operation of a centralized wastewater treatment plant by a group of neighboring properties within the context of an IDC.

The project team will need to carefully evaluate the applicability, benefits and drawbacks of each of these options before choosing the manner in which the property will handle and treat its wastewater flows. The final choice of the option that best suits the needs of the property will largely depend on the factors that are discussed below.

Volume of wastewater - The actual volume of wastewater generated by the property may limit the applicability of some of the possible wastewater treatment options.

- Trucking collected wastewater to an existing treatment system is typically suited only to properties that generate small wastewater flows (e.g., 50 m3/day or less).
- A property that produces small wastewater flows should consider building an advanced wastewater treatment plant, such as an activated sludge system, only if there are no other alternatives or it can guarantee that the system will be properly operated by its own well-trained engineering staff or by a competent outside contractor.
- Any property that plans to use an existing wastewater treatment system will have to ensure that it has the capacity to handle the additional wastewater flows. Larger properties may unfortunately often be unable to find existing systems with the required excess capacity.

The volume of wastewater generated by a hotel is proportional to its domestic water consumption (i.e., the water consumed in all of its operations except for irrigation). It can range from a low of 40% of domestic water consumption for a property equipped with an extensive graywater collection network, to a high of 90% of domestic water consumption for a property with no graywater system.

The possibility to form an IDC or site the property in an existing IDC - Establishing or joining an IDC with centralized utility services is generally the best option for tourism projects, and should be particularly attractive to properties, large or small, that do not have access to an existing wastewater treatment system.

- The IDC structure allows properties to pool their technical and financial resources to design, build and operate an effective centralized wastewater treatment plant.

- An IDC-operated wastewater treatment plant relieves the individual properties from the need to maintain, operate and monitor their own treatment systems. It also shifts to the centralized plant the responsibility for treating the wastewater to the level required for its reuse in irrigation or disposal.
- A large centralized system can take advantage of economies of scale and have lower unit operating costs than a small wastewater treatment plant.

Proximity and capacity of existing systems - The use of an existing system relieves the property from the need to build and operate its own wastewater treatment plant, and produce a treated effluent that is suited for irrigation or disposal. It should, therefore, be an attractive solution for any property that is unable to participate in an IDC and has access to an existing system. However, this option has a several drawbacks whose importance will vary depending on the particular circumstances of each project.

- If the property is not able to convey by pipeline its wastewater to the existing treatment system, the high cost of transporting wastewater by truck will limit the applicability of this option only to properties that generate small wastewater flows (e.g., 50 m3/day or less).
- The property will need to pay a treatment fee to the system's operator. However, this fee may in some cases be lower than the actual cost that would be incurred by the property if it were treating its own wastewater.
- By losing control over its wastewater, the property will lose a potential source of low-cost irrigation water. It will thus have to rely either on its water supply or on purchased treated wastewater to meet its irrigation needs.

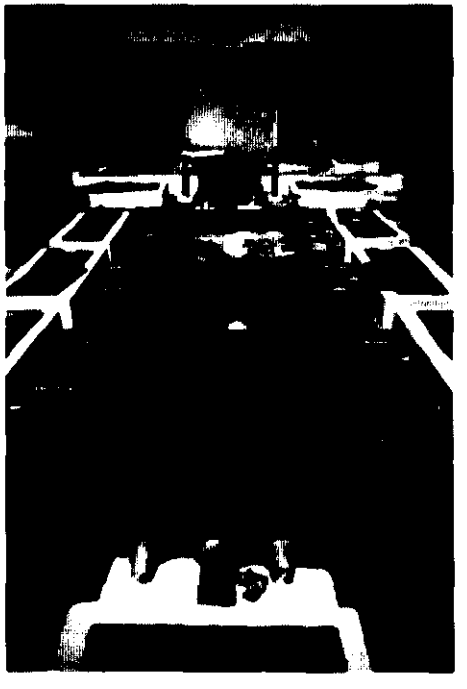


Figure10.1 Activated sludge wastewater treatment plants used in Red Sea hotel

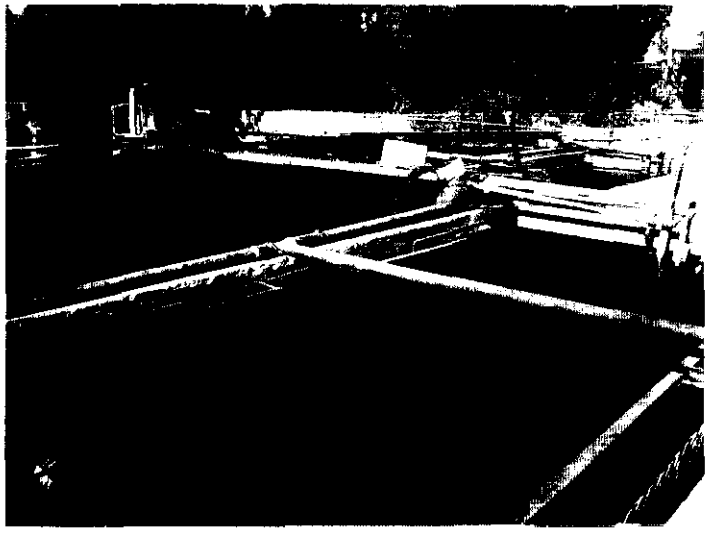


Figure10.2 Activated sludge wastewater treatment plants used in Red Sea hotel

Quality and skill of the future system operators - The operation of advanced wastewater treatment plants, such as activated sludge systems, requires specific technical skills and training. Such systems will produce a treated effluent that meets the strict quality requirement needed for irrigation only if they are managed and monitored by knowledgeable operators. Poorly operated systems will produce a low-quality effluent that, if used for irrigation, will pose severe health risks to the guests and staff and increase the property's potential liability.

