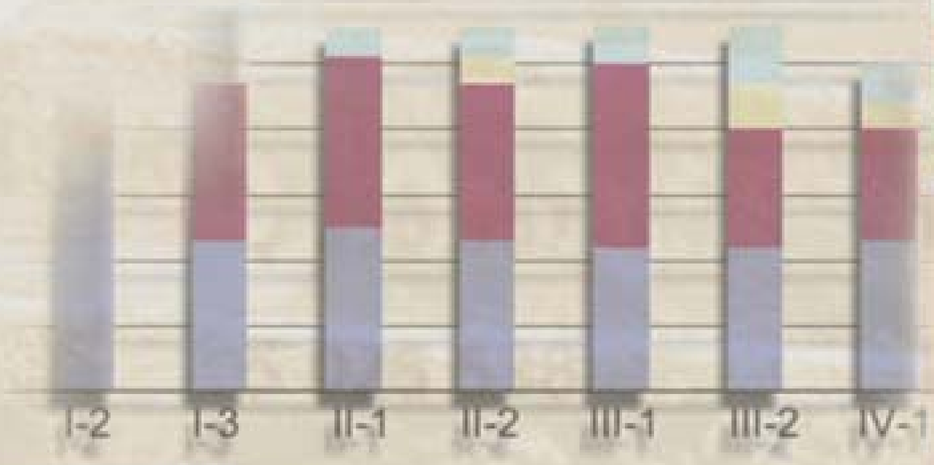
MALTA



WATER RESOURCES REVIEW

Malta water resources review

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Foreword

The Maltese Islands are densely populated but poorly endowed with freshwater resources. Since the 1980s, the drinking-water supply has been heavily dependent on saltwater desalination. The population and the tourist sector are served with good-quality drinking-water, but certain trends give rise to concern: groundwater depletion in terms of both quantity and quality; and a growing dependence on oil imports for water desalination. The public is poorly educated about national water issues and ill-prepared to assimilate information and contribute to shaping the required action. These and other associated trends have raised concerns about Malta's long-term water sustainability and security.

Sustainable water resources are vital to Malta's long-term prosperity. Water is necessary for drinking and it supports everyday life at work, at home and at leisure. Water is essential to agriculture and to the health of the natural environment that supports all human activities. Every sector of the economy depends on secure and sustainable access to water. Despite the very limited resources of the islands and the importance of water to a healthy future, water has not to date been valued as the precious resource that it is. There are no easy solutions to Malta's water shortage yet the nation requires water security for the future. Legal and administrative measures need to be taken according to a plan emerging from a strategy, which in turn is the expression of a national water policy.

A comprehensive review of Malta's water resources was carried out in 2003–04 by the Malta Resources Authority with the collaboration of the Food and Agriculture Organization of the United Nations. This review was presented and examined at a stakeholder workshop in March 2004, and was then open for consultation. Comments were received from stakeholders, and adjustments were made in order to address the issues raised.

The Malta Water Resource Review is intended to provide a strong and objective factual knowledge base on the status of the islands' water resources and trends in water use. It is hoped that it will serve as a platform for discussion among stakeholders and contribute to the development of both a national water policy and a groundwater management strategy for Malta.

List of acronyms

BC	Blue Clay
BRGM	Bureau de Recherche Géologique et Minière
NACE	Classification of Economic Activities in the European Community
EU	European Union
GBH	Gauging borehole
GDP	Gross domestic product
GL	Globigerina Limestone
GS	Greensand
ILI	Infrastructure Leakage Index
LCL	Lower Coralline Limestone
MEPA	Malta Environment and Planning Authority
MOU	Memorandum of understanding
MRA	Malta Resources Authority
NGO	Non-governmental organization
NSO	National Statistics Office
RO	Reverse osmosis
TSE	Treated sewage effluent
UCL	Upper Coralline Limestone
WFD	Water Framework Directive
WHO	World Health Organization
WSC	Water Services Corporation

Glossary

Adaptive management
Adaptive management is based on an acceptance that in complex situations there may never be sufficient information to come to an "optimum" decision. Therefore, it puts the emphasis on flexible planning backed by strong monitoring and information management systems that allow constant adaptation and upgrading of plans and activities.

Aquifer
An aquifer is subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.

Closed basin
A closed basin is a river basin where utilizable outflows are fully committed.

Cost recovery
Cost recovery involves the use of fee or tariff structures that cover the cost of providing the service or investment.

Demand
In economic terms, demand is an expression of willingness to pay for goods or services by those who can afford to pay for them. However, non-economists often understand demand as being the same as needs or requirements. In the context of this report, the definition of demand is usually understood to be somewhere between these two concepts: an expression of need but based on an understanding and acceptance of a "fair price" (monetary and other) for a given level of service. This concept of a "fair price" is subjective, particularly in the case of water and sanitation services, where there is a social aspect to the services, and the traditional price is well below the full economic cost.

Demand management
Demand management involves the use of price, quantitative restrictions and other devices to limit the demand for water.

Externality
An externality is the unintended real (generally non-monetary) side-effect of one party's actions on another party that is ignored in decisions made by the party causing the effects.

Groundwater body
A groundwater body is a distinct volume of groundwater within an aquifer or aquifers.

Information base
The term information base is used rather than the more common "database" to underline the fact that what is being collected and stored is a wide range of physical and societal information (including data) that may require storage in different formats and locations.

Plan
A plan is a coherent set of decisions about the use of resources that, taken together, have the potential to achieve a vision. A plan includes an explicit statement of the methods, costs, responsibilities, schedule of activities, and agreed targets.

Runoff
Runoff (or surface runoff) is the portion of rainfall that flows over the land surface. It can concentrate in depressions or behind impounding structures or it can continue to flow over the land surface into watercourses.

Scenario
A scenario is an internally consistent pathway into the future; stories about the way the world might turn out tomorrow. Developing a set of narrative scenarios helps identify possible pathways into the future based on current trends and some knowledge of sources of greatest uncertainty. Narrative scenarios can and should be a mix of qualitative and quantitative information.

Stakeholder
A stakeholder is an agency, organization, group or individual that has a direct or indirect interest in a project/programme, or that affects or is affected positively or negatively by its implementation and outcome.

Stakeholder platform
A stakeholder platform is commonly defined as a "decision-making body (voluntary or statutory) comprising different stakeholders who perceive the same resource management problem, realize their interdependence for solving it, and come together to agree on action strategies for solving the problem."

Strategy
A strategy is a medium- to long-term planning framework within which plans are developed and funded. Over time, an effective strategy should lead to achievement of a vision. Strategies should be updated constantly in the light of new information. Strategies tend to be highly political and reflect the policies of a governing body or an organization.

Vision
A vision is a desired future state. Consensus on this vision is required before a strategy is developed.

Water governance
Water governance relates to the range of political, social and economic and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society. EMPOWERS focuses particularly on local water governance – governance at a level ranging from the community to the district/governorate.

Executive summary

The state of Malta's water resources is poor. With the support of FAO, the Malta Resources Authority has been undertaking studies and consultations to articulate a national water policy and formulate a set of workable regulations. The rationale behind this process is that involving stakeholders will lead to a policy that is socially and politically acceptable and geared to tackling the complex water-related challenges facing the country. In addition, it is intended that the water policy will ensure that Malta is in compliance with the European Union Water Framework Directive. This directive requires Malta to achieve the status of "good" by 2010.

As part of the policy formulation process, a water resources review was conducted to: (i) assess the current status of water resources; (ii) evaluate the demand trends of different sectors; (iii) provide information; and (iv) identify opportunities for improving the sustainability, efficiency and equity of water resource management.

This review shows that, although the demand for groundwater is outstripping supply, there is scope to reverse current trends through demand management, supply augmentation and strategic protection of groundwater resources. Groundwater quality can be protected and the mean sea-level aquifer stabilized. Policies and practices to do this need to be based on accurate information and acceptance that solutions must be applicable in the long-term. As such, political consensus and cross-party support is vital. This review provides the basis for that consensus.

Malta's core water challenge is one of water governance. Tough decisions will have to be made immediately if the environmental sustainability of Malta's aquifer systems is to be achieved. However, decision-making is currently fragmented, policies are poorly aligned, and awareness of the consequences of continued mismanagement of the sea-level aquifers is poor. Nonetheless, there is much scope for improving Malta's system of water governance. This reports lists 20 practical options and opportunities for improving the sustainable management of Malta's water resources.

Malta faces many infrastructural challenges both in terms of engineering hardware and the institutions that are responsible for service delivery. Considerable investment has been made in desalination plants and further investment has been committed for the construction of sewage treatment plants. However, additional investment will be required if a much higher proportion of Malta's freshwater needs are to be met with desalinated water and if the treated sewage effluent is to be treated further than the statutory requirements of European conventions and conveyed to potential users and/or to locations where it can be used safely to recharge groundwater (using the precautionary principle as a guide).

Considerable private investment has been made in water-related infrastructure (e.g. boreholes and small desalination plants). Private investors are likely to resist a water policy that makes it difficult for them to capitalize on their investments or that necessitates further private investment.

There is scope for augmenting water resources by improving the capture of runoff particularly in urban areas. A 25-m^3 cistern or equivalent in every household is estimated to create a storage capacity of about 4.5 hm^3 (about 25 percent of annual domestic demand). However, logistical constraints hamper the practicability of attaining such levels of storage and self-supply.

Studies undertaken as part of the water resources review indicate that an effective water policy will require:

- improved governance;

- improved awareness;
- staged and adaptive implementation;
- demand management;
- supply augmentation;
- the ensuring of equity and justice;
- targeted interventions.

It is suggested that a water policy should aim to achieve the following vision by 2015:

- levels of water use regulated according to sustainable abstraction levels;
- aquifers restored to a status that represents a strategic reserve;
- water quality of all aquifers restored to within permissible limits;
- widespread use of local and decentralized solutions (e.g. rainwater cisterns, grey-water recycling, and pollution control);
- high levels of collective responsibility for managing and protecting Malta's water resources.

The report describes four demand scenarios (based on current levels of demand and the subsequent projections that have emerged from discussions with various stakeholders). It also discusses different strategies for meeting future demand and achieving the vision.

The report also identifies a set of risks and assumptions that will apply if a proposed water policy is implemented. These are:

- Reversibility of aquifer degradation: It is assumed that a reduction in groundwater abstraction will lead to an improvement in water quality to acceptable levels. The risk is that in some areas this may take many years.
- Climate change: Climate change may become a serious issue in the future.
- Equity: Implementation of the water policy will almost certainly lead to changes in patterns of water availability and use that may result in distinct winners and losers and reduced equity. Provision should be made for compensation schemes that would ensure socially acceptable outcomes.
- Impact on livelihoods: To be effective, the water policy must have an impact on water demand of the water-using sectors and individual water users. There is a risk of negative impacts on some commercial operations and the livelihoods of some users. Attempts should be made to minimize impacts on poorer social groups.
- Non-compliance: There is a history of poor compliance with water-related regulations. Enforcing the water policy effectively will require both resources and political will.

Chapter 1
Introduction

THE MAIN CHALLENGES IN MANAGING MALTA'S WATER RESOURCES

Meeting the demand for water

Malta is densely populated but poorly endowed with freshwater resources. Meeting a high and rapidly increasing demand for water while protecting and conserving the resource base and the environment is a major challenge.

Annual rainfall is about 550 mm and highly variable. There are no surface waters that can be exploited economically, and groundwater resources are subject to increasing competition. Historically, the Maltese people have coped with water scarcity through a limited allocation of water per person. However, in recent decades, urban water users have not experienced prolonged periods of water shortages. One reason for the good supply-reliability record is that, since the early 1970s, a large proportion of the urban water demand has been sourced from desalination plants. While the desalination plants have ensured reliability of supply, a less positive aspect is that they have encouraged a "water" culture that takes only limited interest in conservation or efficient use of water resources. The main control on urban water demand, whether it be for the domestic, industrial or tourist sectors, has been the tariff charged by the Water Services Corporation (WSC). Tariffs have had the desired effect of encouraging some larger hotels to install their own mini-desalination plants and some industries to recycle water. However, they have not been sufficient to encourage widespread rainwater harvesting and reuse at a local/domestic level.

In contrast, agricultural water users continue to be more dependent on the vagaries of the climate and access to water resources for irrigation. Water shortages have resulted in farmers shifting towards cultivation practices and irrigation systems that make efficient use of water resources. The main source of water is groundwater pumped from private boreholes and conveyed to fields via pipe networks and water tankers. Although farmers are relatively more conscious of the importance of water conservation than urban water users, increased agricultural water use and excessive groundwater abstraction in recent years has affected the sustainability and viability of aquifer systems. Severe degradation has taken place in some areas, and the prognosis for other areas is not encouraging. Groundwater degradation linked to agriculture takes two distinct forms. First, there is increasing salinity of the Lower Coralline sea-level aquifer systems as a result of vertical and horizontal seawater intrusion. Second, there is nitrate contamination of practically all the aquifer systems as a result of intensive livestock production, high levels of fertilizer use, and leakages in the sewage collection system (particularly in heavily urbanized areas).

Other users of water include tourism, industry and government organizations (e.g. hospitals and schools). Although there are specific challenges that relate to each of these sectors, their overall water demands are considerably lower than either the domestic or agriculture sectors.

Protecting the resource base

If Malta's water resources are to be protected, some difficult decisions will have to be made in the very near future. To be successful, these decisions must affect the patterns of groundwater abstraction and commercial practices that are currently degrading the water resources. Political imperatives for such actions include:

- the large increase in domestic water bills that will result from sourcing potable water entirely from desalination plants;
- the gradual collapse and/or major reduction in the profitability of irrigated agriculture that will result from further degradation of the sea-level aquifers;
- the penalties that might result from non-compliance with relevant European Union (EU) directives concerning water and the environment.

About 80 percent of Malta's groundwater resources are abstracted from sea-level fractured-limestone aquifers. These support a groundwater body that takes the form of a lens of freshwater floating on the underlying denser saltwater. Such groundwater bodies are inherently fragile and extremely vulnerable to poor management. Continued unregulated overabstraction of groundwater from these aquifers carries the severe risk of, in practical terms, destroying their capacity to store freshwater. Overabstraction is slowly reducing the volume of freshwater in the lenses. Deep boreholes and high-levels of localized abstraction carry the risk of disrupting and broadening the interface between freshwater and seawater and, thereby, further reducing the capacity of the lenses to store freshwater.

The perched limestone aquifer systems sit on impervious clay strata above sea level. Most of these aquifers are overexploited to the extent that groundwater levels have fallen and the flow from natural springs has dwindled. The freshwater flow from a number of these springs also supports important endemic species and ecosystems, which are protected under relevant national and European legislation. As a result of intensive farming practices, high-levels of nitrate pollution have made these bodies of groundwater unusable as sources of water for domestic use.

Improving water governance

Malta's main water management challenge is to ensure that priority demands for water are met while maintaining the viability of the aquifer systems. The challenge facing Malta is a complex one. Moreover, it is not solely linked to the selection of water management strategies that reduce the pressure on the aquifers while maintaining reliable and adequate water supplies to users. The fundamental challenge is to establish systems of water governance that take account of societal, economic and environmental conditions that are characterized by uncertainty, variability and change. It is not possible to make water management decisions and/or plans that will solve all water management problems now and well into the future. Instead, Malta requires the water governance capacity (i.e. information systems, stakeholder platforms, legal and regulatory mechanisms, executive capabilities, and conflict resolution systems) to enable society to respond to uncertainty, variability and change that could be localized or islandwide, short or long term, political, economic or environmental. This includes approaches to water management planning that are flexible and able to adapt or respond to uncertain future challenges.

The effective management of water resources is only possible where good-quality information exists on the status of resources and current and future demands. It is also extremely important that decision-makers at all levels have a good understanding of the characteristics of the water resource systems that they are managing and of the potential consequences of different courses of action. Although a lot of water-related information exists in Malta, this information is fragmented and difficult to access. Furthermore, much of the statistical information is misleading, inaccurate and/or out of date.

There is much scope for an improved alignment of policies that have the potential to affect the resource base or stimulate increased demand for water. There is also scope for better sharing of information and for planning processes that take better account of the fragile nature of Malta's water-resource systems. Water-resource planning and management is not integrated across the relevant line departments, agencies and private-sector organizations. This is leading to situations where certain departments are pursuing policies that encourage increased water demand and use while others are attempting to regulate demand. Planning processes do not exist that maximize the allocation of water to the most beneficial use nor do they consider potential negative trade-offs associated with different courses of action.

Misconceptions have had a major impact on decision-making and behaviour at all levels. In the main, they have led to a mistaken belief that Malta's groundwater resources are unlimited. Although it may be a slow process, carefully structured and well-targeted awareness campaigns are needed urgently to overcome this problem.

Finally, water governance will only improve substantively if there is wide acceptance of the need for a water policy that includes regulations. For this to happen, the regulations must be seen to be equitable and just. Furthermore, there has to be the political will to enforce such regulations. There has been a history in Malta of non-compliance with water-related regulations, including the illicit construction of boreholes. A new water policy must take account of lessons learned from earlier attempts to introduce regulations.

Supplying water at an acceptable cost

In Malta, the pricing of water supplied by the WSC is a political issue. Although nominally the responsibility of the Malta Resources Authority (MRA), the Government sets the tariffs that can be charged for water by the WSC. The Government also sets the price of energy for running the desalination plants. Private groundwater abstractors do not pay a charge for the water they abstract. For farmers, the cost of water is represented by the costs incurred in the drilling of boreholes, installing pumping equipment, and the running and maintenance of such capital. The Government considers the revenue foregone a "social contribution" to the sector. The net result of the active role that the government takes in setting the price of water means that prices rise, the electorate tends to blame the Government.

EU member states are to ensure that by 2010 water-pricing policies provide adequate incentives for users to make efficient use of water resources. An adequate contribution by the respective water users will reflect the utility of this commodity in industry, domestic consumption and agriculture. The costs of water services have to be recovered, and accounted for under the "polluter pays" principle. In structuring this pricing policy, member states should consider the social and economic effects of the recovery mechanism as well as the geographical and climate conditions of the region.

If tariffs are to be used to regulate demand, they will have to be set at a level that changes the behaviour of users to the point that they encourage: improvements in efficiency and productivity; consideration of alternative sources of supply to groundwater; and a shift away from using water for "low-value" activities.

The economic argument for using tariffs to regulate groundwater use is strong. If groundwater quality continues to deteriorate, at some point domestic water supplies will have to be sourced almost entirely from desalinated water. In terms of production costs, the cost of substituting groundwater with desalinated water will be about LM4 million/year (about US$1.333 million/year, at an exchange rate of LM1 = US$0.3332) based on current energy costs. If this increased cost is passed on to the consumers, this will lead to a doubling of household water bills. If groundwater quality deteriorates to the point that it is unusable for agricultural purposes, farmers may have to switch to desalinated ("polished") groundwater or treated and "polished" sewage effluent. Based on current energy costs, this would result in increased per-hectare irrigation costs of about LM1 000 and LM3 000 for crops irrigated with treated sewage effluent (TSE) and desalinated water, respectively. These estimates are based on a crop requiring 500 mm of irrigation per year and estimated TSE and desalinated water charges of LM0.2 and LM0.6 per cubic metre, respectively.

Improving the infrastructure

The main infrastructural challenges include:

- Development of additional desalination capacity. Excess capacity exists to meet Malta's current demand for producing desalinated seawater. However, additional capacity will have to be created if all of Malta's freshwater resources have to be sourced from desalination plants.
- Development of TSE supply and storage systems. It is anticipated that there will be sufficient capacity for treating all of Malta's sewage effluent by 2008. However, challenges exist if all this water is to be used for agriculture. These include infrastructure to convey water to where it is needed and extra-treatment of the effluent if the saline content of the sewage is not controlled. Given the seasonal nature of demand for irrigation water, storage capacity will also be needed to ensure that water is available when needed.
- Leakage reduction. Real losses (i.e. leaks, illegal connections, etc.) from the urban water supply network continue to be about 30 percent. Reducing losses to more acceptable levels is an ongoing challenge facing the WSC.
- Increased water harvesting. Water resources could be augmented by increasing local-level rainwater harvesting, particularly in urban areas. However, sufficient space and adequate fiscal incentives may prove to be a challenge.
- Recognizing the aims and aspirations of private investors. In recent years, considerable private investment has been made in the drilling of boreholes for a range of uses from land clearance to irrigation systems. In the case of agricultural users, the need to pay off debts is likely to be an important factor in whether or not farmers are willing to reduce their water demand or switch to alternative and more costly (to the individual) water sources. Connecting to these sources may require additional investment in infrastructure.

Increasing supply and limiting demand

Although the water resource situation in Malta is extremely serious, there is much that can be done. However, there are no "quick fixes" that might result from a single political initiative such as formulating a new set of groundwater regulations. However, a single policy initiative that is well formulated, equitable and just and that takes a long-term view could prompt the crucial changes in attitude and behaviour needed at all levels if safeguarding the water-resource base is to become a component of political decision-making.

Details of opportunities for augmenting water supplies for different uses and for regulating the demand of different users are discussed in other sections of this report.

COLLABORATION WITH FAO

Malta has no national water law per se. While the Civil Code includes a clause dealing with entitlements to water from springs, it is the Malta Resource Authority Act that sets out the regulatory arrangements for the groundwater resources.

In July 2002, FAO entered into an agreement to assist the Government of Malta in the review and drafting of new or amended legislation for the sustainable management of groundwater. A strictly related objective was to anticipate the implementation and administration requirements of the proposed legislation. A complementary objective was to assist the Government of Malta in the review and analysis of policies resulting from its review work in support of the preparation of a new groundwater allocation policy and new groundwater legislation. The objective of building national capacity in the conceptualization and drafting of groundwater-resources management legislation, in anticipating and meeting the implementation and administration requirements of the proposed legislation and in water resources policy analysis and formulation was also considered to be a necessary component of the project.

Among other activities, the project undertook a large number of studies. The reports from these studies are available from the Web site of the MRA.

Public announcements of a policy approach have to date been limited to the release in March 2004 of the consultation document "A water policy for the future" prepared by the MRA with the assistance of FAO. Seventeen responses to the document were made by government departments, the Malta Chamber of Commerce and Enterprise, academics, consultants and the Farmers' Central Cooperative. There was general support for the need for a holistic water policy. Subsequently, the MRA compiled a document outlining and commenting on the responses received, which is available on its Web site.

AIMS OF THE REPORT

The overall aims of this report are:

- to provide a comprehensive review of the current status of Malta's water resources and an assessment of demand trends for the different sectors;
- to assess the relative factors that may affect water supply and demand;
- to identify specific opportunities for improving the status of Malta's water resources and meeting future demands;
- to consolidate information that can inform discussions on Malta's water policy. In particular, the report has been written in support of the preparation of a national water policy document that will serve as the basis for the establishment of new water regulations, enhanced institutions and governance, and water-demand management programmes.

The preparation of the report involved a review of information on water resources status, use and demand from the studies carried out by the project and others. Particular attention was given to identifying and removing discrepancies and inconsistencies, and to presenting information that has been verified by the relevant stakeholders.

Chapter 2
Basic facts about Malta

PHYSIOGRAPHY AND DEMOGRAPHY

The Maltese archipelago consists of three inhabited islands: Malta, Gozo and Comino, and a number of uninhabited islets scattered around the shoreline of the major islands (Figure 1). Its location is about 96 km south of Sicily (Italy) and 290 km north of Tunisia (between 35° 48' and 36° 05' N and 14° 11' to 14° 35' E). The total surface area is about 316 km^2 and the perimeter of the shoreline of the island of Malta is 136 km while that of Gozo is 43 km.

The Maltese Islands have a population of about 398 000, increasing at a rate of about 2 400 inhabitants/year. Official statistics show that the Maltese population is expected to continue growing for the next 20–year period to a total of 425 000 inhabitants. This increase will impose further pressures on the socio-economic and socio-cultural structures of the country, with significant added strains on the water resources. With a population density of 1 250 inhabitants/km^2, Malta is among the most densely populated countries of the world. Consequently, Malta is highly urbanized and more than 23 percent of the surface area is built-up.