In light of these facts, no property should consider building an advanced wastewater treatment plant, and in particular use its treated effluent for irrigation, unless it is willing to spend the necessary resources to ensure that the system is properly operated.

Selection of wastewater treatment technology -

- Activated sludge treatment plant - Most of the wastewater treatment plants used in properties and Tourism Centers along Egypt's Red Sea coast are based on the activated sludge process. This is a well-established form of secondary wastewater treatment that is recommended by TDA for all tourism properties and IDCs. When properly designed, operated and monitored, an activated sludge system produces a high-quality effluent, which, after filtration and disinfection, can be readily used for irrigation. However, if these conditions are not met, the plant will produce a poorly treated effluent that may affect the performance of the irrigation system (e.g., by clogging the irrigation lines and emitters) and create serious health risks.

Given its higher initial cost and strict operational requirements, an activated sludge system is typically not suited for properties that generate

small wastewater flows (e.g., less than 50 or 100 m3/day) or don't have the resources to guarantee its proper operation.

- Alternative wastewater treatment systems - Besides the activated sludge process, there are dozens of different types of proven and high-performance wastewater treatment systems that could be used to treat the effluent produced by hotels. Examples of these alternative systems include trickling filters and rotating biological contactors, which are normally used to treat small to large wastewater flows; and "natural" treatment systems such as intermittent sand filters, subsurface soil absorption systems, and evapotranspiration beds, which are typically used to treat small wastewater flows (e.g.,50 m3/day or less). As shown in Table 10.1, some of these systems compare favorably to the conventional activated sludge process and constitute attractive wastewater treatment options, especially for properties that produce small effluent flows and don't have the resources to properly operate sophisticated treatment systems. Any property that plans to build a wastewater treatment plant should, therefore, consider all possible options before selecting the system that best fits its needs.

Table 10.1. Comparative performance, requirements and construction cost of conventional activated sludge systems and intermittent sand filters

Treatment system	Typical BOD removal	Typical pathogen removal	Typical land requirements (m^2/capita)	Typical power requirements (watts/capita)	Construction cost (US$/capita)
Conventional activated sludge	85 to 93%	60 to 90%	0.2 to 0.3	1.5 to 2.8	60 to 120
Intermittent	- 95%	- 99%	1 to 6	0	5 to 15

Source: M. von Sperling, 1996. "Performance evaluation of a UASB - activated sludge system treating municipal wastewater".

Intermittent Sand Filters (ISFs)

An ISF consists of a shallow bed of sand that is equipped with a surface distribution system at the top of the filter and a vented underdrain at the base of the filter. Settled wastewater from a septic tank is periodically pumped to the surface distribution system and is purified as it slowly percolates through the sand. The treated effluent eventually collects in the underdrain and is sent to a holding tank for reuse in irrigation.

Advantages

- ISFs can reliably produce a high quality effluent with a biological oxygen demand (BOD) and suspended solids concentration of 5 to 20 mg/liter.
- The treated effluent can be recovered and used for irrigation after filtration and disinfection.
- Construction costs for ISFs are moderately low, and the labor is mostly manual.
- The operation of an ISF is relatively simple and does not require skilled personnel.
- Maintenance requirements are low.
- ISFs have low energy requirements.
- Covered (or buried) ISFs typically have no odor problems.
- ISFs can be installed to blend into the surrounding landscape.

Disadvantages

- The construction of an ISF may requires a relatively large surface area. Depending on its design features, the loading rate on an ISF can range from 20 to 200 liters/m2 per day.
- Open-top ISFs can generate odor problems and should not be installed close to buildings or guest areas.
- Clogging of the filter media is possible.

Evapotranspiration (ET) Systems

An ET system consists of a sand bed that is laid over an impermeable liner and equipped with a subsurface network of wastewater distribution pipes. The settled wastewater from a septic tank is applied across the bed by the distribution pipes, raised to the top of the bed by capillary action in the sand, and eventually evaporated into the atmosphere.

Advantages

- ET systems are well suited to arid climates.
- ET systems equipped with watertight liners will not discharge any wastewater into the ground.
- Construction costs for an ET system are moderately low, and the labor is mostly manual.
- The operation of an ET system is relatively simple and does not require skilled personnel.
- Maintenance requirements are low.
- ET systems have no or only low energy requirements.
- ET systems can be installed to blend into the surrounding landscape.
- The ET bed can be covered with vegetation to enhance the performance of the system.

Disadvantages

- An ET system does not produce an effluent and thus the property loses a potential source of irrigation water.
- The system's construction requires a relatively large surface area.

Subsurface Soil Absorption (SSA) Systems

A SSA system typically consists of a network of slotted pipes that are laid in shallow trenches filled with gravel. The slotted pipes receive the settled wastewater from a septic tank and discharge it below the ground surface, where it is treated as it percolates through the soil.

Advantages

- The system's operation is simple and does not require skilled personnel.
- Construction costs are moderately low, and the labor is mostly manual.
- The operation of a SSA system is simple and does not require skilled personnel.
- Maintenance requirements are low.
- The system has no or very low energy requirements.
- The system can be installed to blend into the surrounding landscape.

Disadvantages

- SSA systems cannot be used in areas with a high groundwater table or unfavorable soil characteristics.
- The system does not produce an effluent and thus the property loses a potential source of irrigation water.
- The system's construction requires a relatively large surface area.

- Effluent polishing for reuse in irrigation - Regardless the type of wastewater treatment system used, treated wastewater must be filtered and disinfected prior to reuse for irrigation. The objective of this polishing process, or tertiary treatment, is to prevent clogging of the irrigation network and protect the health of workers and guests by lowering the suspended solids, biological oxygen demand (BOD), and fecal coliform content of the irrigation water. To ensure its effectiveness, the design of the polishing process must take into account the following issues.