It is expected that the total number of households will increase, a change that will be accompanied by a decrease in household size – mainly as a result of changing family perceptions. A steady decrease in household size has been evident in recent years. The average household size of 3.1 persons registered in the 1995 census is projected

FIGURE 1
The Maltese Islands

to fall to 2.7 persons by 2020. As a consequence, the total number of households is expected to increase from the 119 479 households recorded in the 1995 census to about 160 000 households by 2020. Population statistics also indicate an internal migratory flow from the Southern Harbour to the Northern Harbour and other districts, which will also be reflected in a redistribution of the housing stock in the country.

The Maltese economy is becoming increasingly service oriented. In 2002, the manufacturing sector contributed to about 35 percent of gross domestic product (GDP), while the market/services sector accounted for slightly more than 48 percent of GDP. Sectorally, the percentage employment shares in 2004 for the agriculture, industrial, services and public sectors were 1.6, 24.2, 37.4 and 36.8 percent, respectively.

Tourism plays an important role in the country's development. Through the multiplier effect, it contributes towards an employment complement of about 40 000. About 1.1 million tourists visit the islands, for an average total of 10.5 million days per year. The average daily tourist population is 32 000. Tourist arrivals peak in July and August, placing additional strains on the country's water resources.

Urban development in Malta has increased dramatically in the last 50 years and development has altered the physical characteristics of the landscape drastically, increasing the quantity of impermeable surfaces and, thereby, reducing infiltration processes. The result has been a decrease in natural groundwater recharge.

HISTORICAL DEVELOPMENTS

Historically, Malta has had a lack of natural resources in relation to demand, and water resources have always been considered of strategic importance. Thus, for example, near the world heritage site of Hagar Qim and Mnajdra, there is a group of rock-cut cisterns known as the Misqa Tanks (Plate 1). The antiquity of these tanks is uncertain although they are generally presumed to be contemporary to the megalithic temples.

In 1512, when King Charles V offered the Maltese Islands to the Knights of St John, a fact-finding mission reported that: "The water is salty and putrid but there are good springs which are probably due to rain fallen in winter time. The origin of these springs in not very deep, they often disappear in summer but they always diminish in volume. One generally drinks rainwater collected in tanks or in ditches." (Knight Quintinus Haedus, 1536).

Until 1610, Valletta was supplied solely through stored rainwater. In that year, work began on an aqueduct (Plate 2) to carry water from the springs in the Rabat Plateau to Valletta.

Plate 1
The Misqa tanks.

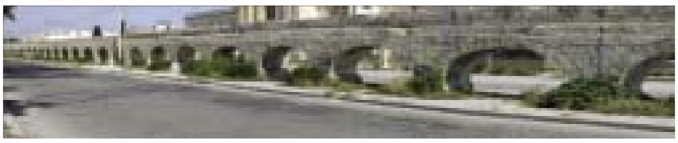


Plate 2
The Wignacourt Aqueduct.

Under British rule, various major infrastructural works were undertaken including the digging of a deep well close to Valletta and the installing of a motorized pump in 1851. In 1866, galleries were constructed to abstract water from the perched aquifers, while in 1881 a boiling-type distillation plant was built at Tigne (Plate 3).

Other important works undertaken over the years included: the construction of the Sta Marija Reservoir in 1886; the construction of galleries and a pumping station at Wied il-Kbir, and the installation of a pipeline water system supplying Valletta, Floriana, Sliema, Birkirkara, Zebbug, Siggiewi, Rabat and Mdina in 1887; the construction of galleries and pumping stations, the Fiddien Reservoir (91 000 m^3), the Qrendi Reservoir (54 500 m^3) and major pipelaying works between 1955 and 1961.

Plate 3
The building that housed the 1881 distillation plant at Tigne.

Between 1965 and 1968, four multiflash seawater distillation units (with a maximum production of 20 500 m^3) were installed. In the 1970s, it was decided to boost groundwater production from the mean sea-level aquifer through an intensive borehole-drilling campaign. Overall groundwater production figures increased, but with a deleterious effect on the qualitative status of the aquifers. By 1980, the average annual salinity of the mean sea-level aquifer had risen to 1 600 mg/litre, exactly twice what it had been in 1969. By this time, it had become evident that the heavily depleted aquifers could no longer meet the growing demand.

Therefore, reverse osmosis (RO) technology was chosen as the strategic alternative water-supply source for the islands. The first seawater RO plant started production in 1982 at Ghar Lapsi on the west coast of Malta, at that time producing 20 000 m^3/day. Since then, other plants at Marsa (brackish-water), Tigne, Cirkewwa and Pembroke have been constructed. Today, desalinated water accounts for about 55 percent of the total potable water production. Malta has one of the longest track records of RO plant operation in the Mediterranean region, with high output levels and reliability.

Chapter 3
National economic and political setting

NATIONAL ECONOMIC, SOCIAL AND ENVIRONMENTAL OBJECTIVES

In 2002, the Government of Malta submitted a report to the World Summit on Sustainable Development (Government of Malta, 2002). The report analyses the major environmental issues facing the Maltese Islands, reviews the progress achieved on these issues and outlines what remains to be done in order to meet the objectives set.

The report highlights the achievements in the five-year period preceding the its publication. It provides specific information on the leakage-reduction and energy-saving programmes initiated by the WSC.

The report presents the main threats relating to the integrity of groundwater as:

- overpumping of the mean sea-level aquifers and a consequent rise in salinity levels;
- point and diffuse pollution from anthropogenic activities namely agriculture (fertilizer and pesticides), industry and waste disposal;
- the effects of land development, including road development on natural aquifer recharge.

The report also notes that "freshwater resources support particular habitats and that their contamination poses an ecological threat. Furthermore, freshwater habitats have been steadily decreasing due to competition with other land-uses."

The main objectives set by the Government in this report with regard to sustainable development in the water sector are:

- attainment of internationally acceptable standards in drinking-water quality through the undertaking of the necessary improvements in the water production and distribution infrastructure;
- protection of high-status sites in line with the EU Water Framework Directive (WFD);
- the designation of the entire Maltese Islands as a nitrate-vulnerable zone in order to protect the quality of groundwater;
- the need to encourage further water conservation measures (with specific reference to the use of cisterns);
- the need to optimize the use of second-class water;
- integrated water resources management coupled with further enforcement of regulatory measures (in particular with regard to illegal abstraction).

NATIONAL LEGISLATION

A review of the history of Maltese legislation (FAO/MRA, 2004d), indicates that groundwater has only recently been recognized as a resource and regulated as such. In fact, in 1886, when the Civil Code was being drafted, water was considered "a natural resource which falls from heaven", but now it is being recognized as an economic good.

The Civil Code and the Code of Police Laws are the earliest legal instruments regulating water resources. The Civil Code regulates the collection of natural water resources and identifies who has the right to collect water flowing naturally on the land. The Code of Police Laws tries to protect "public waters". Furthermore, it was under the Code of Police Laws that the regulation of pollution was first introduced.

Although the legal status of the codes is hierarchically superior to primary and subsidiary legislation, this hierarchic superiority is waived when more recent and more specific primary and subsidiary legislation comes into force. In 1991, the Water Services Act was promulgated, which regulated the management of water resources. This law repealed two ordinances that regulated the abstraction of groundwater as well as the use of groundwater for irrigation, namely the 1939 Irrigation Ordinance and the Groundwater Ordinance.

Under this act, the roles of regulator and operator were attributed to the WSC. The act empowers the WSC to acquire, transform, manufacture, distribute and sell potable and non-potable water. The WSC is also entrusted with the treatment, disposal and reuse of sewage water and wastewater and the reuse of stormwater runoff. Although this act does not define underground water, there is an operative part that lists the duties of the WSC with respect to the supply of groundwater. In fact, it is the duty task of the WSC "to survey, inspect or cause the sinking of bores…for the purpose of ascertaining…the presence, quality or quantity of underground water…" This section is the first legal provision that provides for the quality of groundwater.

In 2000, the Malta Resources Act was enacted. This act defines the functions of the WSC and the MRA as the operator and the regulator, respectively. This new act deleted all the provisions under the Water Services Corporation Act that empowered the WSC to issue licences for the supply, sale or any other functions concerning water, water pumps and other apparatus related to the supply of water.

The functions of the MRA, which has a directorate for the regulation of water resources, have been fashioned upon the functions laid down in the Water Services Corporation Act. The only difference is that the MRA safeguards and manages water resources through the adoption of regulations and granting of licences, whereas the WSC performs its duties and implements these functions as a water-supply utility.

Another pertinent act is the Environment Protection Act of 2001. Under this act, the wide definition of the term "environment" includes "water". The competent authority under this act is the Malta Environment and Planning Authority (MEPA). The MEPA is entrusted with the implementation of the Government's duties under this act. Furthermore, the MEPA has to cooperate and make arrangements with other entities in order to better monitor the implementation of and compliance with the provisions of this act. This can be done through the adoption of memoranda of understanding between the MEPA and other authorities, such as the MRA. Such coordination is needed between the MEPA and the MRA in order to establish which will be the competent authority for licensing operations relating to the abstraction, use or other forms of management of groundwater. However, this act also provides that the minister responsible for the environment may issue regulations under the Environment Protection Act, and may establish that another person or body besides the MEPA shall be responsible for the performance of those regulations.

Finally, the Constitution of Malta states: "Nothing (in this article) shall be construed as affecting the making or operation of any law so far as it provides for vesting in the Government of Malta the ownership of any underground minerals, water or antiquities". Thus, the constitution can be considered to formally vest in the Government of Malta the sole ownership of all groundwater resources in the islands.

EUROPEAN WATER DIRECTIVES

The acceptance of the application submitted by Malta to become a member state of the EU triggered the process of harmonization. This has led to a major re-evaluation of Malta's legislative system, particularly in the field of environmental management. As an EU member state, Malta is obliged to take a more sustainable and integrated approach to groundwater management than was previously the case. The regulation of groundwater management in Malta has also needed to be harmonized with the relative sources of the *acquis communautaire*, which are comprehensive and holistic in their approach.

The Malta Resources Authority Act and the Environment Protection Act paved the way for the adoption of subsidiary legislation that has transposed into Maltese legislation two EU directives regulating groundwater, namely: the WFD; and the Groundwater Directive. These two directives provide for specific measures for the protection of groundwater.

The legal instrument that adopted the EU Groundwater Directive into Maltese legislation is "The Regulations for the Protection of Groundwater against Pollution caused by Dangerous Substances 2002". This is the first regulation completely adopted for the protection and management of groundwater. This legislation defines groundwater as: "all water, which is below the surface of the ground in the saturation zone and in direct contact with the ground or sub soil". These regulations are particularly aimed at protecting the quality of groundwater against pollution caused by dangerous substances. The term pollution has been given a wide definition, and pollution in groundwater occurs whenever there are "anthropogenic direct and indirect discharges of substances,...... which might endanger human health or water supplies, harm living resources and the aquatic ecosystem or interfere with other legitimate uses of water."

The MRA is the competent authority to take preventive measures, grant authorization and the required licences, conduct investigations, and monitor and implement the provisions of these regulations. However, certain provisions lay down general obligations, and in some of them there are no set thresholds for determining when quantities and concentrations are likely to cause deterioration in the quality of groundwater. Hence, the MRA has to set its own policies on these matters.

These regulations also provide for the "polluter pays" principle. Any person found guilty of polluting the groundwater shall be guilty of an offence that entails a pecuniary punishment, imprisonment or both. Hence, the "polluter pays" principle has been introduced to serve as a deterrent and enhance better protection of groundwater from pollution.

The WFD has been adopted into Maltese legislation by "The Water Policy Framework Regulations 2004". These establish a framework of action for the protection of "inland surface waters", "transitional waters", "coastal waters" and "groundwater".

These regulations designate the MRA as the competent authority for "inland water". Hence, it is the task of the MRA to take all necessary measures to ensure that the environmental objectives established under these regulations are met and to coordinate "all programs of measures for the whole of the catchment district". The MRA has a number of obligations to implement under these regulations in order to ensure good management, as well as protect groundwater from pollutants. This exercise of implementation entails a lot of work and numerous studies to identify water catchment districts, and to see which areas within these districts require special protection under specific legislation for the protection of groundwater. The regulations lay down timeframes for the competent authority to achieve and start adopting the required implementation measures (Table 1). This framework has to be worked out together with the public. In fact, the competent authority must ensure that the public is consulted and informed. Furthermore, the regulations also oblige the competent authority to encourage the active involvement of interested parties in the implementation of these regulations, particularly in relation to the formulation, review and updating of water-catchment plans.

These regulations provide new obligations and new implementation measures that the competent authority has to follow in order to protect both the quality and the quantity of groundwater in line with European standards.

Other directives that also have an impact on the regulation of groundwater (e.g. the Nitrates Directive, the Habitats Directive, the Landfilling of Waste Directive, the Plant

TABLE 1
Timetable for implementation of the Water Framework Directive

Year	Requirement
2003	Directive transposed into national legislation.
	Identification of river-basin districts and of the competent authorities that will be empowered to implement the directive.
2004	Completion of the first characterization process and the first assessment of impacts on the river-basin districts.
	Completion of the first economic analysis of water use.
	Establishment of a register of protected areas for the river-basin districts.
2006	Environmental monitoring programmes established and operational.
	Work programme for the production of the first River Basin Management Plan established.
2007	Public consultation process on significant water management issues in the river-basin districts initiated.
2008	Publication of the first River Basin Management Plans for public consultation.
2009	First River Basin Management Plan finalized and published.
	Programme of measures required in order to meet the environmental objectives of the directive finalized.
2012	Programme of measures to be fully operational.
	Work programme for the production of the second River Basin Management Plan published.
2013	Review of the characterization and impact assessment of the river-basin districts.
	Review of the economic analysis of water use.
	Interim overview of significant water management issues published.
2014	Publication of the second River Basin Management Plan for public consultation.
2015	Achievement of the environmental objectives specified in the first River Basin Management Plan.
	Second River Basin Management Plan finalized and published with revised programme of measures.
2021	Achievement of the environmental objectives specified in the second River Basin Management Plan.
	Third River Basin Management Plan to be published.
2027	Achievement of the environmental objectives specified in the third River Basin Management Plan.
	Fourth River Basin Management Plan to be published.

Protection Products Directive, and the Environment Impact Assessment Directive) have also been transposed into national legislation. This process has resulted in a comprehensive legal framework addressing groundwater management for the very first time in Malta's legal history. Although not yet published, the Strategic Environment Assessment Directive and the Biocides Directive should soon be transposed into Maltese legislation and put into effect.

Implementation of EU directives

The process for the implementation of the WFD is guided jointly by the MEPA and the MRA through a memorandum of understanding (MOU) agreed upon by the two authorities. Under this MOU, the MRA is the competent authority in Malta for "inland waters" with the exception of inland surface waters protected under the Development Planning Act or the Environment Protection Act. For such inland surface waters, the MEPA is the competent authority.

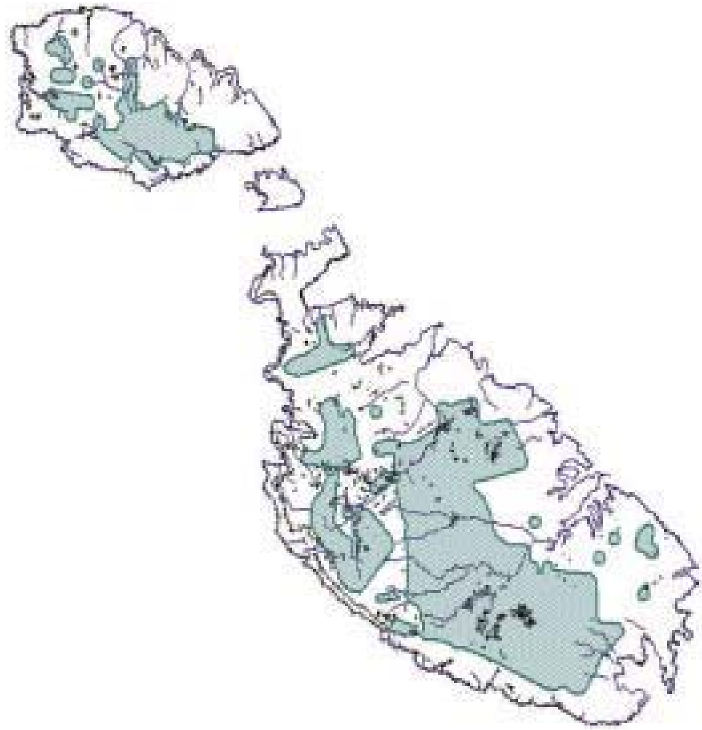
Thus, the MRA is currently carrying out the characterization of the groundwater bodies in the Maltese Water Catchment District and publishing the results of this analysis on its Web site. The MRA has also defined Groundwater Protected Areas (Figure 2) for the protection of groundwater utilized or intended to be utilized for human consumption and it has initiated the economic analysis of water use in the water catchment district. Initial results are also available on its Web site.

In addition, the groundwater monitoring strategies are being re-formulated in order to align them with the requirements of the WFD. The MRA aims to conclude this process by mid-2005 in order to have the monitoring networks operational in hydrological year 2005–06.

The overall objective of the WFD is to harmonize water environmental policy and regulation across Europe. As regards groundwater, the main aims of the legislation can be outlined as follows:

- prevention of deterioration in the status of groundwater bodies;
- protection, enhancement and restoration of all groundwater bodies;
- achievement of good groundwater qualitative and quantitative status by 2015;
- prevention and limiting of the input of pollutants in groundwater;
- reversing any significant upward trend in pollutants in groundwater;
- achieving the standards and objectives set for protected areas in other national and Community legislation.

FIGURE 2
Groundwater Protected Areas in the Maltese Islands



These objectives will be achieved through the setting up of "programmes of measures" within the Water Catchment District Management Plans. The directive requires these programmes to be based on the results of the characterization analysis in order to achieve maximum impact.

Furthermore, the MRA is also involved in the negotiations on drawing up the new Groundwater Directive. This directive is a requirement of the WFD, which states under Article 17 that "on the basis of a proposal from the Commission, the European Parliament and the Council shall adopt specific measures to prevent and control groundwater pollution by defining some common criteria on good chemical status and quality trends".

The current proposal sets out specific measures as per Article 17(1) and (2) of the WFD in order to prevent and control groundwater pollution. These measures include:

- criteria for the assessment of good groundwater chemical status;
- criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points for trend reversals.

The proposal also establishes a requirement to prevent or limit indirect discharges of pollutants into groundwater. Once adopted, this directive will be transposed into Maltese legislation.

Chapter 4
Water governance

REGULATION AND ACCOUNTABILITY

Malta has no national water law per se. While the Civil Code includes a clause dealing with entitlements to water from springs, it is the Malta Resource Authority Act that sets out the regulatory arrangements for groundwater resources.

The MRA is a public corporate body with regulatory responsibilities relating to water, energy and mineral resources in the Maltese Islands. It was set up by the Maltese Parliament through the Malta Resources Authority Act of 2000. The MRA has wide-ranging responsibilities essentially involving regulation of: water and energy utilities; quarry operators and private abstractors of groundwater; and retailers, operators and tradesmen in the regulated sectors. The Directorate for Water Resources Regulation has the duty to ensure the proper and sustainable use of all water resources in the Maltese Islands while respecting hydroenvironmental and socio-economic constraints. As the body responsible for the formulation of water regulations and policies, the Directorate for Water Resources Regulation is currently reviewing existing legislation and working on the implementation of EU directives recently transposed into Maltese law.

The MRA is mandated under Article 2(b) (i) of the founding legislation, the Malta Resources Authority Act XXV Chap. 423 of 2000, to secure and regulate the acquisition, production, storage, distribution or other disposal of water for domestic, commercial, industrial or other purposes. The MRA is also the designated competent authority for the Groundwater Directive. This directive requires the protection of groundwater regardless of its current use and aims to control pollution by a detailed list of substances. Where there is a risk of contamination, prior investigation is required before an authorization of discharge is released. The WFD is "results-oriented" in that it aims to achieve "good status" of surface water and groundwater by 2015. It requires a holistic management at water-catchment scale aiming at the achievement of specific environmental objectives.

Regarding groundwater, the WFD requires:

- the classification of well-defined groundwater bodies into good or poor status by way of quantity and quality;
- an assurance of no further deterioration;
- the restoration of groundwater bodies in poor status.

Further and more precise requirements are spelled out in the EU Directive on the Protection of Groundwater Against Pollution. Some aspects of the policy are covered by the statutory powers of the MRA. However, additional subsidiary legislation will be needed to achieve all the policy objectives.

WATER SERVICES

The WSC is a public utility body responsible for the supply, production and distribution of water in the Maltese Islands. It was set up by the Maltese Parliament in the Water Services Act XXIII 1991. The WSC operates four RO desalination plants with a total nominal capacity of 100 000 m^3/day. It also manages the municipal water-distribution network. This network consists of about 2 000 km of pipework of varying materials and sizes and a further 1 700 km of service pipework connecting more than 200 000 premises to the network. Extensive effort and investment have been devoted to leakage control, improved management practices and water conservation programmes.

Since October 2003, the WSC has also been responsible for the collection and proper disposal of wastewater.

In its strategic plan for the period 2004–08, the WSC spells out its national vision: "The Water Services Corporation is nationally recognized and respected as a top organization. It has a reputation for excellence in providing an essential service to the community, in meeting its social responsibilities, in sharing its expertise to industry and commerce and for not taking advantage of its monopolistic situation. The Corporation considers the customer as its driving force. It ensures the provision of water when and where it is required, and efficient, effective and safe wastewater management, at the lowest possible cost. The Corporation seeks to minimise the negative effects its activities can have on the environment, internationally, nationally and locally, and uses all its resources to champion the cause of environmental protection and enhancement. In that regard, the WSC has a reputation for excellence in its water conservation programme and activities to make optimum use of all water resources."

The WSC acknowledges in its strategic plan that by being the single largest abstractor/producer of water in the islands, it must play a leading rode in the management of the nation's water resources. The key goals of the WSC in the area of water governance, as outlined in the strategic plan, are:

- make water governance central to its efforts for maintaining sustainable development and effective management of Malta's water resources;
- identify and implement on a consistent basis water governance policies and practices through the widespread use of the tools of integrated water resources management;
- lead the way in the allocation and management of water resources in ways that meet current national, social and economic needs, and yet secure the future by ensuring the long-term sustainability of the available water resources;
- analyse all water problems or crises through established policies and practices of water governance to prevent future recurrences;
- seek to create accountable but active and positive relationships between the different and sometimes competing players and stakeholders, to explore common ground and to find equitable regulatory procedures that satisfy all water interests and needs.

The mission statement of the WSC is: "We supply water reliably, and dispose of waste water safely, to recognised standards of quality, aiming to satisfy the expectations, of all sectors of the community, using resources effectively and economically, while safeguarding health and the environment."

SECTORAL RESPONSIBILITIES

The Health Department is currently responsible for regulating drinking-water quality. Subsidiary legislation under the Public Health Act transposing Directive 98/83/EEC is being adopted. A transitional period of three years has been granted for the full implementation of the provisions of the directive with regard to the application of Annex 1 Part B on nitrate and fluoride and Part C on conductivity, chloride, sodium, sulphate and iron. This will allow time for the necessary infrastructural improvements to bring these substances in line with the limits imposed by the directive. The Health Department is also responsible for the quality of bathing waters.

The Department of Agriculture within the Ministry of Rural Affairs is responsible for the implementation of the Nitrates Directive transposed under the Environment Protection Act as Legal Notice 343 of 2001. A code of good agricultural practice has been drawn up to guide farmers on measures to reduce nitrate pollution from agricultural activity.

The MEPA and the MRA are both responsible for the implementation of the WFD (Chapter 3). An MOU has been signed by the two competent authorities for the purpose of clarifying the roles and defining their responsibilities in support of water-catchment management and the achievement of the objectives of the WFD. The agreement also seeks to foster cooperative working relationships between the two authorities by coordinating and simplifying the implementation procedures articulated in the regulations.

The Malta Standards Authority is responsible for setting the provisions for and certification of services in quality management systems (MSA ISO 9001: 2000) and environmental management (against ISO 14000), so guiding institutions and organizations towards improved performance and improved environmental conservation.

CIVIL SOCIETY

The non-governmental sector is considered an important stakeholder for the scope of this policy exercise. There are about 20 non-governmental organizations (NGOs) in Malta, most of which have been and will continue to be consulted on the more important issues of the policy.

Chapter 5
Water resources

CLIMATE
Rainfall

The climate of the Maltese Islands is typically semi-arid Mediterranean, characterized by hot, dry summers and mild, wet winters. During the summer season, the islands are dominated by high-pressure conditions. The mean annual rainfall was about 550 mm for the period 1900–2000 but with high seasonal and interannual variability (variation coefficient: 27 percent), with some years being excessively wet and other years being extremely dry. The highest precipitation rates generally occur between October and February (Table 2). Rainfall is characterized by storms of high intensity but of relatively short duration.

TABLE 2
Mean monthly values of main climate parameters, Malta

Month	Rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)
January	86.4	14.9	10.0
February	57.7	15.2	10.0
March	41.8	16.6	10.7
April	23.2	18.5	12.5
May	10.4	22.7	15.6
June	2.0	27.0	19.2
July	1.8	29.9	21.9
August	4.8	30.1	22.5
September	29.5	27.7	20.9
October	87.8	23.9	17.7
November	91.4	20.0	14.4
December	104.3	16.7	11.4

FIGURE 3
Annual rainfall for Luqa meteorological station, 1947–2004

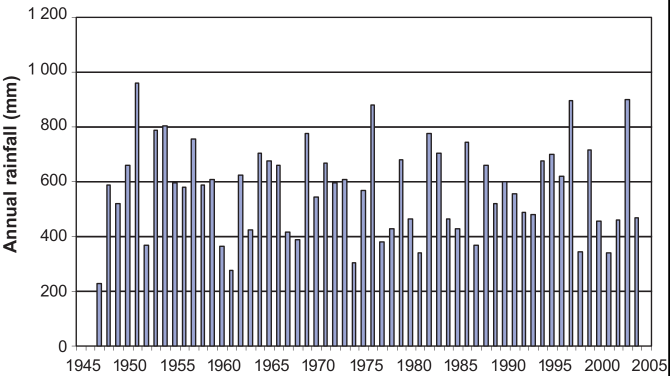


Figure 3 presents the annual rainfall for the Luqa meteorological station for the period 1947–2004. The average rainfall for this site for this period was 569 mm. In order to give a better impression of interannual variability, Figure 4 presents the deviation of annual rainfall from the long-term average for the same meteorological station. This figure shows that annual rainfall of 300 mm more or 250 mm less than the average is common. Although there is no indication of systematic variability, consecutive years of above- or below-average annual rainfall are common.

In Malta and Gozo, the WSC operates 14 rain gauges, 3 weather stations, 3 wind-monitoring stations and 4 runoff recorders. From the data gathered by the WSC from its weather stations (Plate 4 and Figure 5), the highest maximum rainfall intensity was registered in 1994/95 with 56 mm/h; while the lowest maximum intensity was 16.8 mm/h in 2000/01.

During the hydrological year 2001/02, the WSC registered 108 days of rain with the maximum rainfall intensity being 20.4 mm/h. The maximum wind speed was recorded as 24.5 m/s. The highest maximum and minimum temperatures were recorded as 37.1 and 3.2 °C, respectively, with the average maximum temperature of 20.6 °C being the lowest registered in the most recent seven-year period. The average evaporation, wind speed and mean rainfall were 5.4 mm/day, 3.2 m/s and 24 mm/month, respectively.

FIGURE 4
Deviation from mean annual rainfall for Luqa meteorological station, 1947–2004

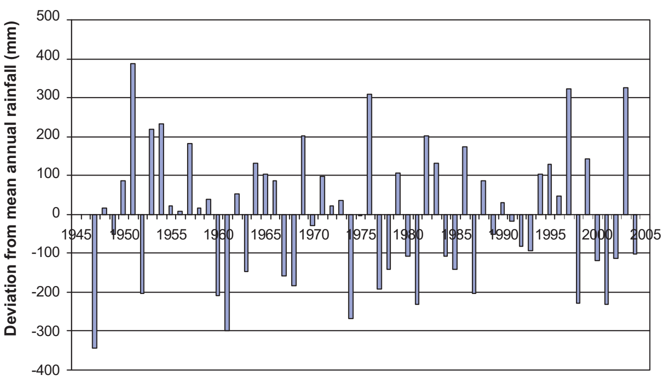


Plate 4
WSC weather station.

Consequences of the semi-arid Mediterranean climate that are of particular relevance to water management include:

- variability in interannual and intra-annual rainfall;
- high-intensity, short-duration rainfall events;
- seasonal scarcity of precipitation when the water requirements of the agriculture and tourism sectors are highest (normally from June to August);
- frequent occurrence of low rainfall years when groundwater recharge is likely to be low;
- frequent occurrence of high rainfall years when runoff is likely to be high.

Evapotranspiration

The potential evapotranspiration calculated by the Penman formula using 1947–1989 climatological data for the Maltese Islands is 1 390 mm (albedo = 0.2) with an interannual variability of 3 percent. Table 3 summarizes various figures for annual average rainfall, actual evapotranspiration, runoff and effective rainfall rates as calculated in different studies.

Based on the models developed by Bureau de Recherche Géologique et Minière (BRGM, 1991), preliminary estimates of actual evapotranspiration rates have been calculated on the basis of daily rainfall values recorded at Luqa Meteorological Office (1948–1998). These estimates indicated that actual annual evapotranspiration varied between 197 and 402 mm, or 36–89 percent of the measured annual rainfall.

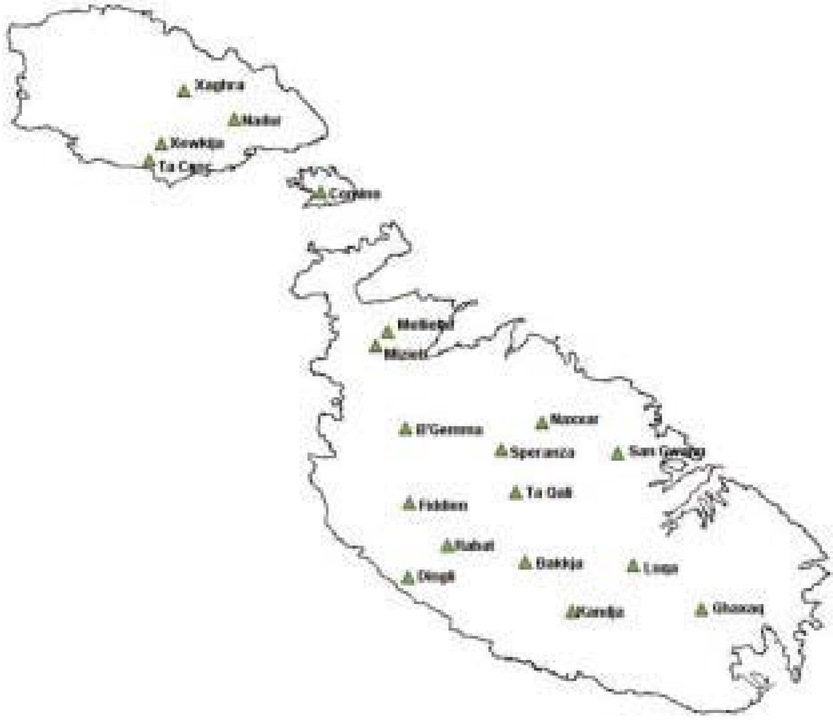
RUNOFF

Most runoff occurs after heavy torrential rain. This is the only time when surface water flows (for a few days at most) along the beds of the major valleys. To retain this storm discharge, 31 small dams have been constructed across the drainage lines (Plate 5). They

TABLE 3
Rainfall, evapotranspiration and effective rainfall

Author	Rainfall	Evapotranspiration	Runoff	Effective rainfall
		(mm)		
Morris (1952)/Edelmann (1968)	522	392		130
ATIGA (Martin)	587	475		95
ATIGA (Verhoeven/Gessel)	536	439		97
ATIGA (WWD Data)	551	431		120
FAO	587	437		150
Spiteri Staines (1987)	508	356	30	122
BRGM (1991)	551	348		203

FIGURE 5
WSC meteorological and rain-gauge stations



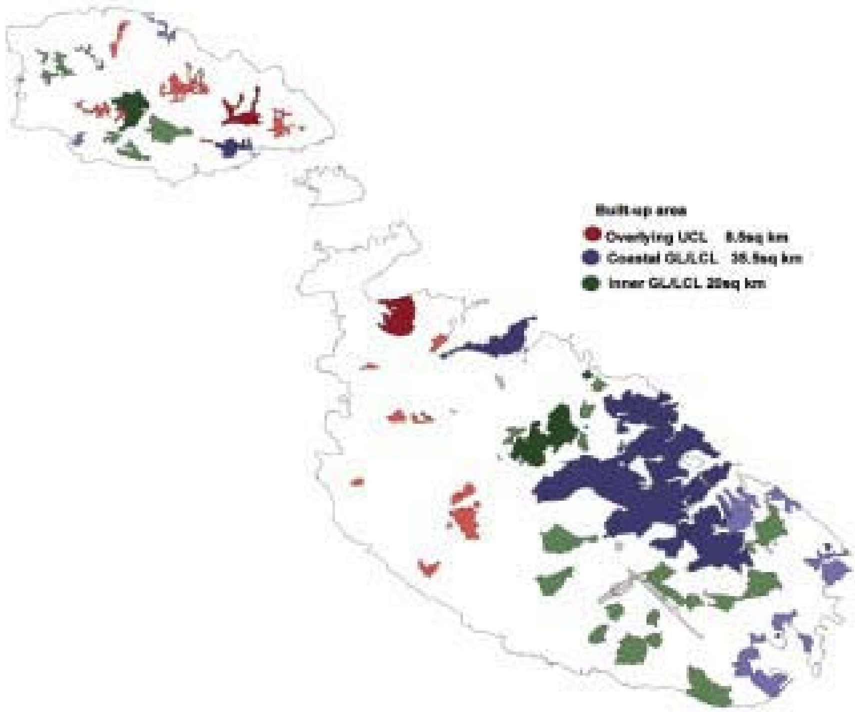
also serve the purpose of reducing the rate of soil erosion. Total dam capacity is estimated at 154 000 m³. A number of open reservoirs have been constructed along roads to catch flowing runoff water; their total volume is estimated at 250 000 m³.

The Rural Development Plan (Ministry for Rural Affairs and the Environment, 2004) reports that in 1993 there were a total of 18 dam systems with a total capacity of 37 000 m³ that were no longer in use and notes that "this number is likely to have increased since then". However, the cleaning and rehabilitation of dam systems has recently been recognized as an important aspect of water management. Major rehabilitation works were undertaken in 1997 on the Wied il-Qlejjgha Dam systems, while rehabilitation and upgrading works have been carried out in the last two years on major dams in Malta including those of the Wied il-Ghasel and Wied il-Kbir valley systems.

Plate 5
Dam at Wied is-Sewda.

According to Edelmann (1968), the eight-year average of surface runoff at the Marsa gauge, which controls a large part of the area, ranged between 2 and 3 percent of the annual precipitation. The same study reports that at the Mannarino gauge, only 1 percent of the rainfall was registered. ATIGA (1972) assumed an average surface runoff of 3 percent of rainfall to take into consideration the distribution between

FIGURE 6
Map showing the extent of urbanization, 2000



inland rural and built-up urban areas. Runoff records for 1961/62 in the Burmarrad Valley basin, which lies north of the Victoria Fault, gauged runoff at about 0.5 percent of the total rainfall.

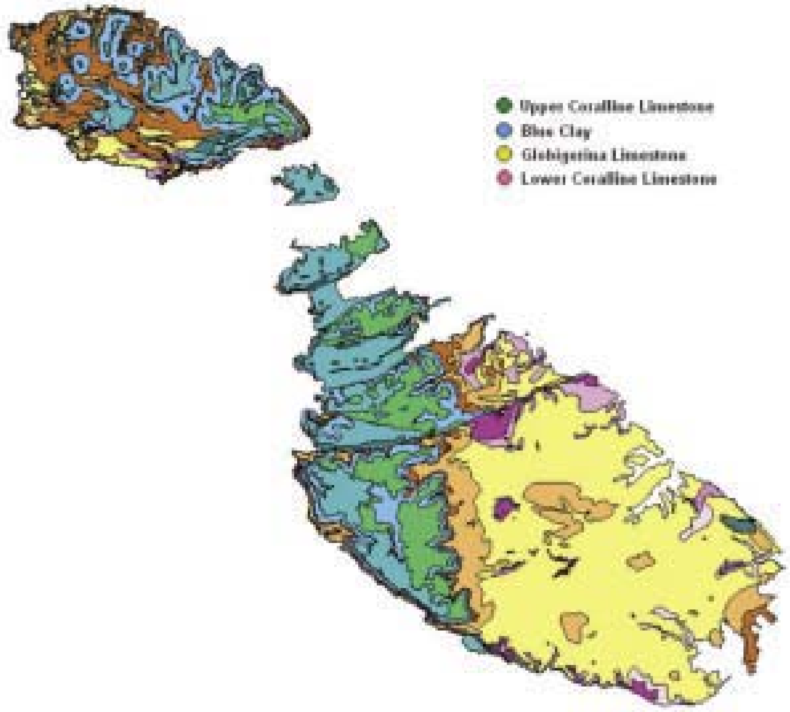
In view of the lack of observational data to support these assumptions, the runoff from rural areas that is lost to the sea is considered to be in the range of 2–5 percent of annual rainfall for the purposes of this study. In urban areas, localized runoff is considered to be as high as 80 percent of annual rainfall with the amount lost to the sea being highly dependent on geographical location. Hence, land use and urbanization have a considerable impact on the hydrology and water balances of different parts of the islands. Figure 6 shows the extent of urban areas.

GEOLOGICAL STRUCTURE

The geological formations exposed in the Maltese Islands are of the Tertiary and Quaternary Ages, having been deposited in the last 35 million years (Figure 7). The Lower Coralline Limestone (LCL) is of the Oligocene Age (23–35 million years old); with the other overlying formations being of the Miocene Age (5–23 million years old). The very top of the Upper Coralline Limestone (UCL) could be of the Upper Messinian Age possibly extending into the early Pliocene Age (1.6–5 million years old).

The UCL is a porous massive formation, which outcrops over the western and northern zones of the island and forms the highest parts of the topography. In view of its lithographic nature and its response to karstic erosion, this formation should be considered as a porous and fissured formation that could contain a generalized aquifer. The UCL formation varies considerably in thickness due to erosion. The existing thickness in the ridges and plateaus averages 30 m, while the range in the valleys

FIGURE 7
Simplified geological map of the Maltese Islands



(structurally low blocks) is 60–90 m with a 100-m maximum at Bingemma, south of the village of Mgarr. The rather small thickness of this formation on the plateaus has historically made possible the direct exploitation of water resources by shallow wells. The outcrops of the UCL act as a generalized recharge area for the underlying groundwater body.

The "Greensand" (GS) occurs as green glauconitic marl and rusty-coloured, sandy-textured limestone. The thickness of this formation varies from 0.25 to 1.5 m, locally increasing up to 12 m.

The "Blue Clay" (BC) formation is considered as an aquitard that supports the groundwater body in the UCL. The karstic evolution that affected the Maltese Islands should have locally but significantly modified this aquitard property, allowing groundwater stored in the UCL to "leak" down to the underlying sea-level aquifer. The average thickness is about 30 m, with the formation generally being thicker in western Malta than in the east.

The "Globigerina Limestone" (GL) is generally a massive and porous formation, which is rather homogeneous all over the Maltese islands. Short regressive periods during its deposition have created hardground and phosphoritic beds. Formations and also sedimentation conditions have changed locally and resulted in thin clayey or marly layers interbedded in the GL. These less-porous layers act as horizontal aquitards in the porous body of the GL, giving rise to small local water tables in a perched position above the main water body. The total thickness of the formation ranges from 30 to 210 m.

The total thickness of the LCL formation is estimated at more than 450 m according to reconnaissance oil-well results. In the LCL, many coral-reef formations have developed under shallow water and shoal conditions. The material of these reefal formations is generally more porous than in the main part of this geological unit. This observation is important from a hydrogeological point of view as these reefs could be considered as higher permeability zones in the porous matrix of the LCL. On the other hand, the vertical and horizontal extensions of these reefs are not known nor are their volumes and their possible interconnections. As such, the heterogeneity they create in the main aquifer body is important when assessing the general hydrodynamic behaviour of the aquifer.

In conclusion, the Maltese Islands are mainly composed of two porous and fissured limestones (the UCL and the Globigerina/LCL), separated by a relatively thin layer of clayey and marly material (the BC formation), sometimes overlain by the GS. The lithologically different natures of these formations together with their geological position give rise to two broad aquifer types: the upper (perched) aquifers in the UCL, and the lower (mean sea-level and coastal) aquifers in the lower limestone units (porous and fissured Globigerina and/or LCL) and, due to the general structure of the islands, in the UCL in the north of Malta.

HYDROGEOLOGICAL CONSIDERATIONS

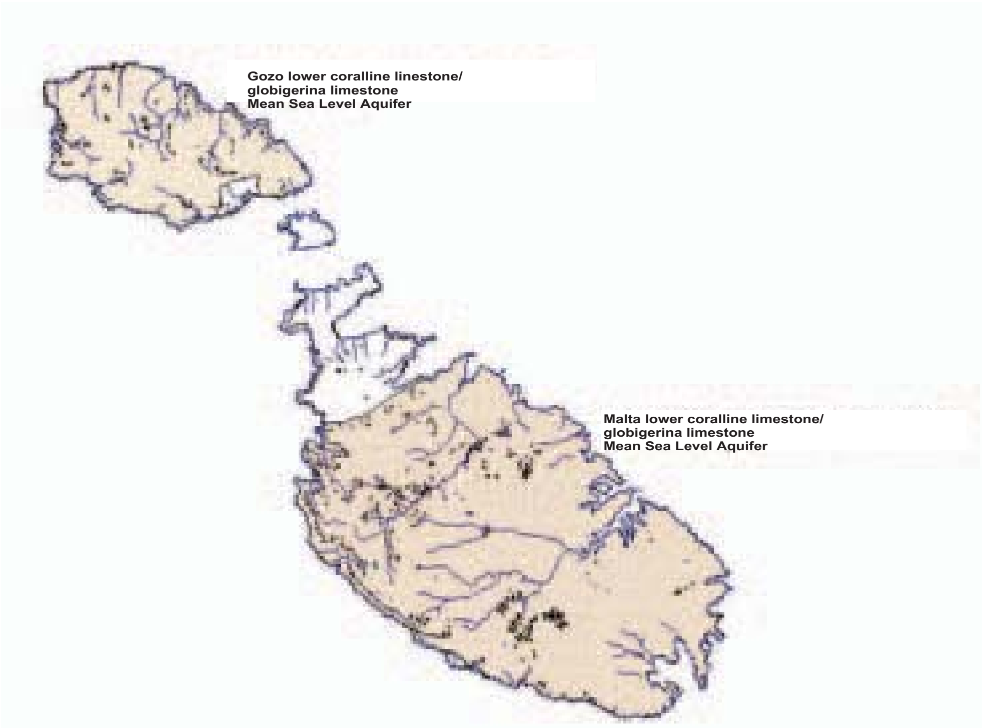
The UCL and LCL formations are considered to function as aquifer rocks. The GL functions locally as an aquifer only where fractured and/or located at sea level, and normally it is expected to transmit water from the surface into the main groundwater bodies along fractures. The BC and the GS are normally impermeable and underlie the perched aquifer. However, faulting, sinkholes and patch reefs partially penetrate these impermeable layers. Although the soils have a high water storage capacity, they are generally present as thin layers.

From a structural point of view, the island of Malta can be subdivided into two parts: the northwest, and the central-southeast; the limit being marked by the major fault line usually called the Victoria Fault (Figure 8). Fault systems in the island are not

FIGURE 8

Structural map of the Maltese Islands showing the major fault lines

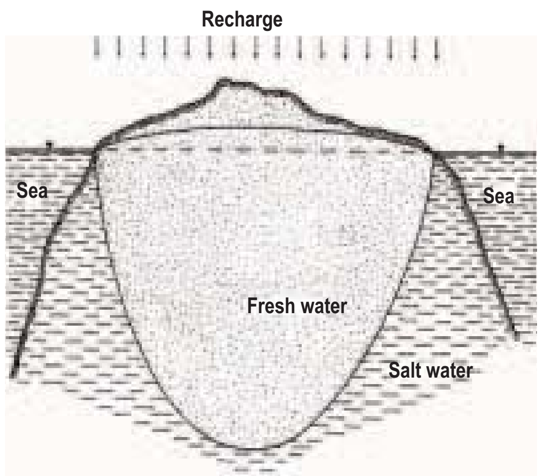
FIGURE 9
Extent of the Globigerina/Lower Coralline Limestone aquifers in the Maltese Islands



consistent in their hydraulic function. There are fault seals, especially where the aquifer is displaced against an impermeable formation. The Ghar Lapsi Fault appears to work as a seal owing to a dragged clay and marl fill along the fault plane. Other faults encourage communication, especially vertically. The Victoria Fault allows communication along and across the fault due to intense fracturing.

In a significant part of the island, south of the Victoria Fault, the UCL and the Globigerina/LCL aquifers are stacked vertically (Figure 9). The LCL aquifer is in lateral and vertical contact with seawater. Because of the density contrast between freshwater and saltwater, a Ghyben-Herzberg system has developed (Figure 10). This consists of a freshwater lens floating on saltwater with a thickness about 36 times more below sea level than the height of the freshwater surface above sea level. In the central regions of the island of Malta, hydraulic heads of about 4–5 m were recorded in the 1940s when the aquifer was still relatively unexploited. Today, the potentiometric surface in these regions has receded to levels of about 1 m above mean sea level, mainly as a result of unsustainable groundwater overabstraction.

FIGURE 10
Scheme showing a Ghyben-Herzberg (floating) groundwater body in an island



The effect of the pumping-station gallery network must also be taken consideration. This is because the galleries skim the surface of the groundwater lens, thereby fixing the piezometric head at the skimming level.

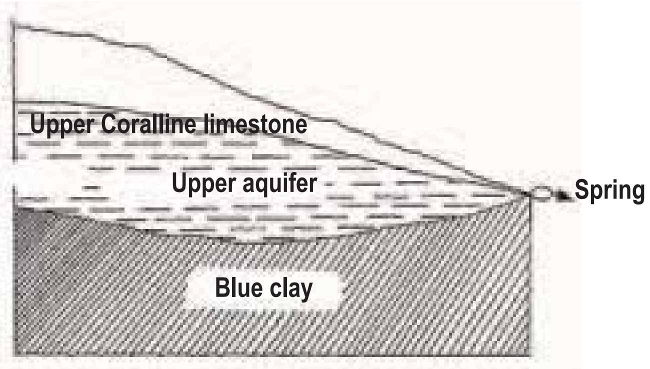
The porosity and permeability of the rock depend to a large extent on fissures and microfractures. Infiltration into the sea-level aquifer is predominantly through fissures in the overlying GL. From this aquifer, extraction takes place through a gallery system near the centre axis of the island and by boreholes further away from the centre. Because of brackish water upconing, the water pumped from the LCL has a chloride level that exceeds 1 000 mg/litre in a number of major sources, with peaks exceeding 2 000 mg/litre.

The UCL aquifer in this zone is perched above a BC seal (aquiclude) on the Rabat-Dingli Plateau. The aquifer outcrops partly below a thin soil cover, and infiltration of surface water is direct. No saltwater intrusion is possible. Large-scale private extraction from shafts and springs takes place.

The northern part of the island is divided by a northeast–southwest fault system into a succession of horst and graben like structures; the graben being occupied by rather flat valleys separated by ridges. This structure, with parallel compartments separated by faults, leads to the view that the resulting aquifer blocks should be considered as independent from one another from a hydrogeological standpoint. The fault bounding the south of the Pwales Valley between Ghajn Tuffieha Bay and St Paul's Bay separates the main aquifer of the island from the northern, smaller graben and horst units. Thus, perched aquifers are developed in the UCL of Mellieha Ridge, Mgarr/Wardija Plateau and Mizieb Valley while coastal aquifers are present at Mellieha Bay, Pwales Valley and Marfa Ridge (Figure 11). The aquifers in the northern part of Malta have only a small potential for water abstraction. The aquifers at Mgarr and Mizieb have a limited vertical contact with saltwater, thus further limiting their potential groundwater yield.