- Disinfection should be conducted after the treated wastewater has been filtered, as the presence of suspended solids in the effluent lowers the efficiency of the disinfection process.
- The system must provide a sufficiently long contact time between the filtered effluent and the chlorine to ensure that the flow is properly disinfected before it is used for irrigation.

Approval from EEAA and TDA - The design of wastewater holding tanks and of the wastewater treatment systems must be submitted to the TDA and EEAA for approval before they can be incorporated into the project.

Sludge management - Properties must have the means to handle properly the sludge generated by their wastewater treatment systems. The typical sludge handling options include:

- Pumping and transport of the sludge to an off-site treatment facility, such as a large municipal or IDC wastewater treatment plant, or a disposal site. This option is typically used to handle the sludge that collects in the primary settling tanks (e.g., septic tanks) of many small-flow wastewater treatment systems (e.g., intermittent sand filters,

subsurface soil absorption systems and evapotranspiration beds).

- Stabilization of the sludge prior to its use as a soil conditioner. This option is often used to process the biological sludge produced by the activated sludge wastewater treatment plants serving IDCs or large properties. The objective of the stabilization process is to eliminate offensive odors, reduce the potential for putrefaction, and reduce the concentration of pathogens in the processed sludge. The steps in a complete sludge stabilization process typically consist of aerobic digestion, dewatering in sand beds, and composting.

Poorly stabilized primary or biological sludge generates odor problems, attracts pests and presents a significant health risk; it should therefore never be used to fertilize hotel gardens or other areas with similar public access.

11- Wastewater modification - volume and pollutant load reduction

The characteristics of the raw wastewater can have a major impact on the wastewater treatment, disposal and/or reuse system. For example:

- Large wastewater flows will increase the required capacity, the capital cost and operating cost of the treatment system.
- Wastewater flows in excess of the design capacity of the wastewater treatment plant will affect its performance and lower the quality of the treated effluent.
- The discharge of hazardous and toxic chemicals into the property's drainage systems can harm the bacteria that purify the wastewater in a biological wastewater treatment process. In the worst-case scenario, such chemicals can completely disrupt the operation of the treatment plant for days or even weeks.
- High concentrations of certain chemical elements, such as sodium and boron, in the raw wastewater can make the treated effluent unsuitable for reuse in irrigation.

A property can therefore save money and enhance the performance of its wastewater system by reducing the volume and improving the quality of the raw wastewater generated by its operations.

Wastewater volume reduction - Water conservation and graywater irrigation are the two main strategies that can be used by a hotel to reduce the volume of wastewater discharged to its wastewater treatment or disposal system. Since many of the features of water conservation and graywater

Figure 11.1 The use of low-quality treated wastewater for irrigation can damage the soil and vegetation

Table 11.1 Benefits provided by wastewater volume reduction measures for the various wastewater treatment options typically used by hotels

Wastewater treatment option	Benefits of wastewater volume reduction measures
On-site wastewater treatment plant and effluent reuse for irrigation	▯- Reduces the hydraulic load on the wastewater treatment plant and thereby improves its performance. ▯- Improves the quality of the treated effluent and facilitates its reuse for irrigation. ▯- Installing a graywater system reduces the required capacity of the wastewater treatment system. This in turn can substantially lower the capital cost of the wastewater treatment system, especially if the property is planning to use a "natural" wastewater treatment system such as an intermittent sand filter, an evapotranspiration system, or a subsurface soil absorption system.
Wastewater collection in holding tanks and transport to an off-site treatment plant	▯- Reduces the wastewater trucking costs. ▯- Reduces the frequency at which the property's wastewater holding tanks must be emptied. ▯- Installing a graywater system reduces the property's fresh water consumption by partially meeting the irrigation needs of its gardens.
Discharge to a municipal or IDC sewer	▯- Installing a graywater system reduces the property's consumption of irrigation water (i.e., fresh water or treated wastewater purchased from the local supplier) by partially meeting the irrigation needs of its gardens.

systems must be included in the property's design and construction, these strategies must be incorporated into the initial planning phase of the project.

- Water conservation - By using water efficient fixtures and appliances, and training its employees to practice water conservation in their operations, a property can greatly reduce the volume of water it consumes and the volume of wastewater it generates. The water conservation measures that should be implemented by hotels are discussed in chapters 3 and 4.
- Graywater irrigation - Graywater consists of the lower-strength wastewater that is discharged mainly from showers, tubs, bathroom sinks, laundry washers, and pool filters, and excludes the high-strength wastewater (or blackwater) that is discharged from toilets, urinals, bidets, and some kitchen and bar sinks. As graywater contains fewer suspended solids and pathogens than blackwater, it can be conveniently reused for subsurface irrigation if it is collected separately and filtered. Given that graywater typically accounts for more than 50% of the total volume of wastewater generated by a hotel, graywater irrigation can significantly reduce the required hydraulic capacity, and the capital and operating costs of wastewater treatment or disposal systems. In addition, graywater systems can provide an ample supply of low-cost irrigation water and, therefore, should be particularly attractive to properties that don't have access to treated wastewater for irrigation.

Pollutant load reduction - The discharge into the drainage system of products that can disrupt the wastewater treatment plant or affect the quality of the treated effluent should be avoided or minimized to the extent possible. Examples of such harmful products include toxic or

excessively harsh cleaning chemicals; certain types of laundry and dishwashing detergents; kitchen grease, fat and cooking oil; and spent maintenance products and brines (e.g., the reject brine produced by a desalination plant). A property can, however, easily achieve this objective by adopting a number of relatively simple and low-cost wastewater management practices.

- Avoid purchasing laundry and dishwashing detergents that produce a washwater with a high alkalinity and conductivity, or a high sodium and boron content. The use of such detergents lowers the chemical quality of the treated wastewater and renders it unsuitable for reuse as irrigation water.
- Minimize the use of excessively harsh or hazardous cleaning agents (e.g., chlorine and strong disinfectants).
- Train the housekeeping, laundry and stewarding staff on how to properly use their chemicals.
- Monitor the consumption of housekeeping, laundry and stewarding chemicals to ensure they are used efficiently by the staff.
- Avoid the routine use of chemicals for tasks that can be accomplished by non-chemical means (e.g., the use of drain cleaning chemicals rather than a plunger or rod to clear clogged drains).
- Collect the fat and used cooking oil generated in the kitchens instead of discharging them into the drains. Recycle or discard the collected material as solid waste.
- Install well-designed grease traps in the kitchen drains and maintain them properly. Grease, fat and cooking oil discharged from kitchen sinks can obstruct sewer lines and lower the performance of wastewater treatment systems.

- Ensure that spent maintenance products (e.g., used motor oil, paints, solvents) are disposed of properly rather than dumped down the drain. These products are generally highly toxic and can severely disrupt biological wastewater treatment systems.

12- Treated wastewater irrigation

Individual hotels or IDCs that operate wastewater treatment plants are required to dispose of the treated effluent in an environmentally sound manner: the discharge of even high-quality treated wastewater into the sea is strictly forbidden. Given this requirement and the high cost of fresh water, the reuse of treated wastewater in irrigation offers an ideal solution for effluent disposal. If done properly, treated wastewater irrigation can provide an ample source of safe and low-cost irrigation water that can benefit the plants and soil to which it is applied. However, any property that uses treated wastewater irrigation should be fully aware of the potential problems and dangers associated with this practice, and take all necessary precautions to ensure the proper performance of the irrigation system and minimize the risks to human health.

The principal issues that must be considered when planning, designing and operating a treated wastewater irrigation system are discussed bellow.

Effluent quality and monitoring - The quality requirements for any treated wastewater that is used for irrigation in a tourism property are defined in Egypt's Environmental Law 44/2000 and 4/1994. These requirements take into account the degree of public access to the irrigated grounds, and impose tighter limits for irrigation water that is used in areas open to guests and staff traffic.

Properties that produce their own treated wastewater must regularly monitor their irrigation water to ensure it meets the specified quality requirements. Depending on the size of the facility, this monitoring can

Table 12-1 Required treated wastewater quality for irrigation of unrestricted and restricted access

Parameter	For unrestricted access areas	For restricted access areas
BOD_5	≤ 10 mg/liter	≤ 30 mg/liter
SS	≤ 15 mg/liter	≤ 30 mg/liter
Free chlorine residual	≥ 0.5 mg/liter	≥ 0.5 mg/liter
Fecal coliform	≤ 100 count / 100 ml	--

Figure 12.1 Irrigation practices should avoid ponding of treated wastewater

either be done in-house or by an outside contractor who is able to perform the necessary laboratory analyses. On the other hand, properties that purchase their treated wastewater must make sure that the supplier conducts the required quality control tests and is able to guarantee the acceptability of the treated effluent

Application of the treated wastewater - The irrigation water should be applied in a manner that minimizes the risk of human contact with the treated wastewater. As such, the property should avoid the use of sprinklers and flood irrigation, especially in unrestricted access areas, and give preference to emitters or bubblers that apply a controlled amount of water directly onto the soil.

Design of the irrigation system - The design of the irrigation system and of its components should take into account the fact that the residual suspended solids, bacteria and nutrients contained in treated wastewater will obstruct small diameter pipes and orifices by promoting the growth of biofilm and sediment buildup. Therefore, irrigation emitters should be large enough to minimize clogging problems, and the irrigation lines provided with cleanout and blowoff features.

Training - The wastewater treatment plant operators should be trained to properly operate the treatment system and monitor its performance and the quality of the treated effluent. Gardeners should be trained to handle and use the treated wastewater in a way to minimize the potential risks to public health and to the environment.

Safety precautions - The following measures should be used to minimize the risks associated with treated wastewater irrigation.

- Provide protective gear (e.g., rubber gloves, rubber boots and, if necessary, face masks) to the gardeners who operate the irrigation

system or may come into contact with the treated wastewater.

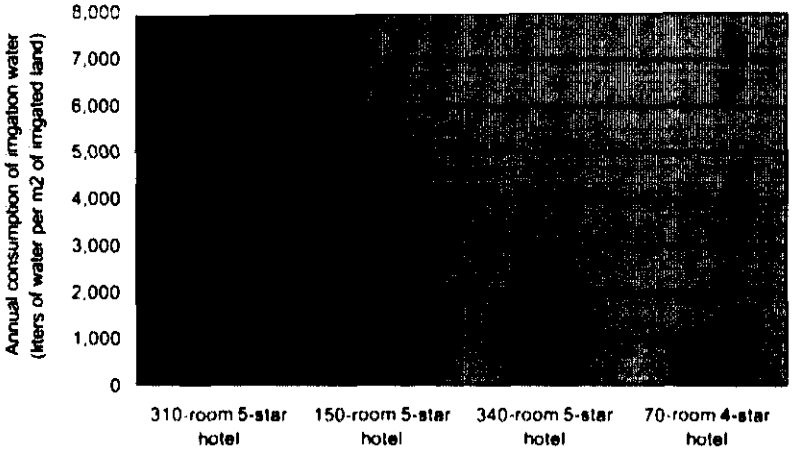
- If the irrigation system is equipped with sprinklers, avoid operating them during periods of strong winds.
- Irrigate at night or dawn when guest and staff traffic is at a minimum.
- Irrigate particularly sensitive areas, such as children's playgrounds and green areas around swimming pools, with fresh water rather than treated wastewater.
- Make sure the irrigation system can only be operated by authorized members of staff. For example, faucets installed on the treated wastewater irrigation system should have lockable or removable handles to prevent tampering by guests or staff.