FIGURE 11
Extent of the Upper Coralline Limestone aquifers in the Maltese Islands

FIGURE 12
Perched aquifer scheme



Source: IGN (1990).

The groundwater is used mainly for public water supply and irrigation. The small broken-up blocks allow little room for economic, large-scale water production development.

In Gozo, the LCL sustains a mean sea-level aquifer displaced over the whole of the island except for a small region around the harbour of Mgarr where the BC formation occurs at sea level due to faulting. The UCL outcrops in the island, namely at Ghajnsielem, Nadur, Xaghra, Zebbug and Victora/Kercem, sustain small perched aquifers which are exclusively used for irrigation (Figure 12). A number of minor perched aquifers are sustained by small outcrops of the UCL, such as those at Ghar Ilma and il-Gordan.

GROUNDWATER BALANCE

Replenishment of the aquifers is by rainfall and leaks from the water-supply system. Surface runoff into the sea is comparatively small because of the morphology, good water absorption by the soil and infiltration into the rock, and runoff interception by numerous dams, walls and terraces built over the centuries. The major surface water loss is by evapotranspiration. Aquifer recharge varies according to the rainfall. The amount of water in storage in the Ghyben-Herzberg lens of the main aquifer is of the order of 1 500 hm^3. Before the impacts of groundwater overextraction, this could be considered quite large compared with yearly recharge, whereas the recharge forms a very large percentage of the water in storage in the perched and coastal aquifers. In the sea-level aquifers, the yearly recharge replaces abstraction and storage water after dry years. In relative terms, a considerable amount of water flows into the sea from coastal and submarine springs or is lost by diffusion into the sea. For a long-term average, the total recharged water that is not abstracted flows into the sea. As the existence of the freshwater lens also implies an outflow gradient, even in years of subnormal rainfall, freshwater is lost in this way and adds to the water deficiency in the sea level aquifers. The occurrence of this outflow is a prerequisite for the existence of the freshwater lens.

Table 4 presents a holistic groundwater balance for the aquifers in the Maltese Islands. However, all conclusions drawn from the water balances presented here are based on figures that are no more than estimates. A major assumption in this water balance is that groundwater outflow was in the same region as the inflow during the base year. This assumption is based on the fact that the piezometric levels in gauging boreholes in the sea-level aquifers during the last five-year period indicate only mild decreases. This fact led to the choice of the ATIGA coefficient of 0.5 for natural groundwater outflow to the sea as opposed to 0.6 for the BRGM coefficient (which would significantly increase the deficit in the sea-level aquifers).

The groundwater balance is based on an average hydrological year with a precipitation of 550 mm. The evapotranspiration coefficient is taken as 63 percent while the runoff coefficient varies from 2 to 5 percent according to the geomorphological conditions of each aquifer catchment area. The WSC official abstraction figures for the period 2001/02 are used; while the private extraction is based on estimates of the irrigation demand of the agriculture sector activities and of the various industrial and commercial concerns.

TABLE 4
Holistic groundwater balance for the aquifers in the Maltese Islands, base year 2002

Inflow		hm^3/year	Comments
A	Precipitation	174	Based on an average annual rainfall of 550 mm
B	Surface runoff to the sea	24	Based on a variable catchment area runoff coefficient (excluding coastal built up areas)
C	Actual evapotranspiration	105	Assumed as 68% of the total surface water
D	Natural aquifer recharge	45	B and C deducted from A
E	Artificial recharge from leaks	12	Estimated inflow from potable water and sewage network leakages
F	Total groundwater inflow	57	Sum of variables D and E
Outflow			
G	WSC groundwater abstraction	16	Official WSC extraction for hydrological year 2002/03
H	Private groundwater abstraction	15	Estimate based on water demand of various sectors (industry and agriculture)
I	Subsurface discharge to the sea	23	Estimate based on groundwater modelling
J	Total groundwater outflow	54	Sum of variables G, H and I
Balance			
K	Total groundwater inflow	57	Equal to variable F
L	Total groundwater outflow	54	Equal to variable J
M	Balance	3	Inflow (K) less outflow (L)

Source: Malta Resources Authority (2003).

TABLE 5
Water balances of the individual groundwater bodies in the Maltese Islands, base year 2003

Groundwater body code	Groundwater body name	Size (km^2)	Inflow	Outflow (hm^3)	Balance	Major extraction
MT001	Malta Main Mean Sea Level	216.6	34.27	36.65	-2.38	Abstraction for potable and agricultural purposes
MT002	Rabat-Dingli Perched	22.6	4.64	4.62	0.02	Abstraction for agricultural purposes
MT003	Mgarr-Wardija Perched	13.7	2.86	3.46	-0.59	Abstraction for potable and agricultural purposes
MT005	Pwales Coastal	2.8	0.69	0.69	0.00	Abstraction for agricultural purposes;
MT006	Mizieb Mean Sea Level	5.2	1.11	0.96	0.15	Abstraction for potable and agricultural purposes
MT008	Mellieha Perched	4.5	0.75	0.53	0.22	Abstraction for agricultural purposes
MT009	Mellieha Coastal	2.9	0.69	0.38	0.31	Abstraction for agricultural purposes
MT010	Marfa Coastal	5.5	0.89	0.62	0.27	Abstraction for agricultural purposes
MT011	Mqabba-Zurrieq Perched	3.4	0.50	n/a	n/a	Abstraction for agricultural purposes
MT012	Comino Mean Sea Level	2.7	0.52	0.30	0.22	Abstraction for agricultural purposes
MT013	Gozo Mean Sea Level	65.8	8.66	9.78	-1.12	Abstraction for potable and agricultural purposes
MT014	Ghajnsielem Perched	2.7	0.73	0.34	0.39	Abstraction for agricultural purposes
MT015	Nadur Perched	5.0	1.15	0.58	0.57	Abstraction for agricultural purposes
MT016	Xaghra Perched	3.0	0.71	0.33	0.38	Abstraction for agricultural purposes;
MT017	Zebbug Perched	0.4	0.10	0.03	0.07	Abstraction for domestic purposes
MT018	Victoria-Kercem Perched	1.5	0.39	0.14	0.25	Abstraction for domestic purposes

This holistic groundwater balance masks the fact that individual, important aquifers are in imbalance. Therefore, Table 5 presents a breakdown of the calculations on an aquifer-by-aquifer basis. The table shows that the sea-level aquifers are in gross imbalance when compared with the perched aquifers and that the overall positive balance in the holistic representation is being achieved through the combined contribution of the smaller perched aquifers.

Large increases in unconventional water resources are planned. In particular, the WSC is planning to treat all sewage effluent by 2008. If this is achieved and if the effluent is desalinated to the level that it can be used for artificial recharge and a wide range of industrial and agricultural purposes, total annual production of TSE should be about 14 hm^3. Although it is too early to estimate the impacts on the groundwater balance, the TSE may be used to reduce groundwater abstraction or to increase artificial recharge to some aquifers. Figure 13 shows aquifer zones that have already been identified for irrigation using TSE (further details in Chapter 6).

FIGURE 13
Aquifers identified for irrigation with TSE

OUTFLOW OF GROUNDWATER TO THE SEA

A number of groundwater bodies are in lateral and/or vertical contact with seawater. The groundwater in the relevant aquifers is not at rest but flows away more or less horizontally. Part of this lateral flow is recovered by public and private abstractions using galleries and boreholes, while the remaining part continues its outward journey towards the coast to be discharged into the surrounding sea. For a long-term average, the total recharged water that is not extracted is flowing out to the sea. Methods to reduce this loss of groundwater but that do not increase intrusion of seawater should be investigated.

This outflow has been estimated by ATIGA (1972) to account for about 50 percent of the recharge of the sea-level aquifers. Aquifer modelling of the main mean sea-level aquifer by the BRGM has quantified outflow from this aquifer at 30 million m^3/year, or about 60 percent of the recharge. The results of the ATIGA report have been preferred in the water-balance calculations, basically to reflect the mildly decreasing trends in the piezometric head registered in the last ten years. Adopting the BRGM estimates would have led to large imbalances in the sea-level aquifers that would not have mirrored the field results obtained by the WSC monitoring network. However, this issue should be tackled through the construction of a mathematical model of the aquifer. In fact, this is one of the projects being currently undertaken in the implementation process of the WFD.

GROUNDWATER QUALITY

The quality of groundwater in Malta is highly variable with contamination of groundwater by nitrates (Figure 14) and chlorides (Figure 15) being the main quality issues of concern.

FIGURE 14
Nitrate content of groundwater abstracted from the LCL and UCL aquifers

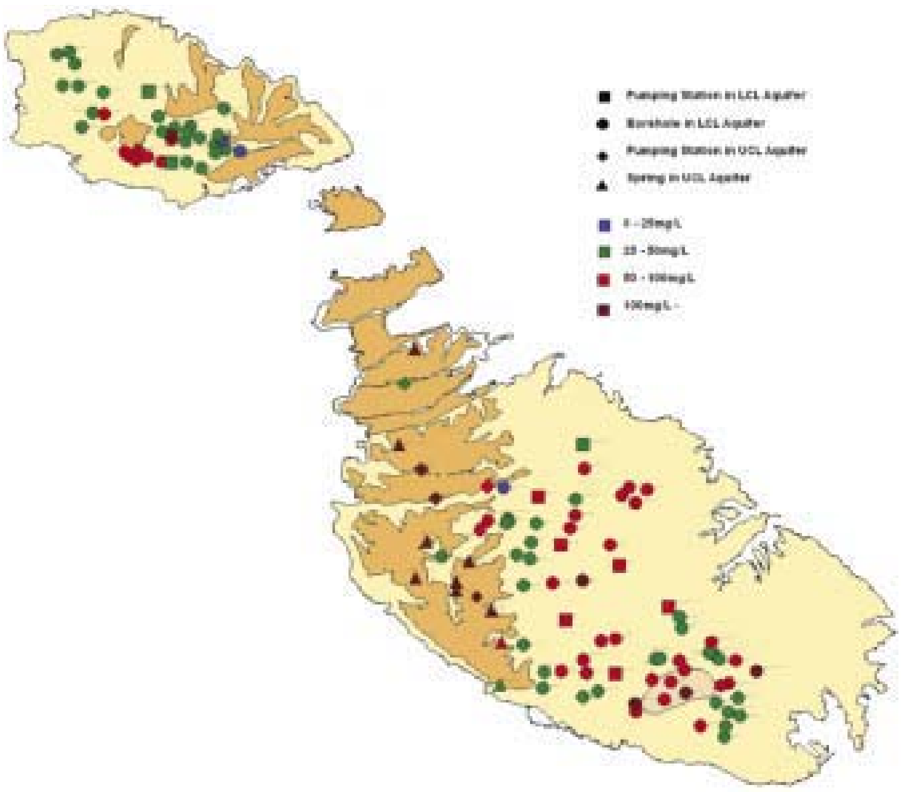
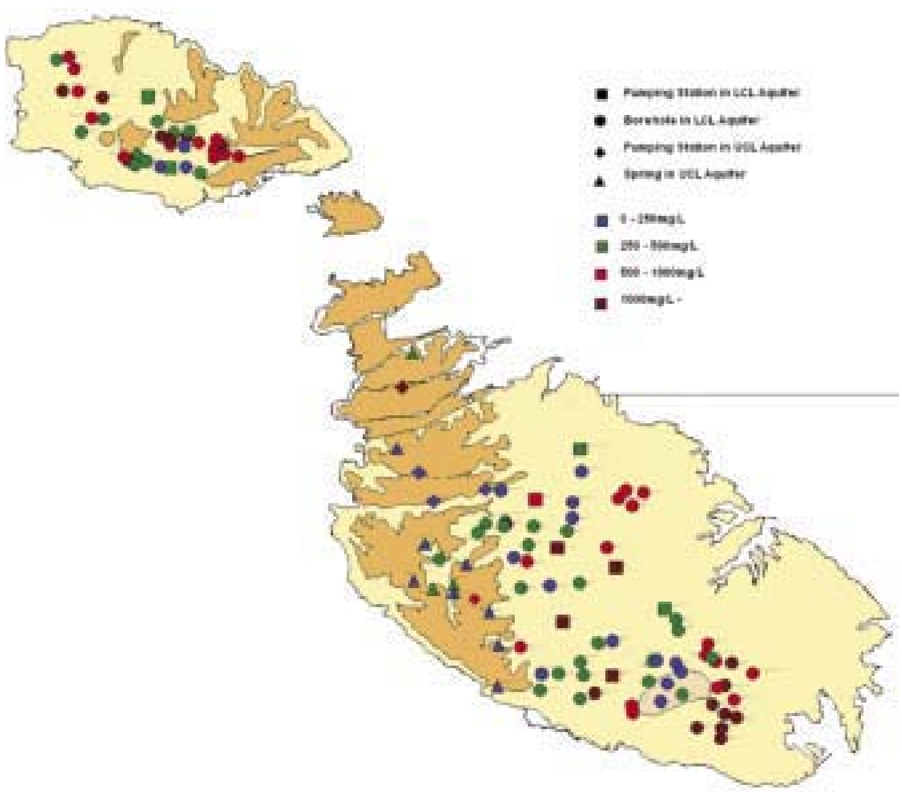


FIGURE 15
Chloride content of groundwater abstracted from the LCL and UCL aquifers



Nitrates occur naturally in the environment and are produced from the decaying of vegetable material in the soil. The natural nitrate level in the mean sea-level aquifer is generally expected to be low. Soil cover in Malta is relatively thin and poor in organic content. Furthermore, there are no naturally occurring formations that contribute towards nitrate content in groundwater. Thus, nitrate contamination in groundwater is largely attributed to anthropogenic activities, e.g.: agricultural practices through the application of nitrogenous fertilizers on arable land; and contamination from human or animal wastes and refuse dump runoff. The movement of these pollutants below the surface is affected by the properties of the underlying strata. Nitrate concentration varies seasonally and by location, with maximum concentrations corresponding to the rainy season (October–March) as a result of the leaching of nitrates in the unsaturated zone. Responses are more direct in the perched aquifers because of the karstic nature of the UCL than in the sea-level aquifers where changes are more subdued.

Groundwater in Malta has generally high levels of chloride concentrations as a result of overextraction of groundwater and seawater intrusion. The situation is further influenced by the large perimeter in comparison to the area of the islands and the karstic nature of the aquifer. Generally, chloride levels in the perched aquifer are significantly lower than the mean sea-level aquifer, and these lower values result from the topographical nature where the aquifer is largely protected from seawater intrusion. However, relatively higher chloride concentrations at the Bingemma and Mizieb pumping stations have occasionally been registered. These are attributed to periods of increased abstraction and they are influenced by seawater intrusion as the top of the confining clay layer lies below the mean sea level.

POTENTIAL IMPACTS OF CLIMATE CHANGE

The sea level of the Mediterranean Sea is expected to rise by up to 96 cm by 2100. This will cause a consequential rise in the freshwater lens. This rise will have a negative effect on the abstraction stations in the sea-level aquifers. This is because these will be more vulnerable to salinization as the degree of saltwater upconing is directly dependent on the distance between the bottom of the well and the freshwater–saltwater interface.

Recent results have shown that in the central regions of the islands, particularly around major pumping stations, the freshwater–seawater interface has reached levels close to the mean sea level. Thus, any relative change in the mean sea level will have more pronounced effects in these regions. In fact, the conductivity logs for the Ta Kandja and Mriehel gauging boreholes (GBHs) show the interface standing at -10 m for the Ta Kandja GBH, located near the Ta' Kandja pumping station and at -80 m for the Mriehel GBH, which is not located particularly close to any pumping station (Figure 16). The state of the aquifer in the Ta Kandja region makes it more prone to adverse effects from sea-level changes.

Annual rainfall is expected to fall by 10–40 percent by 2100 over much of Africa and southeast Spain with smaller but significant changes in other places. The rainfall pattern is also expected to change, resulting in a shorter rainy season with shorter but higher-intensity storms. These two factors are most likely to cause a decrease in the amount of water infiltrating. This situation would affect both aquifer types but would be expected to have a drastic and immediate effect on the perched aquifers where the annual recharge forms a large percentage of the aquifer storage.

In the case of the mean sea-level aquifer, a reduction in precipitation coupled with a sea-level rise would not only cause a diminution of the volume of freshwater available but would also be expected to reduce the groundwater storage capability of the freshwater lens. This is basically because the height of the piezometric head at any point in the island is proportionally dependent on the amount of infiltrating recharge; and the storage capability of the groundwater body for a given set of geological conditions depends exclusively on the hydraulic head.

FIGURE 16

Conductivity logs and relative locations of WSC gauging boreholes

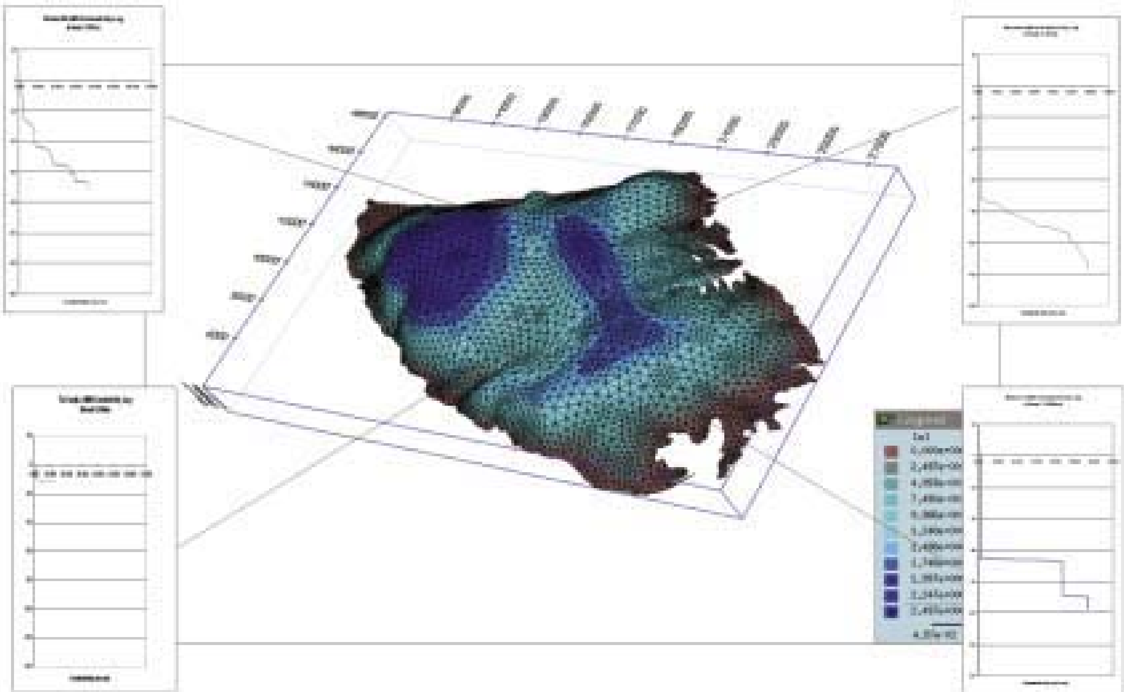
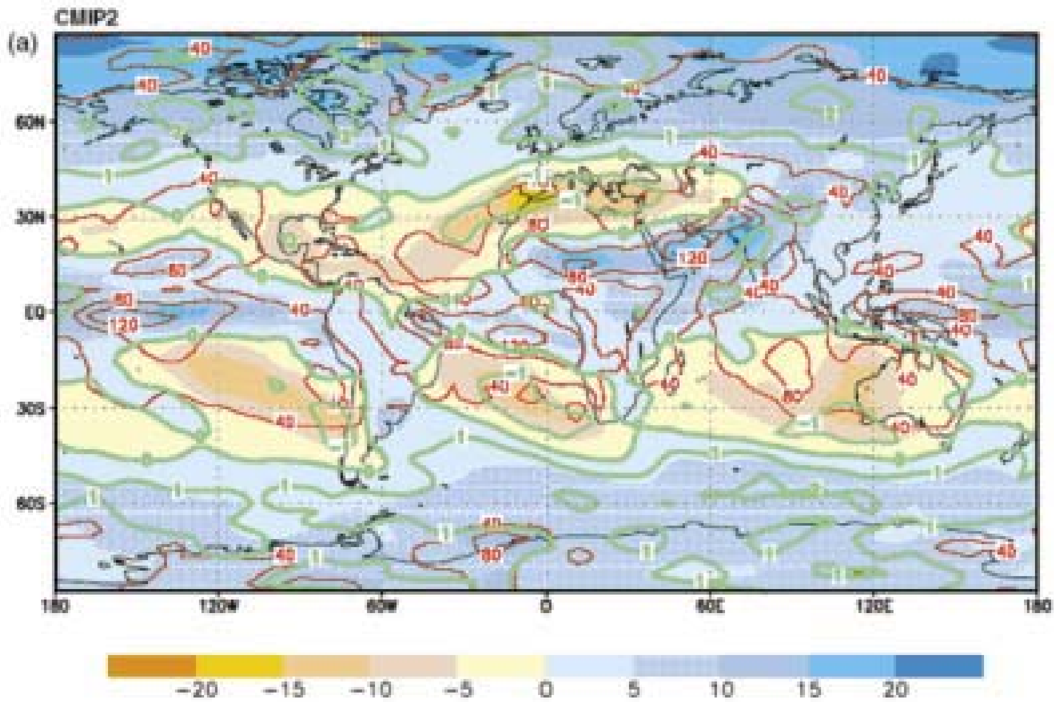


FIGURE 17

Multimodel ensemble: annual mean change in precipitation



Note: Change in precipitation (colour shading); unit percent for the CMIP2 scenarios.

Chapter 6
Water-related infrastructure

WATER PRODUCTION

Figure 18 presents the estimated percentage of water produced in 2003 using various methods. The total volume of water produced in 2003 was an estimated 59 hm^3. The WSC was the single main producer of water in 2003, while the agriculture sector was the main producer of water (or in this case primarily abstractor) in the private sector. The WSC produced slightly more desalinated seawater than groundwater.

URBAN WATER SUPPLY

The two main sources of urban water supply are groundwater and desalinated seawater. The WSC currently does not make use of the perched aquifer springs within the Rabat-Dingli and Mgarr-Wardija groundwater bodies or the Dingli Road pumping station. A number of production sources in the sea-level aquifers have also been discontinued particularly in the northern and southeastern regions of Malta because of high chloride concentrations. Figure 19 shows the location of the public groundwater sources. These include boreholes and pumping stations. The latter consist of horizontal radiating galleries dug in the rock slightly above sea level in order to skim freshwater from the top of the freshwater lenses that constitute the sea-level aquifers.

Private desalination plants are also used primarily as a source of water supply, particularly by users that are charged high tariffs by the WSC (e.g. hotels). In 2003, total private desalination production was estimated to be in excess of 1 hm^3. Rainwater harvesting using cisterns is also a source of urban water supply. In 2003, this was estimated to have a potential capacity of about 2 hm^3.

Figure 19 also shows the location of WSC RO plants that are used to produce desalinated seawater, much of which is blended with groundwater of higher salinity. Care is taken to ensure that the resulting blend has a salinity that is within permissible drinking-water limits. In 2003, the production of desalinated seawater was about 18.9 hm^3 (Table 6). This represents a major reduction in production compared with the mid-1990s. Excess capacity currently exists for the production of desalinated seawater. However, there is insufficient working capacity should all urban water supplies have to be sourced from RO plants.

In 2003/04, desalination contributed about 55 percent of the water supplied to the public distribution system. Currently, the WSC operates three seawater RO plants at Lapsi, Cirkewwa and Pembroke through its subsidiary company Malta Desalination Services Ltd. The RO plant at Marsa, which treats brackish water, is currently not being utilized. Malta has one of the longest and best track records of RO plant operation in the Mediterranean region with high output levels and reliability.