Irrigation water needs - A study conducted by RSSTI at four- and five-star properties revealed that the volume of wastewater generated by Red Sea coast hotels is sufficient to largely meet the irrigation needs of a fairly substantial garden (the size of the irrigated grounds in these hotels ranged from 100 to 180 m2 per room). Hotels that had water efficient gardens and used relatively efficient irrigation practices were able to rely on treated wastewater irrigation during most of the year, and had to supplement their treated wastewater supply with fresh water only during brief periods of very low occupancy.

However, this study also showed that properties with inefficient gardens and poor irrigation practices could virtually become endless irrigation water sinks, and consume up to seven times more water per square meter of irrigated land than an efficient hotel. Unless their gardens are extremely small, these wasteful properties are unable to meet their irrigation needs with the treated effluent of their wastewater treatment plants and typically spend a great deal of money purchasing water for their gardens.

Consumption of Irrigation Water in Red Sea Hotels

Plant selection and distribution, irrigation technology, and irrigation practices have a dramatic effect on the amount of water consumed by a garden. This fact is illustrated in the following figure that presents the total amount of irrigation water consumed per square meter of irrigated garden in several Red Sea hotels



NOTE The water consumption figures include the treated wastewater, the domestic water and any other type of irrigation water used by the properties

Figure 10.2 Annual consumption of irrigation water per square meter of irrigated surface in Red Sea coast hotels

"Although different in style and composition, the gardens of these four properties were all aesthetically pleasing. However, the gardens of the most water efficient hotel consumed only 1,000 liters/m2.year," while those of the least efficient hotel required as much as 7,000 liters/m2.year.

13- Graywater irrigation

Graywater consists of the lower-strength wastewater that is discharged mainly from showers, tubs, bathroom sinks, laundry washers, and pool filters, and excludes the high-strength wastewater (or blackwater) that is discharged from toilets, urinals, bidets, and some kitchen and bar drains. As graywater is largely free of human and other noxious wastes, it contains fewer suspended solids and pathogens than raw wastewater and, therefore, requires a minimum amount of treatment before it can be reused for subsurface irrigation.

Including a graywater system in the design of the property can bring important benefits.

- Since graywater typically accounts for 50 to 70% of the total volume of raw wastewater generated by a hotel, diverting this flow for irrigation can reduce by half the required hydraulic capacity of the wastewater treatment system. This in turn can substantially lower the capital cost of the wastewater treatment system, especially if the property is planning to use "natural" wastewater treatment systems such as an intermittent sand filter, an evapotranspiration system, or a subsurface soil absorption system.
- A graywater system can reduce by more than 50% the wastewater disposal costs in properties that must transport their wastewater by truck to an off-site treatment plant. It also allows these properties to reduce either the capacity and construction cost of their wastewater holding tanks, or the frequency at which they must be pumped out.

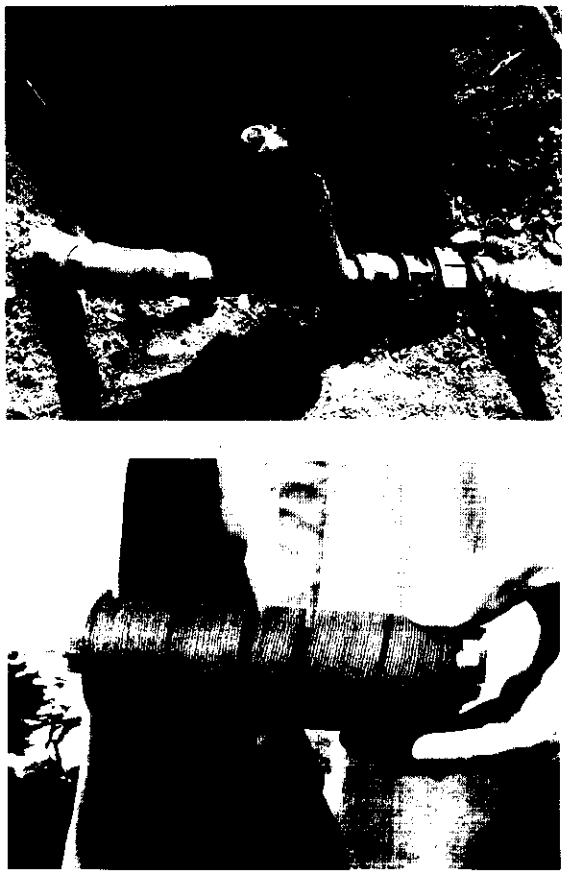


Figure 13.1 and 13.2 Cartridge filter and cartridge filter plates

- A graywater system can provide an ample supply of low-cost irrigation water to properties that don't operate their own wastewater treatment plants and don't have access to treated wastewater for irrigation.
- The valuable nutrients contained in graywater, such as phosphorus and potassium, can benefit the plants and reduce the need for synthetic fertilizers.

A graywater collection and irrigation system is relatively simple and typically consists of the following elements:

- Piping to convey by gravity the graywater from the sources (e.g., showers, bath tubs, sinks, laundry washers) to the holding tank. The design of the buildings must therefore include separate drainage systems for graywater and blackwater.
- A net bag, or other simple filtration device, installed on the holding tank's inlet pipe to remove the larger suspended solids contained in the graywater (e.g., hairs, pieces of paper, fabric).[7]
- A holding tank equipped with a vent and an overflow pipe.
- A centrifugal pump to move the graywater from the holding tank to the irrigation system.
- A filter (ideally a reusable cartridge filter) to remove the fine suspended solids from the graywater before it enters the irrigation network.
- A network of irrigation pipes and subsurface emitters, which must be coarse enough to minimize clogging risks. The simplest form of subsurface irrigation system uses a network of perforated pipes to distribute the graywater into contoured swales that are filled with mulch.

[7] Nylon stockings or fine mesh filter bags designed for airless paint sprayers are commonly used as net bags for graywater systems

The following precautions, recommendations and guidelines should be considered when planning and designing a graywater system.

- Although graywater presents a much lower risk than raw wastewater or blackwater, it still contains pathogens and must be handled and used with proper care. Graywater should never be used for above-ground irrigation unless it has been previously treated to achieve the same quality requirements imposed for treated wastewater irrigation (see chapter 12).
- Graywater must be properly filtered to remove the particles that could clog the irrigation system (pipes, valves and emitters). It is generally recommended to filter the graywater through a 160-micron reusable cartridge filter installed on the outlet of the graywater pump.
- Do not store the collected graywater for long periods of time. Stored graywater turns septic very quickly and should ideally be applied to the soil within a 24-hour period.
- Minimize clogging risks by avoiding the use of small-orifice emitters in the irrigation system.
- Avoid or minimize the use of chemical products that degrade the quality of the irrigation water (e.g., chlorine and other disinfectants, laundry detergents with high sodium or boron content, see chapter 11).
- Don't connect kitchen drains that carry noxious wastes (e.g., grease, oil, food particles, blood) to the graywater collection system.
- Obtain proper guidance for the detailed design of the graywater irrigation system.
- Include a detailed description of the graywater collection and irrigation system in the EIA that must be presented by the property to the EEAA.

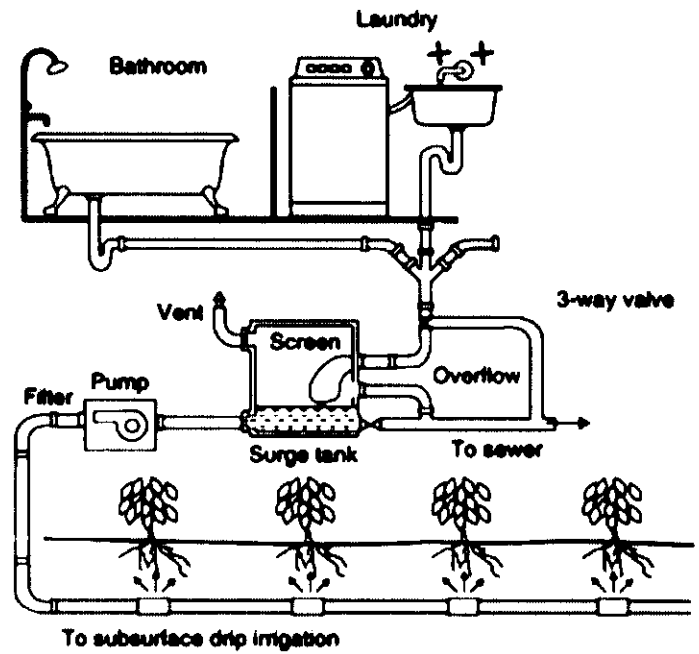
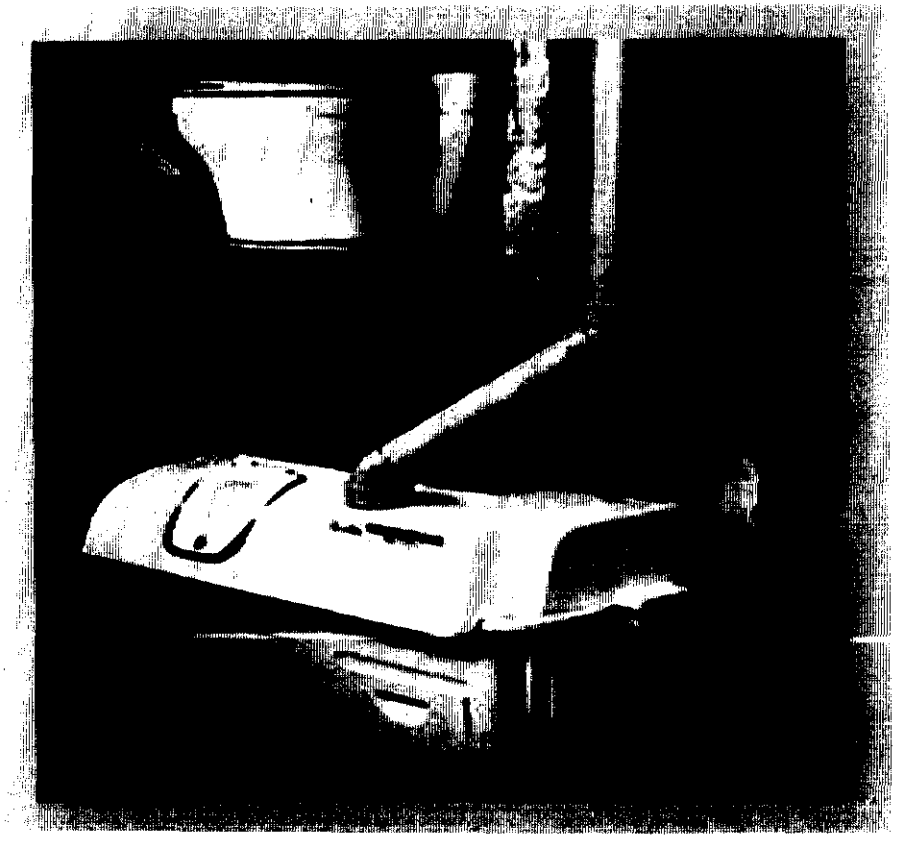


Figure 13.3 Schematic of a graywater collection and irrigation system (www.homeenergy.org)

Best Practices for

Water & Sanitation Systems

in Red Sea Tourism Centers



I

Framework and requirements for the planning and implementation of water and sanitation systems for tourism centers

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Water and Sanitation Systems for Coastal and desert eco-tourism properties

IV

Water and sanitation systems for coastal and desert eco-tourism properties

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14- Characteristics of eco-tourism properties

Although there are many different definitions and interpretations for eco-tourism, all agree on a common set of characteristics that clearly differentiate eco-tourism properties from traditional tourism hotels and resorts.