FIGURE 18
Breakdown of estimated water production, 2003

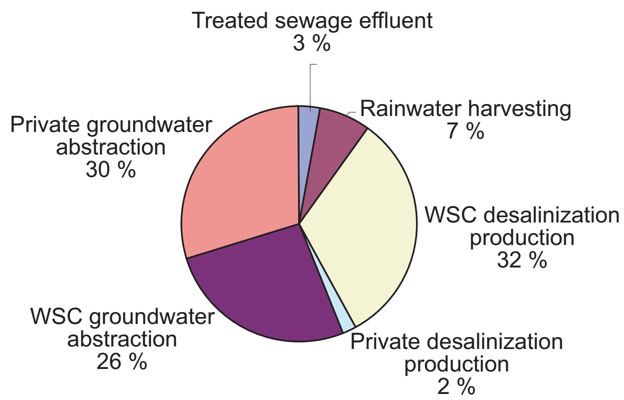
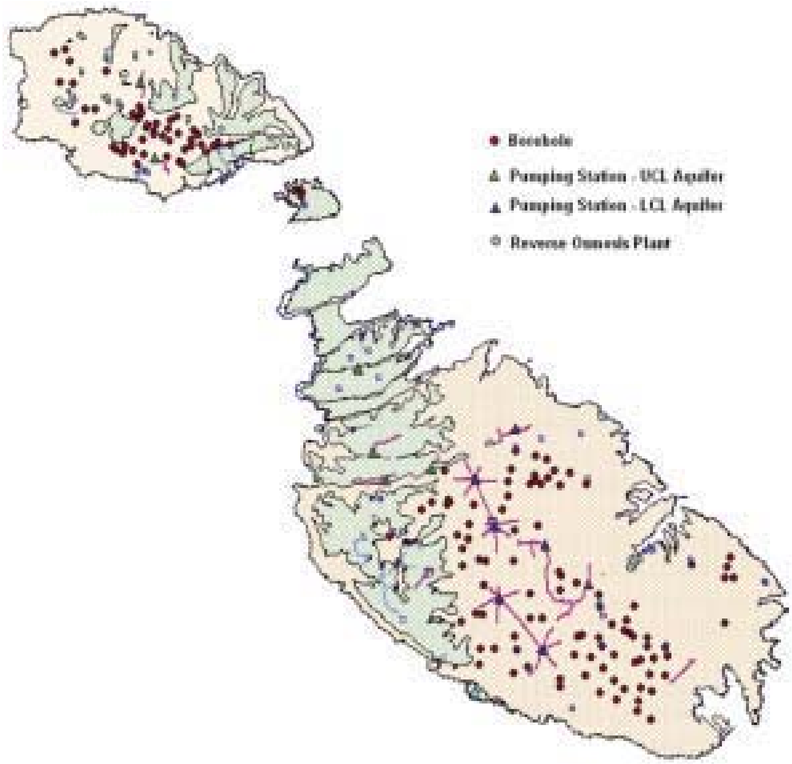


FIGURE 19
Public groundwater production sources in the Maltese Islands



There has been a significant decrease in RO-water production since 1994/95 (Table 6). RO production reached a minimum in 2001/02 largely as a result of water-demand management actions adopted by the WSC. These actions included intensive leakage control, improved management practices and water conservation programmes. This downward trend in production has been reversed with slight increases in RO production in the last three hydrological years. However, this figure must seen in relations to the reduction registered in groundwater abstraction by the same WSC and the stabilization of total annual production at about 33 hm^3 in the last four years (Figure 20).

TABLE 6
Desalination production trends

	Lapsi	Cirkewwa	Pembroke	Tigne	Marsa	Total
			(hm^3)			
1994/95	7 474 547	5 330 357	14 313 367	4 471 061	1 135 732	32 725 064
1995/96	7 230 901	5 025 538	12 545 201	2 767 145	1 198 332	28 767 117
1996/97	6 184 113	3 744 213	13 348 596	29 431	1 196 526	24 502 879
1997/98	5 717 995	3 777 559	11 753 338	-	1 201 697	22 450 589
1998/99	3 933 032	3 787 597	10 566 473	-	1 113 979	19 401 081
1999/00	3 511 275	3 669 047	10 079 919	-	81 533	17 341 774
2000/01	3 085 585	3 702 376	9 786 928	-	35 185	16 610 074
2001/02	3 482 973	5 981 059	10 360 825	-	-	17 924 857
2002/03	3 829 721	4 046 030	10 352 358	-	-	18 228 109
2003/04	4 250 263	3 706 696	10 945 033	-	-	18 901 992

AGRICULTURAL WATER SUPPLY

The amount of irrigated land amounts to just more than 9 percent of all agricultural land in the Maltese Islands. Most of the irrigated land is found in the UCL regions in the north and west of Malta. Historically, the shallow depth of the perched aquifers and the occurrence of natural springs made water resources for agriculture more easily accessible. However, in the last decade, a large number of "illegal" boreholes have been dug, particularly in the main LCL aquifers. New and more accurate data regarding the extent of irrigated lands are expected to be available with the completion of the agricultural land registration currently being conducted by the Agricultural Department.

Figure 21 shows the location of registered boreholes and springs as registered in the 1997 water-source registration process.

FIGURE 20
Trends in WSC water production

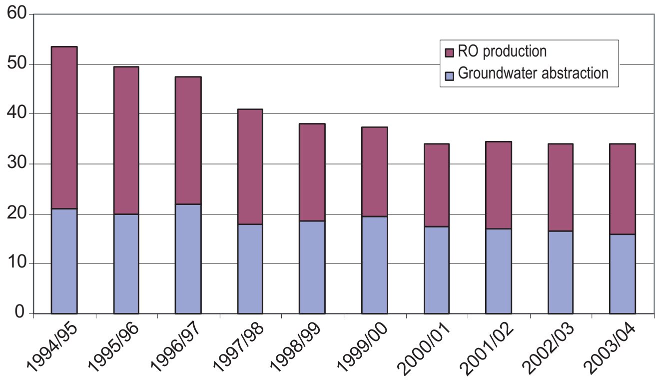
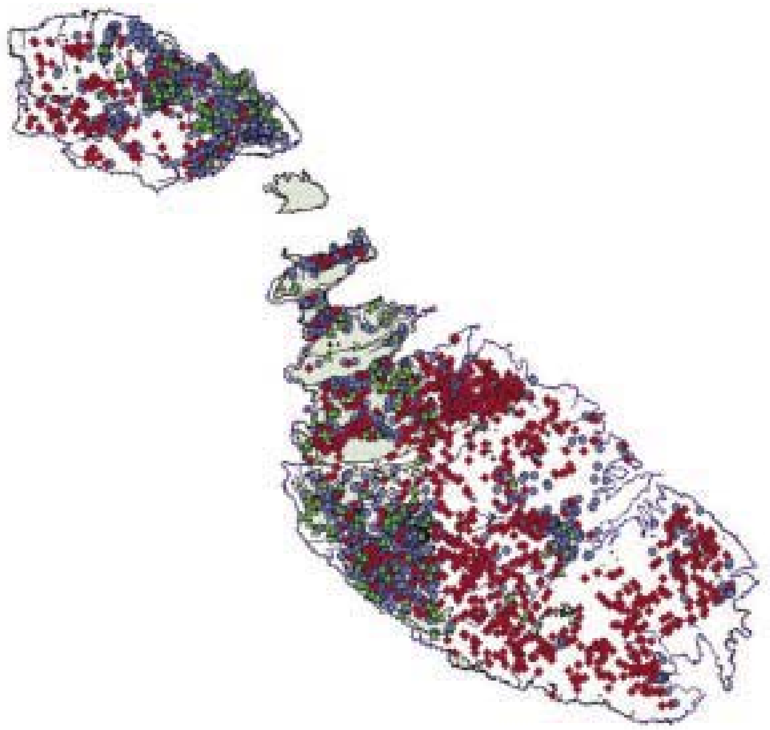


FIGURE 21
Location of registered private water sources in the Maltese Islands



Note: Blue dots – old private boreholes; red dots – new boreholes registered for the first time in 1997; green dots – springs.

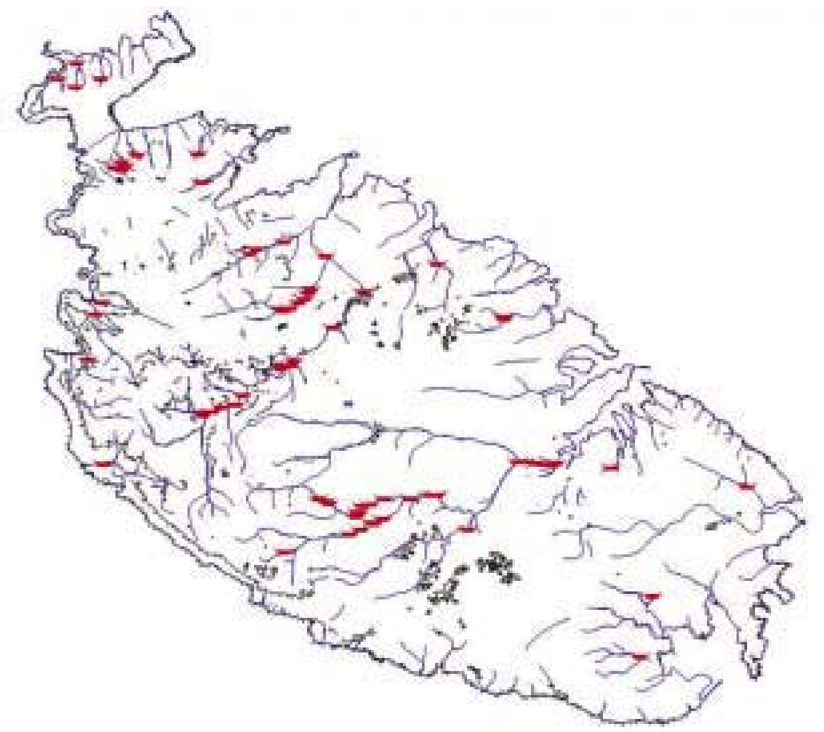
RUNOFF COLLECTION

Historically, responsibility for storm-water management has been shared among a number of government departments/agencies. This arrangement has traditionally led to a fragmentary approach to stormwater management. A stormwater master plan is being prepared by the WSC, which aims to transform existing threats into opportunities by optimizing stormwater use. Most runoff occurs after heavy torrential rain. To retain this storm discharge, 31 small dams have been constructed across the drainage lines (see Figure 22 and Chapter 5). The water collected is mainly used for agriculture and recharging the sea-level aquifers.

Runoff generated from urban areas should also be reduced with the enforcement of legislation concerning the construction of rainwater cisterns. In "old" villages, a large number of private cisterns have a certain influence on the surface runoff. This helps reduce the amount of floodwater currently occurring after heavy rainfalls in built-up areas, particularly in Msida and Marsa. The cisterns also provide a source of second-class water for household use, thereby reducing the load on the public distribution system. It is planned that all major housing projects should also have common runoff-water storage facilities. A 25-m^3 cistern or equivalent in every household would result in the collection of about 4.5 hm^3 of stormwater runoff, which amounts to more than 40 percent of the official billed domestic water consumption. However, this potential figure may be constrained by factors related to creating storage as part of high-density apartment developments.

The total potential surface runoff generated in an average year has been estimated at 30 hm^3 in Malta alone, of which more than 80 percent occurs in the built-up areas. The main drawback facing the harnessing of this resource is the fact that it occurs as large volumes in a comparatively short period.

FIGURE 22
Location of dams in the main watercourses in Malta



In addition to groundwater resources, agriculture also makes use of harvested rainwater. The agricultural census of 2001 registered about 9 000 agricultural cisterns. Preliminary figures place the total rainwater harvesting potential of the agriculture sector at 2 hm^3.

USE OF TREATED SEWAGE EFFLUENT

Currently, 13 percent of the total sewage generated in the Maltese islands is being treated and made available for subsequent reuse by the agriculture and industrial sectors. The situation will change by 2007 as the planned construction of three new sewage treatment plants will result in the production of about a further 38 000 m^3/day. Thus, the total amount of TSE available will be an estimated 14 hm^3/year.

Four agricultural areas were earmarked in a preliminary study carried out by the WSC in 1998 as test sites where TSE can be safely applied for irrigation and the gradual re-instatement of severely depleted aquifers. Land in these localities is considered to be suitable for irrigation with TSE as the aquifers are heavily overpumped, polluted and not used for the abstraction of water intended for drinking purposes. These are the catchment areas of the aquifers at Cirkewwa (310 ha), Qammiegh (184 ha), Pwales (141 ha) and Burmarrad/Maghtab (728 ha), all of which are detached from one another and from the mean sea-level groundwater body south of the Victoria Fault.

Currently, there is only one wastewater treatment plant, located at Sant' Antnin, l/o Zabbar, which was constructed in 1983 (Plate 6). In 1996, this plant was upgraded to a treatment capacity of 17 000 m^3/day of raw sewage. At present, the plant treats an average of 3 500 m^3/day in winter and 10 500 m^3/day in summer; which annually results in more than 3 hm^3 of raw sewage being directed to the plant. Thus, the plant normally operates at 50–65 percent of its capacity. The treatment includes preliminary, primary, secondary and tertiary treatment facilities supplemented with disinfection. The treated waters are used for agriculture (with requirements fluctuating seasonally) and for industry.

The quality of the treated effluent from the plant is as follows: five-day biochemical oxygen demand (BOD_5) ≈ 10 mg/litre; chemical oxygen demand (COD) ≤ 70 mg/litre; ammonia (NH_3^+) ≤ 30 mg/litre; $P–PO_4^{2-}$ < 30 mg/litre; faecal coliforms (FC) ≤ 5 counts/100 millilitres; and electrical conductivity (EC) ranges from 7.00 to 15.00 dS/m. The major problem encountered with reusing the effluent produced is its high electrical conductivity. Measurements taken in 1992 indicated that these high values are caused by a number of factors, the most important of which is seawater infiltration through confined parts of the sewerage system, whose occurrence was identified for the Malta North, Marsa Sea and the Zejtun-Zabbar sewers. In addition, the same study concluded that the dumping of brine reject from inland private RO plants into the sewers and the use of seawater for flushing purposes in hotels also contributes significantly to the high salinity of the sewage in the Malta North sewerage system.

Plate 6
Aerial view of the Sant' Antnin wastewater treatment plant.

The second-class water produced by the plant amounts to an average 2 hm^3/year. The treated effluent is distributed to agricultural concerns in the Zabbar-Marsascala area and to the Bulebel Industrial Estate. Current estimates indicate agriculture consuming 1.5 hm^3/year of treated effluent with the remaining 0.5 hm^3 being used by industry. Losses in the treated effluent distribution network are very high, reaching peaks of about 90 percent, with theft of water being a major concern in the area.

The current plans for future sewage and wastewater treatment envisage a centralized approach, with one new treatment plant planned for the southern region of Malta. This plant will be operational by mid-2007 and will have a capacity to treat up to 58 000 m^3 of effluent per day (based on 2020 projections and assuming the decommissioning of the Sant' Antnin plant). It is likely that this wastewater treatment plant will not be sufficiently advanced to produce effluent for reuse for agricultural purposes and/or artificial recharge of groundwater in aquifer zones utilized for the abstraction of groundwater for potable purposes. Other treatment plants are planned by the end of 2006 for ic-Cumnija (capacity: 6 700 m^3/day) and Ras il-Hobz, Gozo (capacity: 6 000 m^3/day). These two relatively small plants are intended to produce water mainly for agricultural use.

PRIVATE AND COMMERCIAL BOREHOLES AND RO PLANTS

In recent years, there has been a large increase in the construction of private boreholes for commercial use or for leisure-related activities such as filling swimming pools. In some cases, small RO plants have been purchased and are being used to desalinate the pumped groundwater. However, accurate information on this infrastructure does not exist.

PIPE NETWORK

The water distribution network operated by the WSC consists of more than 2 500 km of pipework of varying material and sizes. The network includes transfer mains linking sources to reservoirs, intrareservoir connections and distribution mains with trunk mains and reticulation mains. There are also a further 1 700 km of service pipework serving about 220 000 accounts. Extensive development has been carried out by the WSC on the distribution system in recent years, mainly as part of the drive to curb water leakages. However, in 2002 the network still comprised more than 1 000 km of cast-iron or galvanized pipes with no internal lining. These pipes are contributing to an increase in the concentration of corrosion products, resulting in water discoloration. Also contributing to the same problem are the old galvanized iron service connections.

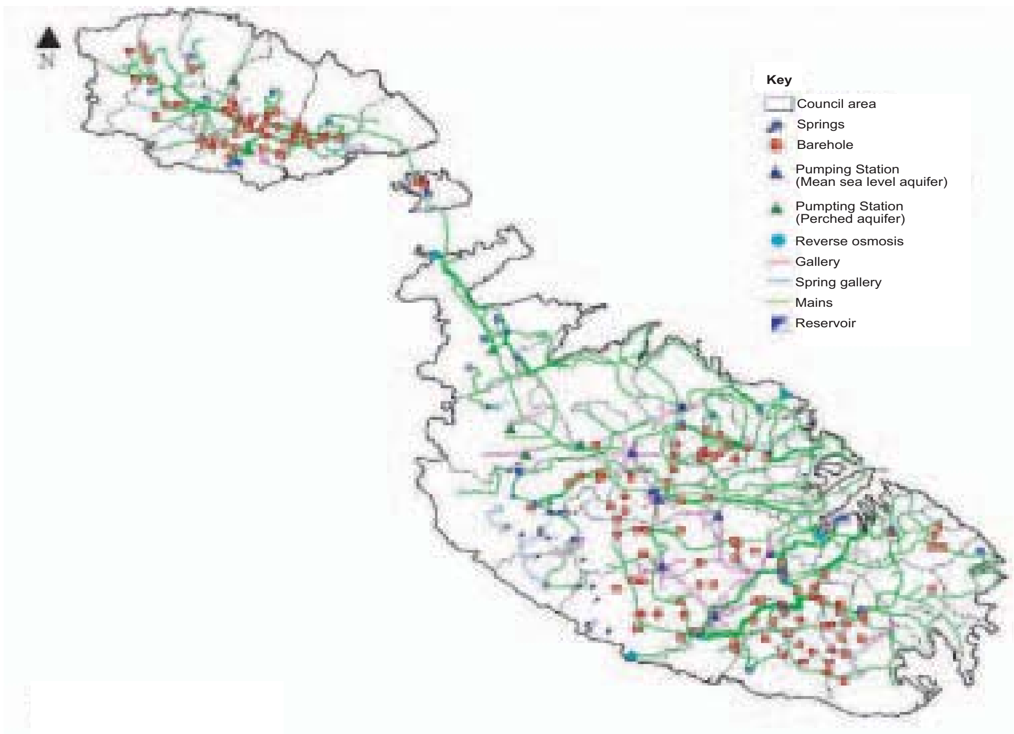
Currently there is no network infrastructure for the distribution of second-class water, apart from the limited network in the southeastern regions of Malta used for the distribution of treated effluent produced in the Sant' Antnin treatment plant (Figure 23).

DELIVERY SYSTEM LOSSES

The control of water losses in the national water distribution system plays a vital role in the operations of the WSC, particularly as these represent a substantial loss of revenue in real terms. Real losses consist of all forms of leakage within the network, such as service-pipe leakage, leakage on fittings, reservoirs, trunk/transfer/street mains, etc. Any leakage downstream of a production source and upstream of the consumer revenue meter is termed a real loss (Rizzo, 2000). The management of water losses includes both real water losses, more commonly known as water leakages, and apparent water losses, which represent any water consumed but not paid for, such as water theft, metering errors and billing anomalies (Figure 24).

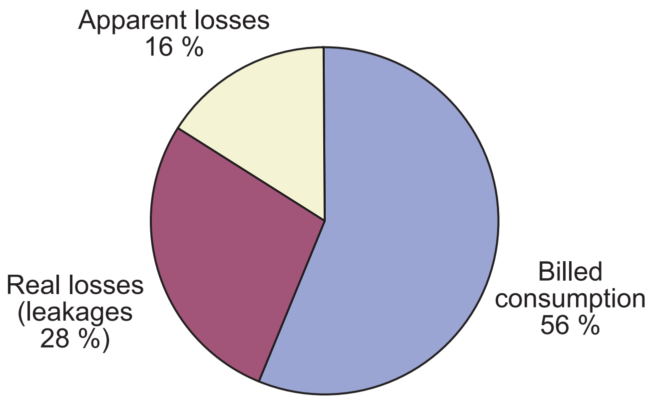
Leakage control (comprising active leakage localization, leakage repair, pressure control and network infrastructure management) is considered to be a major contributor towards a reduced national system demand. The WSC distribution network has been segmented and rationalized into hydraulic zones. Water balances have been developed, and studies of flows and minimum night flows in areas, system rationalization and establishment of more than 300 hydraulic zones have been carried

FIGURE 23
WSC infrastructure



out. Furthermore, high-leakage zones have been further subdivided into step-testable areas, and data logging of zone inlets permits computation of accurate leakage figures. Comprehensive and pilot leakage studies and trials carried out successfully by the WSC in Gozo achieved an infrastructure leakage index (ILI) of 1.5. High-pressure zones in the distribution system caused by improper system design and network conditions are being eliminated through automated pressure control. Existing methodologies for estimating and operating within economic leakage levels are also being refined by the WSC.

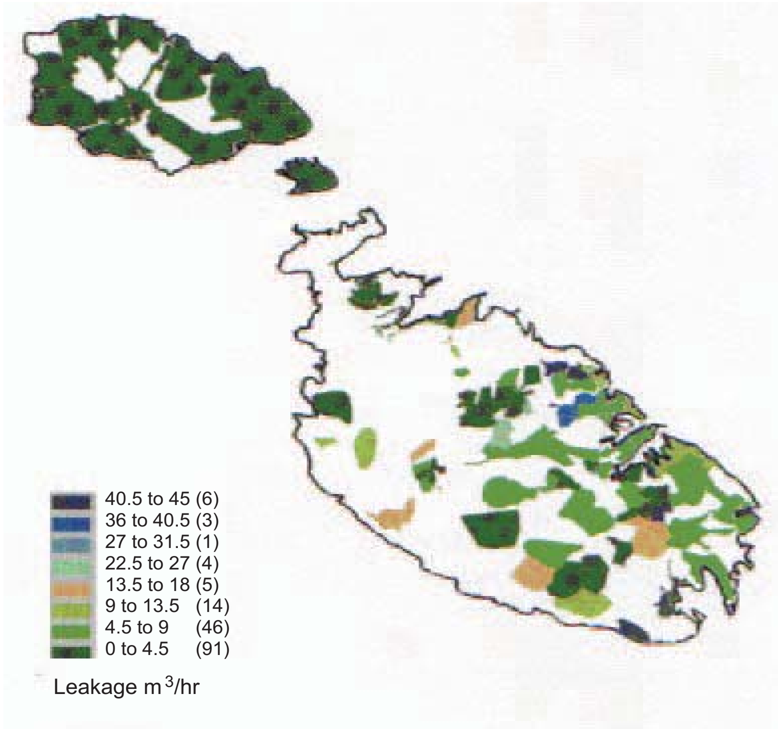
FIGURE 24
Billed water consumption and losses in the public distribution system, 2003



It has been estimated that leakage has been reduced over the whole distribution system from 2 692 m^3/hour (19.0 m^3/km/day) in 1995 to about 900 m^3/hour by July 2004. The unavoidable annual loss of the distribution system is estimated to be 300 m^3/hour, and the WSC plans to reach this target by 2010.

The ILI levels for the distribution networks in Malta and Gozo, reported in the WSC annual report as at July 2004 are 3.6 and 1.5 respectively (Figure 25). These ILI levels represent a total leakage loss of 9.6 hm^3 (1 100 m^3/hour), which represents about 28 percent of the total WSC water production.

FIGURE 25
Map of the leakage zone clusters in the Maltese Islands indicating relative leakage levels



Source: WSC (1999).