- Location: Eco-tourism properties are typically located in remote areas that are chosen for their unique natural and, possibly, cultural attributes.
- Size: Eco-tourism properties are small and typically accommodate less than 20 guests.
- Guest type: Eco-tourism generally attracts guests who seek a rich sensory experience based on a close interaction with the natural and cultural elements of the site. They are typically very sensitive to environmental and cultural issues, and expect the property to demonstrate the same degree of sensitivity in its operations, activities, and in the design and management of its facilities.
- Facilities: The facilities should be unique in character, but designed to be in harmony with the local natural and cultural environment. Emphasis must therefore be placed on simplicity, minimizing the disruption to the site, eliminating unnecessary demands on resources, and minimizing the generation of wastes and pollution.
- Services: Eco-tourism properties generally provide fairly basic and rustic services. This allows them to achieve two important objectives: first, to minimize their negative impact on the environment; and, second, to allow their guests to experience a simpler way of life that is more in tune with the local environment and customs. Although there are

exceptions, eco-tourism properties are typically not luxurious nor meant to provide the same level of service and comfort expected from conventional tourism hotels.

- Guest activities: The activities offered to the guests in eco-tourism properties are centered on the surrounding environment rather than on the facility itself (e.g., hiking, desert safari, diving, snorkeling).

These unique characteristics permeate every aspect of the eco-tourism property and, as presented in the following chapters, also have a profound impact on the planning and design of its waster and sanitation systems.

15- General considerations for the planning and design of water and sanitation systems for eco-tourism properties

- Energy needs - The property should ideally be self-sufficient in its energy needs but avoid relying on non-renewable energy sources. This goal can be largely achieved by eliminating operations that require the use of energy-intensive equipment, using energy efficient technology to meet essential needs (e.g., energy efficient lighting), and using alternative sources of energy (e.g., photovoltaic panels, solar water heaters, solar ovens, manual or wind-powered water pumps). This emphasis on minimizing conventional energy requirements should drive the property to avoid the use of any water and sanitation process, technology or equipment that has an excessively high power demand.
- Maintenance needs - Given their small size and isolation, eco-tourism properties will typically not have a qualified maintenance worker on staff or quick access to outside maintenance service contractors. As such, the property should ideally rely on systems and technologies that have basic maintenance and monitoring needs, and stock the necessary spare parts to promptly carry out any required repairs.
- Environmental impact - The design of the water and sanitation system must take into account the property's commitment to environmental protection and the efficient use of resources. Preference should therefore be given to systems that do not generate potentially problematic waste streams (e.g., the blackwater generated by flush toilets and the brine produced by an RO plant) and allow the property to meet its water and sanitation needs in the simplest and most natural manner possible.

16- Guidelines for the planning and design of water systems for eco-tourism properties

Water conservation - Eco-tourism properties must pay particular attention to water conservation, not only because of the probable high cost of water but also to fulfill their commitment to the efficient use of resources. However, given the special nature of eco-tourism and of its clientele, these properties have the opportunity to go far beyond the standard water conservation measures used by conventional hotels (see chapters 3 and 4). Some examples of water conservation measures and strategies that have been adopted by eco-tourism properties are presented below.

- Use composting toilets to eliminate the need for flush water and the generation of blackwater (i.e., wastewater containing human wastes). Conventional flush toilets typically account for more than 30% of the domestic water consumption; thus, eliminating their use will significantly reduce the property's water needs.
- Use high-efficiency plumbing fixtures (e.g., 2 or 4 liter/minute faucet aerators, and 6 liter/minute low-flow showerheads).
- Eliminate the need to process linen by having guests use their own sleeping bags and towels.
- Keep the size of green areas to a minimum in order to reduce water consumption and, if applicable, avoid altering the nature of the site.
- Use graywater irrigation to reduce water consumption and simplify the required wastewater treatment and/or disposal system.
- Train the staff on how to practice water conservation in their daily operations.

- Provide adequate maintenance to the water system. The property should keep in mind that even simple technologies and systems need proper maintenance and monitoring.
- Monitor water consumption versus occupancy in order to track the water efficiency of the property and identify leaks and other problems.

The extent to which some of these practices can be adopted will obviously depend on the level of comfort the property wishes to offer to its guests. However, the more rustic properties should have few limitations in applying these and other innovative water conservation measures.

Water needs - Given that a typical eco-tourism property has no swimming pool and decorative water features, only basic food preparation and housekeeping operations, and water efficient bathrooms, its per capita water consumption should be much lower than that of a conventional hotel. The water consumption should typically vary between 100 and 200 liters per person per day (i.e., counting staff and guests) depending on the type and the effectiveness of the water conservation measures implemented by the property.

Water source -

- *Direct connection to a water supply pipeline* - Drawing water from an existing pipeline is an ideal solution for any tourism property. However, given that most eco-tourism properties are located in remote areas, it is highly unlikely that many will be able to even consider the possible application of this option.
- Well or spring - The eco-tourism properties that are centered around natural water sources, such as wells or springs, may be able to use them to meet their water needs at low cost. However, these properties

will have to pay particular attention to water conservation and ensure that their water demands do not harm the sustainability of the water source.

If the water drawn from the source does not meet the chemical and bacteriological quality requirements imposed by TDA, it may be possible to use this water for general sanitary applications (e.g., showering and cleaning) after it has been properly disinfected. However, it should never be used for human consumption unless it is fully treated to ensure it meets all chemical and bacteriological quality requirements.