The term apparent losses refers to the three principal sources of unaccounted-for water that is consumed but not billed successfully (Rizzo, 2000). For this reason, these components are not considered as a "real loss" (as is leakage) but an "apparent loss". These components are:

- Metering errors: This component can be further subdivided into two categories: (i) revenue-meter underregistration resulting in a lower than actual computation of consumer water usage; and (ii) production-meter overregistration, resulting in a higher than actual computation of system demand.
- Water theft: This consists of the illegal or unauthorized usage of water taken from the system.
- Billing anomalies: These include a multitude of factors that contribute to a distorted picture of legitimate consumer usage stemming from the ineffectiveness of the water utility's billing system.

Over the years, the WSC has sought to reduce the apparent losses through a number of measures. An ongoing programme by the WSC aims to replace old Class C meters with Class D meters. By 2001, more than 115 000 Class D meters had been installed. Results showed (WSC, 1997) that, for 1996, consumption through Class C meters was an average of 18 percent less than Class D meters. The WSC is also in the process of upgrading its meter-reading section with the extension of an on-site meter reading system, which was launched in 2003.

One of the problems facing the WSC regards the estimation of consumption made whenever meter readings are not available. Reasons for the unavailability of readings include closed premises and non-functioning meters. Estimates accounted for about 15 percent of billed volume in 2000/01. Meter accessibility varies from a low of 64 percent in domestic garages to a high of 88 percent in "social assistance" households.

Table 7 gives details regarding the levels of meter accessibility as at 2000/01.

TABLE 7
Ratio of meters read to total, Cycle 1, 2001/02

Consumer type		Number of invoices	Meters read "OK" or not in use	Percentage read
Domestic	Residential	158 561	132 849	84
	Social assistance	11 939	10 516	88
	Other	14 843	9 520	64
Industrial		1 046	875	84
Farms		1 817	1 430	79
Tourist		1 975	1 509	76
Government		1 909	1 585	83
Commercial	Bars and restaurants	1 577	1 214	77
	Others	16 073	11 831	74
Other		541	405	75

SEWAGE AND SEWERAGE

The sewerage system in Malta collects domestic and industrial wastes as well as a certain unquantified amount of stormwater runoff. The system is made up of about 1 050 km of gravity mains and includes 125 km of galleries, 45 km of pressure mains and 82 pumping stations. Basically, it comprises two main networks, commonly called Marsa Land and Marsa Sea, and three subsidiary networks: Malta North, Malta South, and Gozo (Figure 26). The two main networks service the southeastern and central parts of the island and converge at the Marsa sewage pumping station, from where sewage is pumped to the submarine outfall at Wied Ghammieq, and the sewage treatment plant at Sant' Antnin.

There are currently two main outfalls in Malta (Wied Ghammieq and Cumnija) and one in Gozo (Ras il-Hobz). Other minor outfalls are present but their discharge rates are much less. They include Anchor Bay (Malta) and Wied Mielah and San Blas (Gozo). No direct measurements are kept for the discharge rates from these outfalls. However, discharge rates are generally estimated on the basis of water consumption.

The Wied Ghammieq outfall is located on the southeast coast of Malta and discharges raw sewage at an average rate of 33 000 m^3/day (about 12 million m^3/year). This flow

FIGURE 26
Main sewer network and outfalls

is made up of the contributions of Marsa Land, Marsa Sea and Malta South, less the flow which is conveyed to the Sant' Antnin sewage treatment plant. Wastewater from the northern region of Malta is conveyed mainly to the outfall at ic-Cumnija, with a small fraction conveyed also to the Anchor Bay outfall. Both stations are located on the west coast of Malta, in the Mellieha region. The estimated average discharge rates at ic-Cumnija for 2000 were about 4 000 m^3/day. Therefore, on an annual basis, the Cumnija outfall discharges about 1.5 hm^3 of sewage.

In Gozo, almost 85 percent of all wastewater is discharged through a submarine outfall at Ras il-Hobz. Another two outfalls are located on the north coast of Gozo at Wied Mielah and San Blas. These outfalls discharge minor quantities of wastewater. The total wastewater generated in Gozo is estimated at 5 500 m^3/day, or an annual total slightly exceeding 2 hm^3.

Estimates for the total amount of wastewater discharged into the marine environment for 2000 indicate an annual volume of about 19 hm^3 (52 000 m^3/day). These figures indicate a substantial reduction in the discharge of sewage from the estimated 23 hm^3 produced in the early 1990s. This reduction is mainly attributed to the reduction in water consumption.

Although the sewerage network covers most of the Maltese Islands, there are still about 1 000 households that are not connected to the main network. Instead, they are linked to cesspits that are emptied weekly at authorized discharge points. To these, small villages (such as Bahrija and Bidnija) served by communal cesspits must be added. It is estimated that about 98 percent of all the wastewater is collected. Cesspits are also found on animal-rearing facilities. These are regularly emptied into the public network.

The sewerage collection and treatment system is being upgraded to meet the requirements of EU Directive 271/91. By 2007, it is expected that all domestic and industrial wastewater will be treated to a secondary level, and the treated effluent will be either discharged to the marine environment through submarine outfalls or reclaimed and reused. However, the subsequent use of treated effluent depends on: the real and perceived health considerations; the cost of production, storage and distribution; and the quality of the water produced.

ASSETS AND ASSET MANAGEMENT PLANS

The WSC currently operates 131 groundwater abstraction boreholes, 13 pumping stations and 3 RO plants, which are supplied through 76 sea-wells. The WSC also operates a groundwater polishing plant at Ta Cenc, Gozo, with the capacity to treat 4 000 m^3/day. Apart from these, the WSC also administers a number of water sources that are currently not being used for production purposes. These include 4 pumping stations (Via Dingli, Wied Dalam, Mgarr and Wied is-Sewda), 26 springs, 256 boreholes and a brackish water RO plant at Marsa together with 10 associated sea-wells. To these, one must add the water distribution network with all the associated reservoirs. These facilities are regularly maintained by the Groundwater Operations Unit of the WSC.

As from October 2003, the WSC also assumed ownership of wastewater collection, disposal and treatment facilities, which include the wastewater collection/disposal network and relevant pumping station as well as the wastewater treatment plant at Sant' Antnin.

However, the WSC does not possess a comprehensive asset management plan; although regular maintenance/upgrading of facilities are undertaken. It is planned to develop such a management plan under the licence proposed by the MRA.

SERVICE-LEVEL AGREEMENTS

The WSC currently possesses no formal service-level agreements, but the licence proposed by the MRA to the WSC envisages the development of such standards. The

WSC is also in the process of preparing its customer service charter. The charter will eventually contain a list of corporation and client responsibilities as well as the basic level of service customers should expect from the WSC.

The building blocks of this charter can be established from the vision of the WSC as outlined in its latest Annual Report:

"A number of customer-first measures have been introduced, which are regularly reviewed to ensure long-term improvement. The established code of the WSC sets out precise service-delivery standards. The areas covered in the code are:

- customer friendly, customer care set-up;
- response time and style to written enquiries;
- arranging appointments;
- meter reading and billing organization;
- response time to flooding from the water/wastewater service and other leaks;
- response time to requests for new services;
- planned and unplanned interruptions to the water supply and wastewater disposal;
- level of service – water pressure;
- commitment to improve the quality of water;
- commitment to an ambitious leakage control programme."

This vision is further defined in the current strategic plan of the WSC, where the customer service objectives are outlined. The strategic plan indicates a number of initiatives that are being implemented with the aim of improving the efficiency and effectiveness of the WSC. Among these initiatives are the following actions:

- bringing the quality of water up to the highest standards required by the EU directives;
- continual monitoring;
- implementing works to improve the system to ensure quality potable water to all parts of the Maltese Islands (Figure 27);
- implementing works to improve the system to ensure the safe disposal of wastewater in all parts of the Maltese Islands, with minimum impact on the environment;
- keeping the customer informed about intended projects and problems that might affect the supply of quality water.

An analysis of the service levels of the WSC was last performed in 2001. From this study, two main indicators were identified for monitoring service-level trends: (i) access to safe drinking-water; and (ii) share of distributed water not conforming to quality standards.

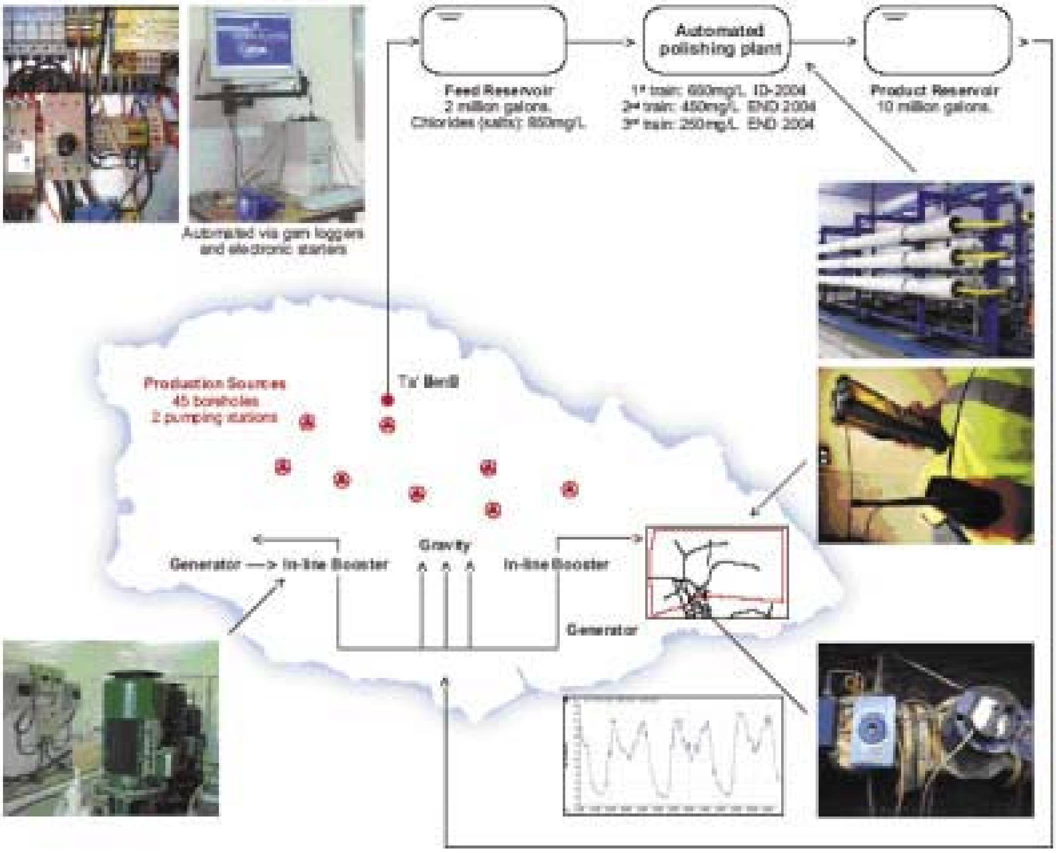
The first indicator represents the proportion of the population with access to safe drinking-water (more than 20 litres/day/person), and it is expressed as a percentage: access to safe drinking-water (2000/02) = 100 percent.

The second indicator represents the quality of drinking-water supplied at the consumer's tap in accordance with the EU drinking-water quality directive 98/83/EC. It is further subdivided into three components to account for the different categories defined by the same directive, i.e. microbiological parameters, mandatory chemical parameters, and indicator chemical parameters. The percentage of water supplied at consumer's tap in 2000/01 not in accordance with drinking-water quality standards was as follows:

- microbiological parameters: 6.2 percent;
- mandatory chemical parameters (EU Directive 98/83/EC Part B): 1.3 percent;
- indicator chemical parameters (EU Directive 98/83/EC Part C): 23.8 percent.

The WSC has also recently invested heavily in order to achieve a better quality for the water supplied through its network. These investments include the construction of a water-collection system and a "polishing" plant in Gozo in order to decrease saline

FIGURE 27
Measures to improve potable water quality in Gozo



Source: WSC (2004).

content in potable water as well as the implementation of a nitrate reduction programme in Malta. These programmes are intended to align potable water production with the EU Drinking Water Directive by the end of 2005, as negotiated in the EU accession agreement, as well as attain the indicative concentrations for chlorides by the end of 2007.

EMERGENCY PLANNING

A contingency plan is envisaged under the WSC licence. At present:

- On average, 250 000 m^3 and 48 000 m^3 of water are stored in first-class storage reservoirs in Malta and Gozo, respectively. This approximates to a reserve supply for an estimated 2.7 days for the Maltese Islands.
- The RO plants are all operating well below full capacity.

Chapter 7
Water demand

OVERVIEW OF CURRENT DEMAND

Table 8 presents the breakdown of estimated water demand by sector for 2003 along with the sources of water used to meet this demand.

Features of demand in 2003 include:

- when apparent losses are taken in account, domestic water use was the sector with the highest water demand;
- although an improvement on previous years, apparent and real water losses were still very high;
- agricultural water use for irrigation was the second largest user of "blue" water and the main user of groundwater;
- compared with the potential availability of TSE of about 14 hm^3 by 2008, use of TSE in 2003 was very low.

OVERVIEW OF THE CURRENT STATUS OF WATER RESOURCES

Figure 28 shows the current estimated balance between average inflow and outflow for the main groundwater bodies on the Maltese Islands. The areas in green and blue represent the Upper Coralline and the Lower Coralline Limestone aquifers respectively. However, because the perched aquifers overlie the sea-level aquifers, some deep boreholes in the areas marked as green will actually be abstracting water from the underlying sea-level aquifers, resulting in part of the estimated demand for that particular groundwater body being actually derived from the underlying sea-level aquifers and thereby increasing the existing imbalance in the sea-level aquifers.

Figure 28 helps to illustrate the following points:

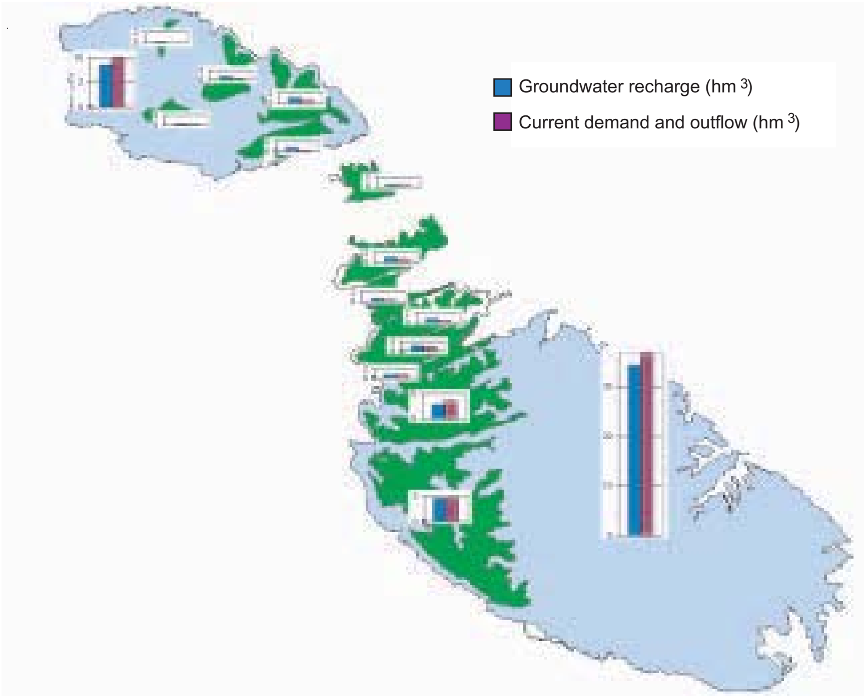
- Current levels of estimated abstraction from the sea-level aquifer systems exceed estimated aquifer recharge. Therefore, current levels of abstraction are not sustainable. Projected increases in demand by the agriculture sector will further exacerbate a deteriorating situation.

TABLE 8
General water accounting matrix, 2003

Malta: General Water Accounting Matrix Year: 2003 Production	WSC		Private				Total
Use	Billed (000 m^3)	Unbilled	Groundwater	RO	Treated effluent	Runoff harvesting	
Domestic	12 620	3 686	1 000			2 000	19 306
Tourism	1 134	331	500	1 000			2 965
Farms	1 336	390	500				2 226
Agriculture			14 500		1 500	2 000	18 000
Commercial	1 247	364					1 611
Industrial	941	275	1 000		500		2 716
Government	818	239					1 057
Others	869	254					1 123
Total consumption	18 965	5 540	17 500	1 000	2 000	4 000	49 005
Real losses		9 636					9 636
Total + losses	18 965	15 176	17 500	1 000	2 000	4 000	58 641
WSC:							
Total apparent losses	5 540	16%					
Total loss	15 176	44%					

Note: Unbilled consumption was estimated on the basis of the volumetric distribution of the billed consumption.

FIGURE 28
Map of the Maltese Islands showing the balance between estimated inflow and outflow for main aquifers, base year 2003



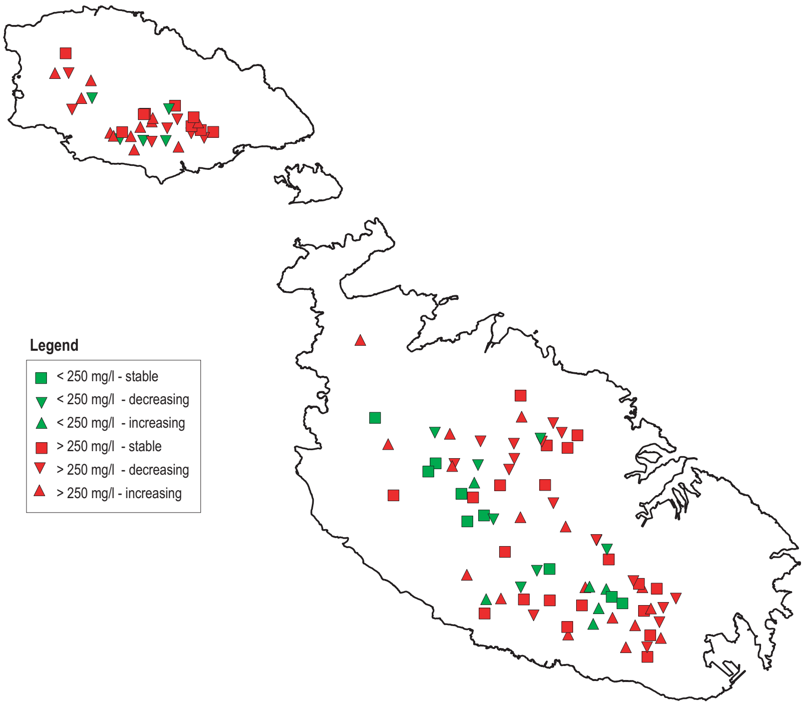
- ➢Current levels of estimated abstraction from the main perched aquifers in Malta are also at a critical level.
- ➢The abstraction potential of the perched aquifers in the north of Malta and in Gozo is limited mainly by the small size of these systems.

Figure 29 shows salinity levels and the salinity trends in groundwater production boreholes in the Maltese Islands. The threshold used in developing this figure assumes a limit of 350 mg/litre. New standards issued by the World Health Organization (WHO) recommend a limit of 250 mg/litre. Boreholes marked as green have a salinity level lower than the WHO permissible limit for drinking-water whereas boreholes marked as red exceed this limit. The WHO adopts a taste-based standard of 250 mg/litre for chloride content in potable water as "chloride concentrations in excess of 250 mg/litre can give rise to detectable taste in water". The directions of the arrows indicate whether salinity levels have been increasing or decreasing in the last five-year period. The boreholes marked with points have salinity levels that are relatively stable.

Figure 29 illustrates the following points:

- ➢Salinity levels for many boreholes in the central part of the island exceed indicative limits. The situation in other parts of the island is more difficult to assess because observation boreholes do not exist. However, abstraction from boreholes in the south and north had to be discontinued because of the relatively high chloride content of the abstracted groundwater.
- ➢Many of the boreholes that are within permissible limits are exhibiting a rising trend in salinity level. Hence, it is only a question of time before these boreholes exceed permissible limits.
- ➢Many of the boreholes that are in excess of permissible limits are exhibiting a downward trend in salinity levels. This could be caused by the fact that pumping

FIGURE 29
Salinity levels and trends compared with previous five-year mean in WSC groundwater abstraction boreholes, 2003



rates from these boreholes have been reduced or abstraction from nearby boreholes has been discontinued, resulting in relaxation of the aquifer and leading to dilution of localized upconed saltwater.

However, past hydrogeological studies on the sea-level aquifers indicated a complex relationship between abstraction rates and chloride content. Thus, the situation described above cannot be considered as a conclusive indication of the situation in all abstraction sources.

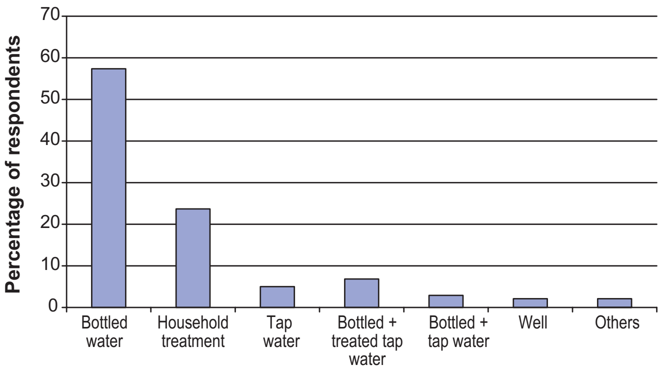
However, given the fundamental characteristics of the sea-level aquifer systems, changes in water quality are still a very good indicator of unsustainable localized abstraction of groundwater from the freshwater lenses. Additional evidence for unsustainable supply comes from research studies involving the profiling of the freshwater lens in deep boreholes, carried out jointly by the WSC and the MRA. These studies show a decline in the overall volume of Malta's sea-level aquifer along with the formation a much wider mixing boundary. The indications are that the lenses are reducing in both size and water quality.

The findings from research studies and monitoring by the WSC are supported by the observations of water users and the general public. These include:

- Farmers observing increasing problems of poor crop quality and yields as a result of deteriorating groundwater quality;
- Dwindling flows from springs.

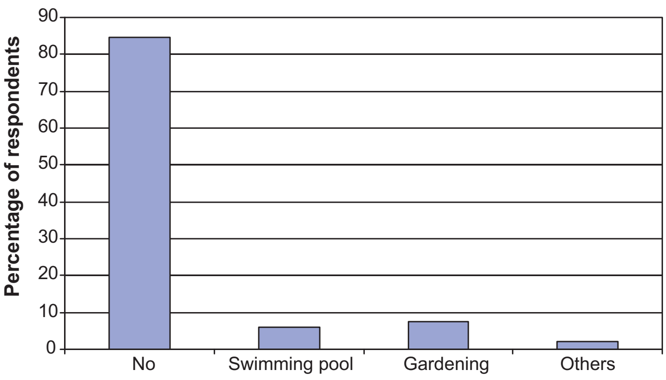
The overall conclusion is that demand is outstripping supply and that in many areas of the island a crisis has already been reached. If there is no reduction in groundwater demand from 2003 levels, the prognosis for the sea-level aquifers is extremely poor.

FIGURE 30
Preferred source of drinking-water



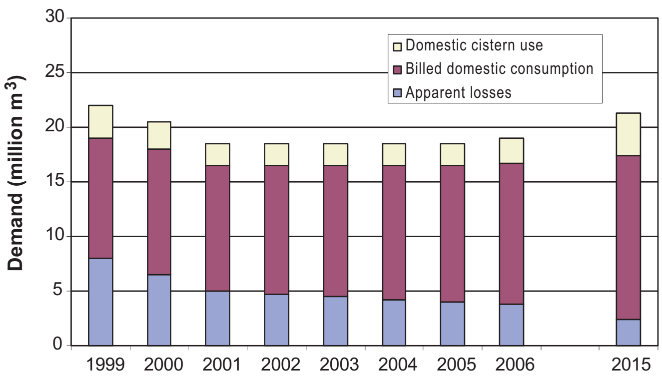
Source :MRA Water use survey 2005.

FIGURE 31
Usage of water for recreational purposes



Source :MRA Water use survey 2004.