- Trucked water - Tanker trucks will be in many cases the best option for supplying water to a property that does not have access to a spring, well or other source of water. Although trucked water is generally expensive (transportation can more than double the cost of water), this option will free the property from the costs, energy needs, trouble and responsibility associated with the operation of an on-site RO plant.
- Reverse osmosis (RO) plant - Because of their strict maintenance and operating requirements, brine disposal needs, and high energy consumption, RO plants are typically not suited for eco-tourism projects. RO plants should be considered only by the properties that have no other practical option to meet their water needs.
- Potable water supply - Unless the property is able to guarantee that its source provides water of potable quality and prevent its contamination during storage and distribution, it will need to purchase bottled water or, possibly, use a "point-of-use" (POU) treatment system to produce its own potable water. The exact composition of the POU system will vary depending on the quality of the available feed water. However, since it will be used only to produce the potable water consumed by

guests and staff, the POU system will be small and simple to operate, and have a low energy demand.

Water pressurization system -

- No pressurization system - A very rustic property could altogether avoid the need for a water pressurization and distribution system by using a hand pump to draw water from an underground storage tank, and transporting the water to the point of use with pails or other suitable containers.
- Gravity pressure system - Since a gravity pressure system is easy to operate and maintain, and has low and intermittent energy requirements (see chapter 7), it is an ideal solution for supplying pressurized water to an eco-tourism property. The pressure provided by the system can be very low (less than 0.4 bar at ground level) and can be obtained by a locating the elevated storage tank above one of the buildings, on a small water tower, or on a nearby rise in the land. The pump used to lift the water to the storage tank should ideally be powered by a renewable energy source (e.g., an electric pump powered by a photovoltaic panel, an electric pump powered by a wind turbine, a mechanical wind pump). If water is supplied by a tanker truck that is equipped with a pump, the water should be pumped directly from the tanker truck to the elevated storage tank and thereby free the property from the need to operate its own pump.
- Hydropneumatic system - Although hydropneumatic systems are simple in design, maintenance and operation (see chapter 7), they have a few drawbacks that affect their potential use in eco-tourism properties.
- Since the volume of water stored in the pressure tanks is low, the system's pump must operate at regular intervals and thus requires a

constant source of energy (e.g., batteries or a generator that is able to operate at any time of the day or night).

- The pressure generated by a hydropneumatic system typically ranges from 2 to 4 bars. The capacity and energy consumption of the system's pump is therefore much greater than that of a low-pressure gravity system.
- The higher pressure generated by a hydropneumatic system increases the volume of water consumed by faucets and showerheads, and the loss of water through leaks.

Water distribution system - The design of the water distribution system should be simple and compact in order to minimize pressure and leakage losses. The typical strategy used to achieve this objective consists of grouping together the points of water use in only a few areas of the property (e.g., a central bathroom instead of individual bathrooms in every cottage). If the water is supplied by a low-pressure gravity system, the elevated storage tank should ideally be located close to the point of water use.

17- Guidelines for the planning and design of sanitation systems for eco-tourism properties

- Graywater irrigation - An eco-tourism property should ideally collect all its graywater and reuse it for subsurface irrigation (see chapter 13). Graywater irrigation will greatly simplify the property's wastewater management system and eliminate the use of fresh water for irrigation.

The irrigation system should be as simple as possible and should ideally rely on gravity, rather than a pump, to convey the graywater from the collection tank to the green areas.

- Composting toilets - The use of composting toilets offers many benefits and is by far the best solution for managing human wastes at an eco-tourism property.
  - Composting toilets do not use water and thereby produce no blackwater (i.e., wastewater containing human wastes). All of the wastewater generated by a property equipped with composting toilets consists of graywater, which requires only a minimum amount of treatment before it can be used for subsurface irrigation. The use of composting toilets can therefore completely eliminate the need for building a wastewater treatment and/or disposal system at the property.
  - Composting toilets use no water and significantly reduce the property's water needs and costs.
  - A composting toilet system has minimal energy needs. The exhaust fan is the only feature of the system that consumes energy, and it can readily be operated from a photovoltaic panel equipped with a small battery pack.

What is a Composting Toilet?

A composting toilet system is designed to contain and control the composting of human waste. Unlike a conventional flush toilet that is connected to a wastewater treatment system, a composting toilet uses no water (or a minimum amount of water) and therefore the decomposition of the wastes is carried out in unsaturated conditions (i.e., not immersed in water) by naturally occurring bacteria and fungi. A composting toilet breaks down the waste to 10 - 30% of its original volume. The end product of this decomposition is a stable and safe soil-like material (compost), which has no unpleasant odor and is an excellent soil conditioner.

Composting toilet systems are generally equipped with a ventilation system, which draws air down the toilet, into the compost chamber and out through an exhaust pipe (chimney), thereby eliminating odors in the toilet room. This ventilation also carries away moisture from the compost pile and assists in its aeration.

Figure 17.1 Composting toilet system showing the toilet, the waste chute, the reactor and the ventilation pipe (www.sun-mar.com)

- Composting toilets should not be confused with pit latrines: they are hygienic, do not generate odors, and are not aesthetically offensive.
- The maintenance requirements for composting toilets are minimal and simple.
- Composting toilets transform wastes into a stable and safe soil-like material (compost), which is removed from the base of the reactor only after it has been fully decomposed. The resulting compost is an excellent soil conditioner.

• Flush toilets - Flush toilets increase water consumption and generate a liquid waste, which must then be handled through an appropriate wastewater treatment system. They have many drawbacks compared to composting toilets, and should ideally not be used in eco-tourism properties.

• Blackwater treatment and/or disposal - Any property that uses flush toilets will need to build a blackwater treatment and/or disposal system. In order to minimize the property's maintenance and energy load, the selected system should be as simple as possible and have no (or very low) energy requirements. The blackwater management options that are best suited to eco-tourism properties include:

- Collecting the blackwater in a watertight holding tank and transporting it by tanker truck to an off-site treatment plant.
- Pre-treating the blackwater through a septic tank and discharging the settled effluent to a subsurface absorption system or an evapotranspiration bed (see chapter 10).
- Pre-treating the blackwater through a septic tank, discharging the settled effluent to an intermittent sand filter, and reusing the treated effluent for irrigation (see chapter 10).