FIGURE 32
Domestic water demand



DOMESTIC WATER DEMAND

The domestic sector has registered an increase in consumption caused by higher living standards. WSC figures indicate that the consumption of water exclusively for domestic purposes was 142 litres/person/day in 2000/01. This figure falls to 76 litres/person/day when losses and unaccounted-for water are taken into account. Modern housing and a heightened demand for better-quality drinking-water have indirectly created a market for new sources of water supply (Figure 30). The consumption of bottled water has increased sharply in recent years, reaching an estimated annual volume of 50–60 million litres; while an increasing number of property owners source their recreational needs (swimming pools, etc.) from private "bowser" suppliers who use groundwater as their main source of supply. However, "swimming pool" demand is determined by the total physical volume of pools. MRA databases indicate a total number of about 3 500 registered pools in the Maltese Islands, with a total combined volume of about 250 000 m^3.

A number of in-house water sources have been "illegally" drilled recently and are being used exclusively for recreational purposes. A recent survey on water use found that about 14 percent of respondents "were using large quantities of water other than for domestic and hygienic purposes", which were indicated as being swimming pools and gardening (Figure 31).

Figure 32 shows the current and projected demand for water supplied to domestic users by the WSC. These figures do not include real losses (e.g. water lost as leaks, illegal connections, etc.) but take into account a proportional volume of apparent losses.

Figure 32 takes account of discussions on domestic demand that involved staff from the WSC. The figure illustrates the following points:

- In recent years, domestic demand has been relatively stable at about 17 hm^3 per year.

- Although tariff increases may dampen overall demand temporarily, demand is expected to increase steadily in the next ten years.
- The proportion of domestic demand that is met from water harvesting into cisterns is expected to increase. The rate of increase will be influenced by tariff increases and availability of incentives.
- Apparent losses have been falling and, with the introduction of new billing arrangements, further decline is anticipated.

FIGURE 33
The Malta Environment and Planning Authority – policy and design guidance 2004

Rainwater runoff should be collected and recycled (for those uses which do not require potable water). This applies both to residential and non-residential development, where the collected runoff may be a useful resource. Collection also reduces the amount which needs to be dealt with by the storm water drainage system and so may have wider benefits. Plans submitted with application should show the proposed location of the water cistern.

All new development shall be provided with a water cistern to store rainwater runoff from the built up area. The volume of the cistern (in cubic metres) shall be calculated by multiplying the total roof area (m^2) by:

(a) dwellings – × 0.3;
(b) villas – × 0.45;
(c) industrial and commercial buildings – × 0.45;
(d) hotels – × 0.6.

The design of non-built development which paves or hard surfaces large areas should also take into consideration the provision of water catchment for surface water runoff.

For larger scale development, the authority may require the submission of details on how the water collected is to be used.

Given the deterioration in groundwater quality, it seems likely that an increasing proportion of domestic water demand will be met from RO plants or further treatment (desalination) of abstracted groundwater. The limit of this process of substitution will depend on the rate of deterioration of the sea-level aquifers and whether or not a policy of regulating groundwater demand is introduced (Figure 33).

There is considerable scope for increased use of household cisterns in the Maltese Islands. However, an increase is only likely if tariffs are set at a level that encourages users to switch to alternative sources. Introduction of fiscal incentives would also encourage uptake among users with existing properties (as opposed to properties under construction, which are obliged to construct cisterns). The increased use of cisterns makes service delivery more complicated as demand for WSC water can be expected to increase substantially in low rainfall periods, when the potential for harvesting water is much reduced.

In terms of reducing pressure on aquifers and allowing a strategic reserve to be established, the WSC is in the position of being able to substitute pumped groundwater with RO water. Thus, unlike agricultural users, the WSC has an alternative source of supply (or "safety net"). However, strategies that involve reduced groundwater abstraction and increased RO production involve additional costs, which will be passed on to users in the form of increased water tariffs or taxes. The question, which requires political debate, is whether or not some fiscal pain before the aquifers deteriorate further is better than the much higher fiscal pain that can be anticipated if the aquifers do deteriorate further.

AGRICULTURAL WATER DEMAND

Agriculture's share of the GDP for Malta is about 2.5 percent. The development of agriculture in Malta is constrained by the natural and geographical characteristics of the islands. The major constraints facing agricultural activity are the opportunity cost of land, scarcity of water resources, and high labour costs.

The total number of registered tenants of agricultural land was 11 444 in 2000. Of these, 974 were full-time farmers and 10 426 were part-time farmers. An analysis of agricultural land shows that the total area of agricultural land (inclusive of dry, irrigated and garigue land) decreased from 20 500 ha in 1955 to about 11 600 ha in 2000 (Figure 34). The period also saw an increase in irrigated land (that is land which has a continuous supply of water all year round irrespective of whether it has a natural

FIGURE 34
Land cover distribution in the Maltese Islands, 2000

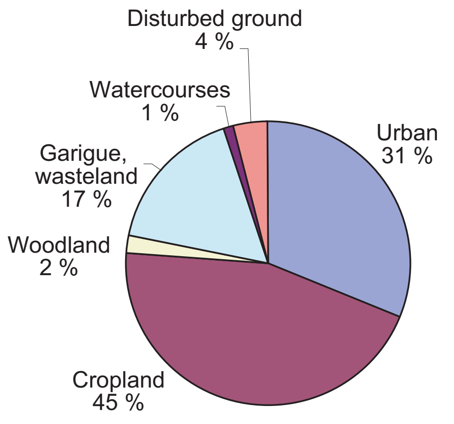
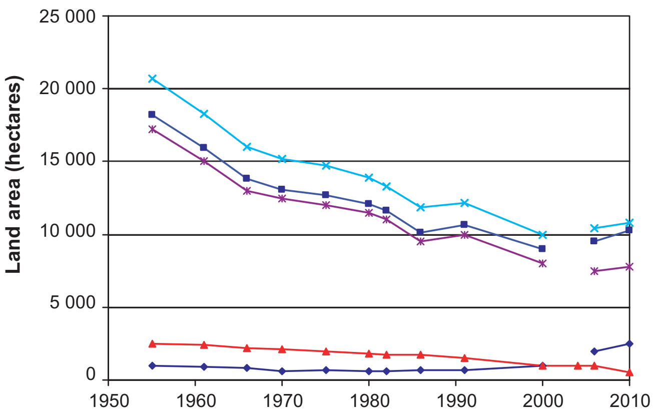


FIGURE 35
Agricultural land-use development in the Maltese Islands



spring, is served by second-class water or water supplied by other sources) from the 816 ha registered in 1955 to the 1 508 ha declared in the 2000 census. The main driver behind this increase in irrigated land area was revenue generation, backed by liberalization in water use, declining costs of borehole construction, and improvements in irrigation technology.

The Farm Structure Survey, carried out by the National Statistics Office (NSO) in 2003, showed an increase in agricultural land area for the first time since 1955. This increase was almost entirely at the expense of the garigue/wasteland. In fact, while the total for agricultural land increased marginally to 11 680 ha, utilized agricultural land showed increased from 10 150 ha to 10 350 ha while the garigue/wasteland decreased by about 150 ha (Figures 35 and 36). This change was probably brought about by the land-based subsidies on agricultural investment from the EU that became available in 2003.

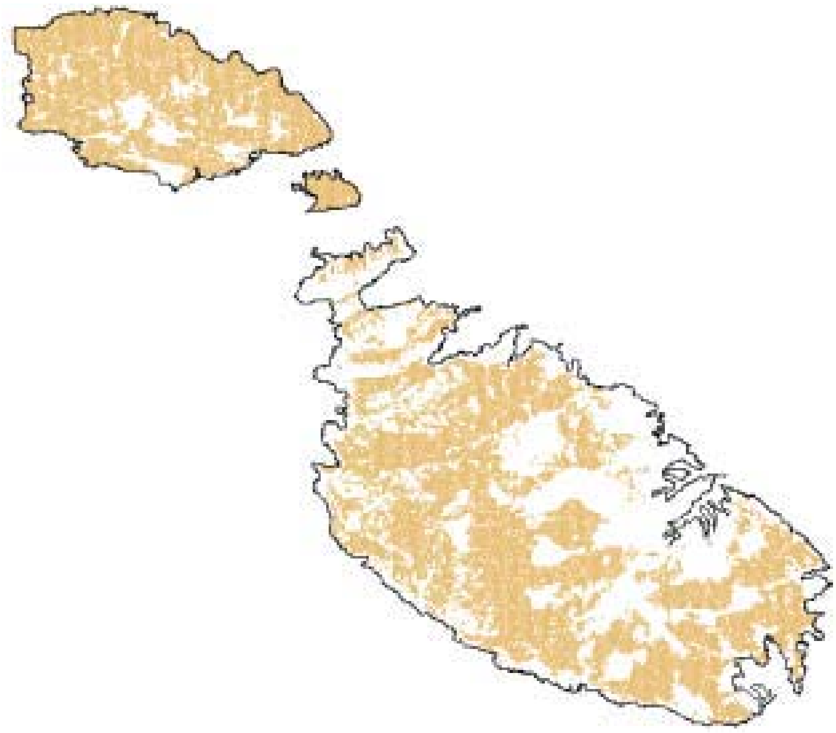
The outcome of the negotiations preceding Malta's accession to the EU can be considered as a viable starting point for projecting possible changes in the agriculture sector. The main points of interest from these negotiations are:

- The EU agreed that the base area applicable to Malta for arable crops would be set at 4 565 ha.
- The EU accepted that Malta should be granted new planting rights for the production of quality wines up to a total planted wine area of 1 000 ha.
- The national guaranteed quantity of olive oil for Malta was set provisionally at 150 tonnes (requiring between 50 and 75 ha of olive plantations).
- An area of 1 800 ha was indicated for the cultivation of potatoes.

Assuming that the utilized agricultural land area remains constant, attaining these thresholds will result in net irrigated land increasing to about 2 250 ha. Minimal increases are envisaged in the vegetable-cultivation sector as domestic demand is being met by the current levels of production and the possibilities of the sector being involved in large-scale exports are almost non-existent.

Figure 37 shows historical, current and projected irrigated water use on the Maltese Islands. The main concern is that the proposed expansion in agricultural demand will not be achievable without further deterioration of water quality in the sea-level aquifers. As presented in Table 9, the strong likelihood is that irrigated agriculture is going through the "boom and bust" cycle seen in many parts of the world where irrigated expansion has been based on unsustainable groundwater abstraction. The major questions are whether immediate improvements in water-resource planning can

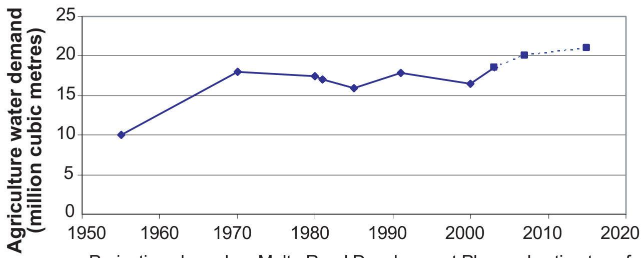
FIGURE 36
Distribution of agricultural land in the Maltese Islands



prevent the "bust" occurring at all and whether the most severe impacts of a "bust" can be mitigated. The important factors are:

- the extent to which unconventional water sources can substitute for the demand for groundwater;
- whether or not the cost of unconventional water sources will enable irrigated agriculture to remain profitable;
- the extent to which an improved water policy can have a very rapid impact on water use by individual agricultural users and the sector as a whole.

FIGURE 37
Historical, current and project irrigated water use on the Maltese Islands



Projections based on Malta Rural Development Plan and estimates of irrigation increases driven in part by Malta's accession to the EU. Details of methodology and assumptions are described in Hoogeveen (2004).

Table 9 is a rather simplified description of the four stages of Malta's groundwater development. As described, Stage 4 is an optimistic description of the future if an effective water policy is implemented.

Figure 38 shows estimated average monthly irrigation requirements. Demand is highest during the summer months. The uneven nature of monthly irrigation demand complicates the challenge of increasing the use of TSE for irrigation. As TSE production is continuous throughout the year, it may be necessary to create surface storage for TSE or use TSE as a source of water for artificial recharge when irrigation water requirements are low.

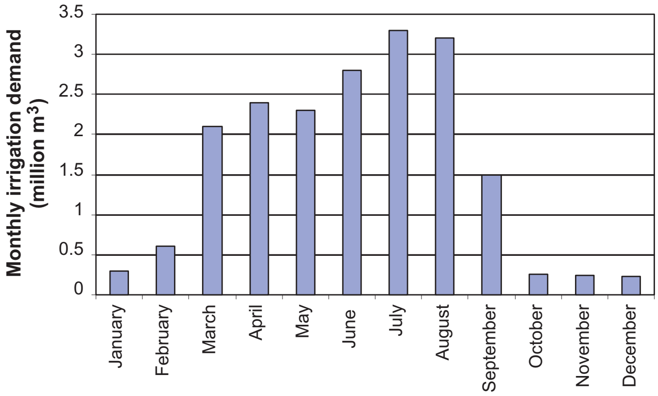
TABLE 9
Simplified view of stages in groundwater development in Malta

	Stage 1 (Hundreds of years up to the early 1980s)	Stage 2 (Early 1980s to mid-2000s)	Stage 3 (Mid-2000s to late 2000s)	Stage 4 (Late 2000s onwards)
Stages	Low-level of irrigation meeting local demand for vegetables, olives, grapes, wine, etc.	Agrarian boom prompted initially by availability of drilling technology and subsequently sustained by EU-accession land-based subsidies. Large increase in area under olives and vineyards.	Symptoms of groundwater overexploitation increasingly apparent and starting to affect yields and crop quality.	Decline in overall groundwater use. Increased use of unconventional sources for irrigation.
Characteristics	Total irrigated area less than 500 ha. Use of spring water for irrigation and gradual development of the perched aquifer using shallow wells.	Total irrigated area increased to more than 2 500 ha. Large increase in use of supplemental irrigation. Deep boreholes used to exploit sea-level aquifers.	Peak reached in irrigated area and agricultural water use as a result of declining groundwater quality and introduction of regulations and tariffs.	Low-value crops no longer profitable. Area under irrigation declines. Agri-environment planning becomes the norm.
Impacts and sustainability	High-level of sustainability. Some decline in water levels and spring flows from perched aquifer. Onset of a nitrate pollution problem.	Unsustainable use of groundwater and high levels of pollution as a result of intensive livestock production and high levels of fertilizer use.	Impacts of groundwater regulation, awareness campaigns and improved planning starting to have an impact on sustainability.	A balance achieved between groundwater inflow and outflow. A strategic reserve created. Water quality improving steadily.
Interventions	Limited government support. No groundwater regulation.	Protected local market. No groundwater regulation. Financial support for activities that increased agricultural output and water demand.	Local market not protected. Groundwater regulation (including tariffs) and catchment planning introduced.	Adaptive management of groundwater becomes the norm. Good environmental awareness established at all levels.

Source: After IWMI (2005).

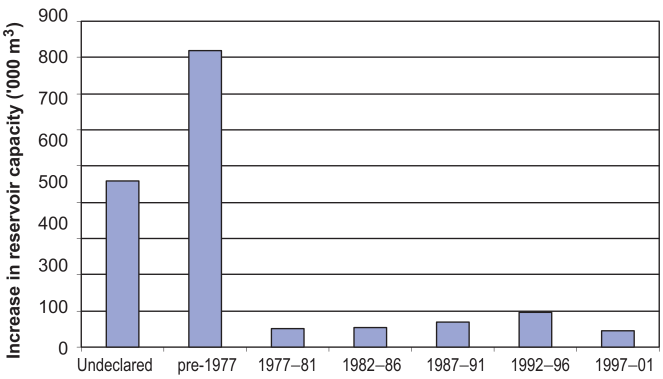
It is estimated that the agriculture sector is meeting about 80 percent of its demand from groundwater while non-conventional sources such as treated effluent and rainwater harvesting are only of marginal importance. In fact, from data collected during the 2001 agricultural census, it can be concluded that investments in rainwater harvesting have decreased substantially since 1997, possibly providing an indicator of the greater reliance of the sector on groundwater. The borehole drilling spree is normally associated with 1997.

FIGURE 38
Estimated monthly irrigation demand



The 2001 agricultural census registered about 9 000 agricultural reservoirs (Figure 39). A number of these reservoirs are currently being used to store abstracted groundwater. However, they can potentially be converted to store surface runoff and, thus, contribute to reducing the sectoral dependence on groundwater, particularly during the winter months. On a long-term basis, the total estimated storage capability of these reservoirs is about 2 hm^3.

FIGURE 39
Increase in agricultural reservoir capacity



The demand of the sector (either the current 18 hm^3 or the projected 21 hm^3) cannot be met by groundwater alone. Other sources must be brought into play – treated effluent and rainwater harvesting in particular. More efficient methods of groundwater management, such as supply augmentation measures involving aquifer recharge with excess treated effluent and rainwater runoff, should also be considered. Thus, in the long term, unless the demand generated by the agriculture sector is met through the involvement of unconventional sources, the current levels of agricultural activity cannot be maintained.

Apart from groundwater, treated effluent is the only source of freshwater that is available all year round in significant quantities. Annual TSE production is estimated to reach about 14 hm^3 by 2008. TSE will be available in almost constant monthly volumes. Thus, a significant volume produced during the winter months will not be utilizable, being in excess of the periodic demand. This water can either be stored (and the cost effectiveness of constructing large reservoirs is questionable), used for recharging the aquifers, or discharged into the sea. At current estimates, only about 6 hm^3 of TSE can be potentially utilized owing to the disjuncture between availability and demand (Figure 40). Thus, the excess TSE is expected to be about 7 hm^3, considering usage of about 0.5–1 hm^3 by the industrial sector. If this excess TSE were used for recharging the aquifers, this would increase the abstractable proportion of groundwater in the long term, thus, ultimately increasing the sectoral quotas.

The 6 hm^3 of potentially usable TSE requires substantial investments in distribution facilities in order for it to be available where and when needed. The utilization of TSE for different applications must be treated with caution and with full consideration

FIGURE 40
Correlation of irrigation demand with availability of unconventional water sources

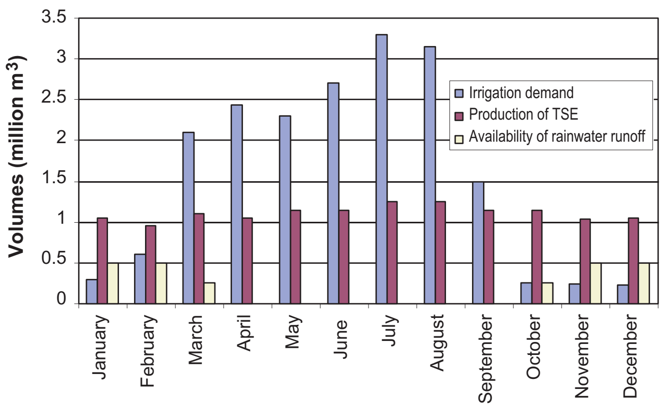
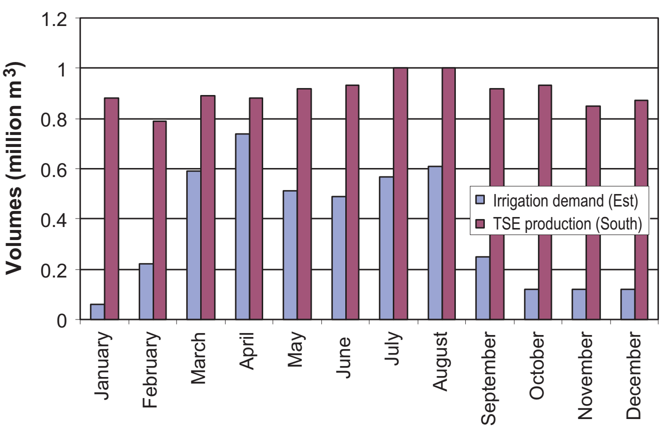


FIGURE 41
Correlation between irrigation demand in the southeast and the volume of TSE produced by the Malta South plant



of public health issues. Any type of application involving the infiltration of TSE into the ground, as in the case of irrigation, is thus constrained by hydrogeological conditions, the quality of the effluent, and the cost of treatment. Other constraints on TSE usage involve the cultivation of crops that "can be eaten raw" for which effluent use is not recommended.

TSE utilization is further constrained by the centralized location of the treatment plants. It is expected that the TSE produced during the summer months in the Malta North and Gozo plants will be utilized fully as the plants (particularly Malta North) are located in the middle of agricultural areas. However, production from the Malta South plant is expected to exceed the demand in the southern region.

Agricultural areas in the region of the Malta South plant have a current water demand of 2.7 hm^3, projected to increase to about 3.3 hm^3 by 2010. In fact, a correlation of TSE production in the Malta South plant with the irrigation demand in the region (Zabbar, M'Scala, Zejtun, Xghajra and Kalkara local council areas) shows that the supply is expected to exceed demand throughout the whole year (Figure 41).

Considering the long-term scenario, this would leave about 1.7 hm^3 of excess TSE production in the Malta South plant during the summer months. The usable TSE from the Malta North and Gozo plants (about 1 hm^3) faces the same "distribution" problems. However, the volumes in question are quite within reach of the carrying capacity of water hawkers in Malta – practically producing a "legal" market for their service.

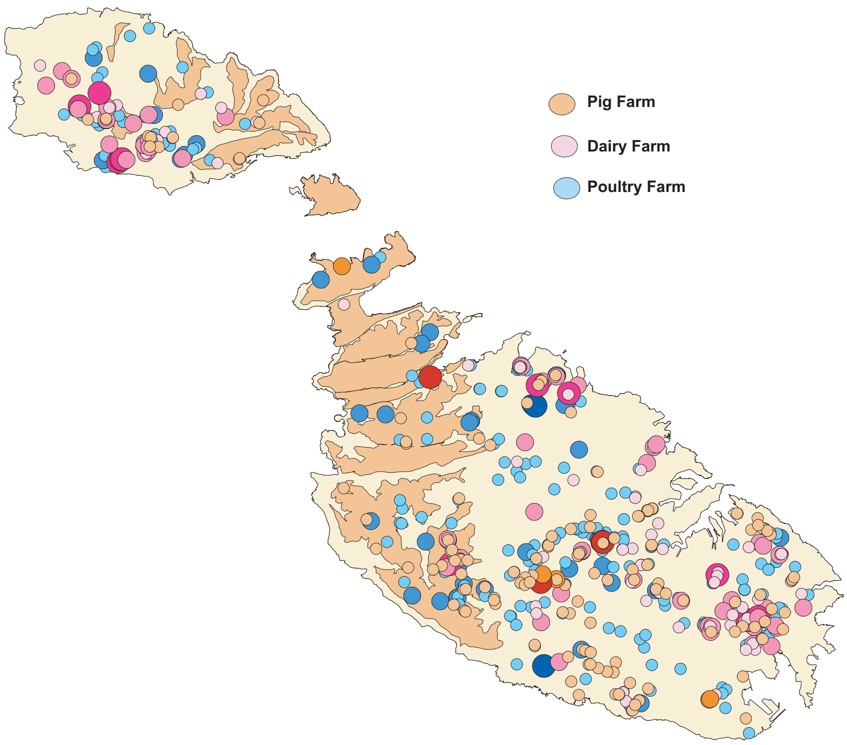
LIVESTOCK WATER DEMAND

According to NSO data, there are 260 dairy and beef cattle farm units in Malta and Gozo (Figure 42). Most of the farms (about 55 percent) are not specialized and are engaged in both milk and beef production. The cattle herd on the islands was established at about 18 000 head (Table 10). The breeding stock totalled 11 989 head, of which 9 306 were milk cows.

There are 174 pig farms in the Maltese Islands, of which 138 are production units, 18 are fatteners, 16 farms are engaged in both activities, and another 2 farms are involved in other activities. The pig stock amounted to about 73 000 animals.

In Malta there are about 1 100 breeders of sheep and goats with a total herd of about 15 000 sheep and 5 500 goats. Most of these are small farms concentrated in rural areas and operated as a small cottage industry. The number of poultry animals is estimated

FIGURE 42
Distribution of pig, cattle and poultry farms in Malta



Source: MRA.

TABLE 10
Annual water demand by animal category, 2003

Animal category	Number of animals	Daily water demand (litres/day)	Annual demand (m³)
Pigs	73 067	Summer: 20.25 Winter: 13.5	450 000
Cattle			
Calves 1 year	4 909	Summer: 139.5 Winter: 94.5	209 500
Cattle 1-2 years	4 983	Summer: 182.25 Winter: 137.25	290 500
Cattle 2 years	8 093	Summer: 195.75 Winter: 150.75	511 800
Total	17 985		1 011 800
Sheep	14 861	Summer: 18.0 Winter: 13.5	85 500
Goats	5 374	Summer: 18.0 Winter: 13.5	31 000
Rabbits	55 254	Summer: 3.0 Winter: 1.5	45 000
Poultry			
Layers (others)	756 288	Summer: 0.36 Winter: 0.32	94 000
Broilers	1 184 157	Summer: 0.22 Winter: 0.28	108 000
Total			202 000
Equine	853	Summer: 58.5 Winter: 49.5	16 800
Total			1 842 100

Note: The daily water demand per animal includes drinking and the corresponding amount for cleaning the shed.

FIGURE 43
Distribution of water demand for animal husbandry, 2003

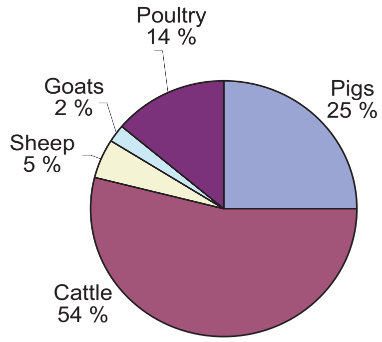


FIGURE 44
Decrease in water demand due to water recycling

- In Malta, large volumes of water are used during silicon wafer cutting. In the slicing process, silicon dust is too fine to be captured by traditional filters. The site installed a microfiltration unit to remove the fine particles and the water was then further purified by passage through ion-exchange resin columns. Water is then sufficiently clean to be recycled for operations requiring extremely high purity water. As a result, the use of city water was reduced by some 13 000 m^3 per year.
- The Malta site also recycles waste brine which is discharged by the plant's Electrodialysis Reverse (EDR) water purification system. EDR is a system in which a potential difference is applied to remove 80 percent of salts from the mains water. The concentrate waste is filtered and chlorinated and is suitable for non-potable use in toilet flushing, for instance. Through this means, city water consumption dropped by a further 6 500 m3.
- In 1998, the Malta site made a major effort to recycle waste water from its electroplating operations. A new design using ion exchange resins recovers metals from electroplating water. This is followed by a reverse osmosis system to further purify the water.
- Other water conservation strategies set up by Malta include the installation of a rainwater capture and recycling system. In 1999, the facility reduced its consumption from city mains from 183 000 m^3 for the year down to 48 000 m^3 – a remarkable reduction of 73 percent.

Source: ST-Malta Web site.

at 5 500 000, the number of rabbits at 2 400 000, and the number of horses at about 850.

The most important environmental implication of livestock farming is the generation of animal waste, and its disposal in a manner such as to prevent contamination of the freshwater aquifers, drinking-water supplies, bathing water, air and soil. If managed properly, animal waste can become an important nutrient resource of economic value.

Estimates for the billed potable water supplied through the public distribution system amount to a total of 1 822 premises classified as "farms" for the period 2003/04 amounted to about 7 percent of the total billed potable water consumption for this period (Figure 43). Annually this amounts to 1.3 Mm^3. Thus, comparing demand to billed supply indicates that the animal husbandry activities are acquiring about 75 percent of their water supply from the main distribution system, with the other water source most probably being groundwater.

INDUSTRIAL WATER DEMAND

The industrial sector accounts for about 8 percent of the total water demand in Malta. Water efficiency and water recycling (Figure 44) are being introduced slowly, particularly in the major industrial concerns as it is recognized that these measures reduce costs in the long term. However, cost-effective programmes are still a long-way off for medium-small industrial concerns.

The construction industry (particularly batching plants) and the food and beverage industry (bottlers) are the concerns that are most dependent on groundwater in this sector. However, no appreciable expansion is envisaged. Thus, the sectoral demand for groundwater will most probably remain stable. Fiscal incentives should be promoted in order to reduce this dependence through runoff harvesting and recycling.

With the possible availability of increased volumes of TSE, further use by the industrial sector of this source is a possibility, also in view of the fact that the Ricasoli, Marsa and Bulebel industrial estates are all within range of the new Malta South plant. Currently, industry in the Bulebel region meets part of its water needs from the TSE produced at the Sant' Antnin sewage treatment plant. The annual volume of treated effluent supplied is relatively stable and in 2003/04 amounted to just more than 500 000 m^3.

In 2000/01, the WSC started an exercise in which consumers were classified in sectors according to categories used internationally. The classification was based on the Classification of Economic Activities in the European Community (NACE).

The resulting distribution is shown in Table 11.

The classification according to the NACE shows that the industry concerned in the manufacture of food products, beverages and tobacco is the major user of water in the industrial category, using about 58 percent of the total billed water consumption in this sector.

An analysis of these data shows that the mining and quarrying industry used about 0.2 percent of the total billed consumption (Figure 45), which works out to an annual figure of 36 000 m^3. Industrial statistics for Malta show the production of ready-mix concrete to be somewhere between 250 000 and 350 000 m^3/year. Assuming a water requirement of 0.25 m^3 for every cubic metre of concrete produced and a grossly inefficient process with 100-percent losses would result in an annual demand for this sector of 125 000–175 000 m^3. To this must be added the volumes of water used in the manufacturing of prefabricated concrete units, which, using similar assumptions, is estimated at about 40 000 m^3. This indicates that the mining and quarrying industry could be acquiring about 16–22 percent of its water requirement from the official distribution network, and with the remainder being obtained from groundwater.

TABLE 11
Water consumption according to the NACE (WSC interim results)

Category	Consumption (%)
Non-commercial	61.60
Agriculture, fishing, hunting and forestry	2.30
Mining and quarrying	0.10
Manufacture of food products, beverages and tobacco	9.30
Other manufacture	4.10
Electricity, gas and water supply	0.50
Construction	0.10
Wholesale and retail trade	0.70
Hotels and restaurants	10.40
Transport, storage and communication	1.10
Public administration and defence; compulsory social security	0.60
Education	0.70
Health and social work	3.60
Other community, social and personal service activities	1.60
Other (business activities, financial intermediation, etc.)	0.40
Consumption still unclassified	2.89
Total	100.00

FIGURE 45
Distribution of water use by industry

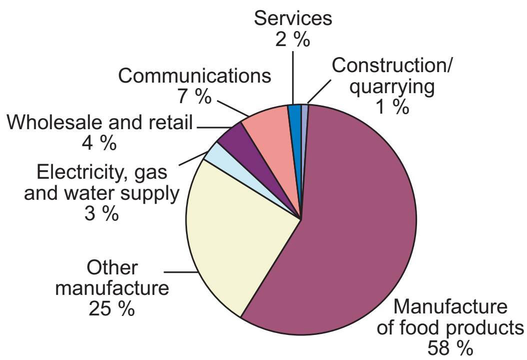
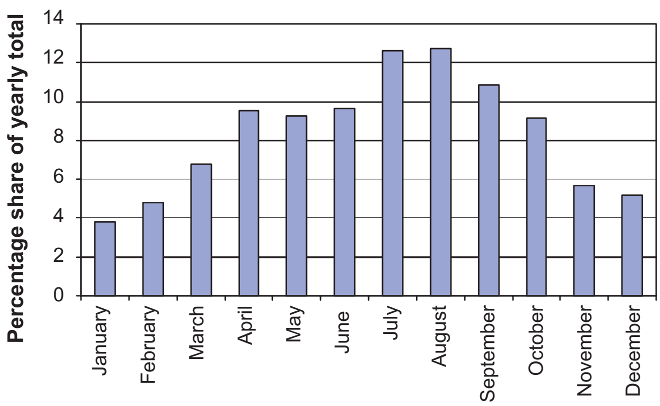


FIGURE 46
Percentage share of tourist arrivals by month in 2000



TOURISM WATER DEMAND

Data generated by the NSO show that the total annual guest nights in the period 1998–2000 varied between 10 and 11 million nights; or an average daily tourist load of 32 000 tourists. In the same period, tourist accommodation increased to 40 688 beds with a further 7 500 beds in holiday apartments. Tourist arrivals peak in the summer months of July and August and place additional strains on water resources (Figure 46).

The WSC estimates that tourism activity accounts for 10 percent of water consumed. Table 12 presents the demand for water by the tourism sector. The table presents estimated figures based on

TABLE 12
Water demand by tourism for the period 1997/98 – 1999/2000

	1997/98	1998/99	1999/2000
	(m^3)		
Total annual water production	40 772 926	37 963 808	36 604 128
Production to satisfy tourist demand	3 669 563	3 416 742	3 294 371
Per capita demand per day	0.324	0.293	0.321

Source: Azzopardi (2001)

FIGURE 47
Water demand management in hotels

The Radisson SAS By Point Resort produces over 45 000 gallons of water a day for its own use through an on site Reverse Osmosis Plant. The property is therefore self-sufficient and pulls practically no water at all off the national system. With the recurrent problems of water shortages on the Island the positive effect of such an investment is obvious.

In addition to this the property is also using a Dual Drainage System whereby water from the baths and wash hand basins within the guest bedrooms is filtered through a waste water treatment plant and pumped up for use in the toilet flushings. In this way the water is used twice. Any excess water produced is then stored and used for irrigating within the gardens of the Resort. Additionally, all rainwater catchment areas have been designed so as to achieve optimum levels of water collection

Source: Island Hotels Group Web site.

production levels. However, the billed consumption for tourist establishments for 2000/02 stood at 1.74 million m^3. This would mean that each tourist used about 149 litres/day of water.

These official figures for consumption of water by the tourist industry are low when compared with the situation in other Mediterranean countries. The corresponding official figure for Spain is 440 litres/day (with a maximum of 880 litres/day at tourist resorts) and that for Cyprus is 465 litres/day. These figures are inclusive of distribution network losses, and are reduced by about 300 litres/person/day when losses and unaccounted for water are eliminated.

The fact that the official demand figures for Malta are artificially low can be confirmed from other sources. It is customary for hotels with a bed capacity of 350–400 to install a 125-m^3/day RO unit (Figure 47). Assuming this RO unit to be the sole water supply for such a hotel yields a water production figure of 312 litres/bed/day.

These facts indicate that the tourist industry in Malta could be acquiring up to 50 percent of its water from sources other than the potable water network. These sources include in-house RO plants and private suppliers of groundwater (bowser operators).

Tourism demand should not increase appreciably in the near future as it has become cheaper for hotels (which are mainly situated near the coast) to install private RO units rather than buy water from hawkers or the WSC. The price per cubic metre from a hawker varies between LM0.6 and LM0.8 while an RO unit would produce the same amount for LM0.30–0.35. Moreover, the RO unit is a more reliable form of supply of better-quality water.

Therefore, any increases in tourism demand are expected to be met by private RO production, with the dependence of the sector on private groundwater sources gradually decreasing.

ENVIRONMENTAL WATER DEMAND

Groundwater is also essential to sustain terrestrial surface-water ecosystems. These habitats depend on a year-round supply of freshwater. Thus, they are quite rare and of limited distribution. However, they support distinctive types of flora and fauna, some of which are endemic to the Maltese Islands. A reduction in groundwater abstraction could be necessary in certain aquifers in order to sustain groundwater flow to these dependent ecosystems. A study is underway to determine the degree of dependence of these ecosystems on groundwater in order to better ensure their future protection and sustainability.

Chapter 8
Economics of water

FINANCING

In 2003, 36 percent of the total cost of production and distribution of water was financed directly by government. In addition, bank loans undertaken for investment projects by the WSC are backed by government guarantees. Such loans amounted to LM9.782 million in 2002. The exposure of the WSC with the banks in loans and overdrafts amounted to LM31.836 million in 2002.

Government also finances the cost of collection and purification of wastewater. Owners of new buildings pay a contribution that covers the cost of connecting the premises to the sewage network. The MEPA receives 10 percent of these receipts and the rest is paid to government and not to the operators, i.e. the WSC. The capital and infrastructural cost of constructing the Gozo recycling plant is being financed from funds made available by the Italian Protocol. EU funding is being sought to upgrade the RO plants and other projects.

COSTS

The cost of producing and distributing tap-water in 2003 amounted to LM17.923 million. Turnover of LM11.486 million covered 64 percent of the total cost of production. The WSC is planning to spend LM450 000 to renew and upgrade the transfer mains connecting the Ta' Qali reservoir and the Luqa reservoir. The upgrade is intended to reduce the level of nitrates. Leak repairs cost the WSC LM104 000 annually. In 2004, these repairs resulted in a saving of 1.185 million m^3 of water. If these are costed at LM0.55 per unit, then the total savings made by the WSC amount to LM1.2 million.

The WSC is also proposing to refurbish and upgrade the desalination plants while addressing issues of water quality, security of supply, and costs. This investment will cost about LM33.86 million (about US$11.3 million at the current exchange rate). Such investment will:

- upgrade plant capacity from the present 67 000 m^3/day to 95 000 m^3/day;
- improve the water quality by reducing chlorides from 360 mg/litre to 200 mg/litre;
- raise power efficiency from 5.57 kWh/m^3 to 4.74 kWh/m^3.

The total operating costs of public collection and purification of wastewater amounted to LM3.6 million between January and August 2004. This statistic is inclusive of a depreciation charge of LM2 265. The WSC is conducting an audit to establish the costs of fixed and working capital.

Further investment is needed to continue operating the Sant'Antnin recycling plant. Part of these costs may be offset by a fall of 50 percent in the running costs once the WSC starts managing the plant. At present, the cost recovery is nil.

The cost of setting up the sewage treatment plants at Gozo, Malta North and Malta South is estimated at LM36.016 million (about US$12 million).

The cost of private abstraction for agriculture and industrial purposes is unknown.

PRICING

Water pricing has always been a sensitive political and social issue. Successive governments have followed a policy of supporting water consumption by households and of maintaining such water tariffs stable for several years at a stretch. This policy measure meant that the actual consumption of water by households was not conditioned directly by changes in tariffs because prices were held constant for successive periods. Thus, in the period 1987–1999, prices were changed four times. There were no price changes between 1987 and 1990 or between 1994 and 1996. Tariffs were raised to 109.03 in 1997 and 154.17 in 1998 and 1999 (1995 = 100).

The demand for water is price inelastic. The price elasticity of demand was estimated at -0.28 in the short run and at -0.37 in the long run. The higher value in the long run implies that households respond to a price change when they are given time to adjust their consumption patterns. At -0.28, the short-run price elasticity of household demand for water falls within the range observed for other countries.

WATER TARIFFS

Malta operates a rising-block water-tariff system, where successive blocks of water are sold at a higher price. Before 1994, the first block of 27 m^3 was free of charge. A service charge is paid regardless of the amount of water consumed (it includes a sewage charge). More favourable tariffs are charged to vulnerable consumers, such as persons receiving social assistance and pensioners. Such measures are in line with the WFD. Article 12a of the WFD refers to "an affordable price" in order to guarantee a basic level of domestic water supply. Table 13 lists the different water tariffs and service charges paid by the various economic sectors.

TABLE 13
Water tariffs as at January 2005

Type of consumer	Service rent	Consumption charge	Tariff per cubic metre (LM)
Domestic	LM12	0 33 m^3/person	0.165
		> 33 m^3/person	1.100
Social assistance	Free	0–16.5 m^3/person	Free
		16.5–33 m^3/person	0.165
		> 33 m^3/person	1.100
Agriculture & agrofood	LM24	0–6810 m^3	0.165
		> 6810 m^3	0.350
Personal health use in field	LM24	0–15 m^3	0.225
		> 15 m^3	0.600
Industrial	LM18		0.850
Food & beverage	LM24		0.600
Tourist flats	LM24	0–252 m^3	0.750
		> 252 m^3	1.100
Hotels	LM24	0–42 m^3/bed	0.900
		> 42 m^3/bed	1.100
Laundry	LM24	0–6810 m^3	0.750
		> 6810 m^3	1.100
Sea craft	LM24		1.100
Government	LM24		1.100
Boat house, garden & garages	LM24		1.100
Non-commercial	LM12	0–171 m^3	Free
		> 171 m^3	0.350
Commercial & other	LM12	0–33m^3	0.165
		> 33m^3	1.100

WILLINGNESS TO PAY

A survey carried out in August 2004 among 468 households in Malta and Gozo, showed that 60 percent of the households were not prepared to pay more than the current price (Table 13). The term "current price" stands for bills paid by households in recent months. These bills reflect the existing water tariffs and already include subsidies on water consumed, reflecting the particular household participating in the survey. Table 14 presents the data on households' willingness to pay.

Three percent of respondents considered the tariffs to be high and would be willing to pay less than the current tariffs. Respondents in a survey of industrial units operating from the Bulebel Industrial Estate, and the beverages, services and tourism sectors also claimed that the present tariffs are high and some argued they could produce RO water more cheaply at LM0.25/m^3.

TABLE 14
Willingness to pay: water tariffs in Malta

Multiple of tariff	Number of respondents	Percent
Five times	8	1.7
Three times	9	1.9
Two Times	39	8.3
One and Half Times	96	20.5
Twenty percent more	18	3.9
Current Price	271	58.0
Less	13	2.8
No reply	14	2.9

Source: Water Surey (2004)

WILLINGNESS TO PAY FOR RECYCLED WATER

Some 46 percent of Maltese households will consider using and paying for recycled water provided that its quality is "guaranteed" safe for health purposes (including use for gardening and other domestic uses). Some respondents emphasized that they are not willing to pay for any additional infrastructure costs that the water suppliers may have to incur for distribution. Those households that already resort to water bowsers to obtain water indicate that they will be willing to consider buying recycled water provided that it is cheaper than the price they are currently paying.

REVENUE COLLECTION

In 2003, the WSC recovered 64 percent of the cost of producing and distributing tap-water. In 2004, the WSC undertook a massive campaign to collect arrears due to it. Customers who fail to pay for arrears due within a stipulated date will have their services discontinued. This campaign is having a positive effect on the cash flow of the WSC. In November 2004, the government announced its intention to introduce a surcharge of 17 percent on water and electricity bills. Discussions are underway at the Malta Council for Economic and Social Development on the implementation of this surcharge and its impact on household consumption and industrial production. In line with government policy, families in the social case category are exempted from payment of such surcharges.

VALUE OF WATER

Water as an intermediate input varies from one industrial sector to another. According to official input–output data that rely on billed consumption data, the demand for water is relatively low in relation to output. It falls in the 0.1–0.45-percent bracket for most industries, that is out of every LM100 worth of output, the outlay on water ranges between LM0.10 and LM0.45. For the electricity-generating sector, it is LM1.65 per LM100; for services and tourism, it is LM1.46. In agriculture, the share of water in output is LM2.40 per LM100. However, the exact value of water in use is not known. Industrial units in manufacturing and the leisure sector are known to utilize additional sources of water. For example, water is abstracted from boreholes or privately produced mechanically. Research is being carried out to establish the volume and value of such water.

ECONOMIC INCENTIVES AND PRICING PRINCIPLES

In the past, public authorities in Malta focused on the social implications of water-pricing policies and on ensuring a regular water supply for homes and industry. There was no systematic attempt to encourage water conservation, as such, via a pricing system that made it worthwhile for consumers to avoid unnecessary consumption. The government subsidized water use as a matter of policy. Moreover, in industry and agriculture, producers ensured their regular water supply through extraction, at times even illegally. It is only in recent months that there has been a greater awareness of the need to use water optimally and channel the consumption of this resource to its highest economic value. Indeed, the drive by the WSC to collect outstanding bills due is a sign of the determination to introduce accountability in water consumption. This is the first step towards generating an effective cost-recovery system and introducing widespread conservation attitudes and habits.

Chapter 9
Options and opportunities for improved water management

CONSTRAINTS ON IMPROVED WATER MANAGEMENT

Constraints that should be considered in the development of Malta's water policy and that limit the number of resource-focused options include:

- Climate: The climate of the Maltese Islands is semi-arid and, consequently, rainfall is extremely variable in time and space. Hence, groundwater recharge and runoff into cisterns is also extremely variable, as is the productivity of rainfed arable and non-arable lands. It is this variability that makes access to irrigation so important to the agriculture sector.
- Extreme events: Meteorological drought and floods are recurring natural phenomena. Estimates of sustainable annual aquifer yield must consider the probability of prolonged periods of drought. Similarly, rainwater-harvesting strategies need to consider potential damage to structures from flooding and the technical and economic viability of harvesting runoff resulting from large intense-rainfall events.
- Aquifer characteristics: The two main aquifer types in Malta, namely the perched and the sea-level aquifers, have distinctly different characteristics and levels of vulnerability.
- The "desalination" safety net: By decreasing the dependency of domestic users on groundwater, desalination plants have reduced the political imperative for long-term protection of the aquifers. Arguably, it is only the agriculture sector that has a high-level dependency on sustainable access to groundwater of adequate quality. To put it another way, farmers growing low-value crops do not have the safety net that is afforded to other water users who have the ability to pay high water tariffs.
- Awareness: Although there is increasing concern among some farmers that overextraction may be damaging the sea-level aquifers, there is generally poor awareness of the current poor condition of the sea-level aquifers and the consequences of their continued mismanagement.
- Water governance: There is scope for improvement in all aspects of water governance. Decision-making is fragmented and policies that affect water supply and demand are poorly aligned.
- Poor-quality information: Much water-related decision-making is based on data that are incorrect and/or out of date. There are also discrepancies between water-related information held and/or published by different organizations.
- EU water directives: While Malta's water policy should be tailored to the needs and the specific characteristics of the demands and the resources available, accession to the EU places some constraints and pressures on the Maltese authorities.
- Water-related myths: A number of water-related myths have become accepted wisdom at all levels in Malta (Box 1). Subscription to these myths can lead to poor decision-making, ineffective policies and a waste of financial and human resources. Without an effective awareness campaign, subscription to these myths is likely to undermine support for a water policy and affect its implementation.

BOX 1
Water-related myths

Water-related myths that are widely held in the Maltese Islands include:

- Salt is filtered from seawater as it passes through the limestone geologies that underlie the islands. The logic is that saline intrusion does not occur when groundwater depletion takes place and, hence, the quality of water in aquifers will not deteriorate as a result of overextraction.
- Aquifers under Malta are replenished by groundwater systems that are linked to the Nile River and/or Continental Europe. This myth is also linked to the concept that the aquifers can provide an unlimited source of freshwater.
- Water quality improves with depth of borehole. This myth is still held by many despite increasing failure of deeper boreholes as a result of deteriorating water quality.
- Crops grown with TSE are of inferior quality. In particular, there is a belief that these crops have a shorter shelf-life than those grown with untreated water. However, more justifiable concerns on the use of TSE also exist.

RISKS TO THE SUCCESSFUL INTRODUCTION OF IMPROVED WATER MANAGEMENT PRACTICES

Risks and assumptions that are inherent in the proposed water policy include:

- Reversibility of aquifer degradation: It is assumed that a reduction in groundwater extraction will lead to an improvement in water quality to acceptable levels. The risk is that in some areas this may take longer than anticipated.
- Climate change: While there is no compelling statistical evidence of climate change affecting the water resources of the Maltese Islands, there is a risk that climate change will become a serious issue in the future.
- Equity: Implementation of the water policy will almost certainly lead to changes in patterns of water availability and use that may result in distinct winners and losers and reduced equity. If there is a risk of this happening, conflicts should be managed by ensuring that losers are compensated.
- Impact on livelihoods: In order to be effective, the water policy must have an impact on the water demand of the water-using sectors and individual water users. While there is scope for many users to make more efficient and productive use of water, and thereby to reduce their overall demand, there is a risk that there will be negative impacts on some commercial operations and the livelihoods of some users. Attempts should be made to minimize impacts on poorer social groups.
- Non-compliance: There is a history of poor compliance with water-related regulations. Even a perfect water policy will fail if the resources and political will do not exist to enforce it.

OPTIONS AND OPPORTUNITIES

Table 15 lists 20 options and opportunities for improving water management.

TABLE 15
Options and opportunities for improving water management

Options/opportunities	Main components	Potential nature & scale of impact
Improved awareness of the characteristics and vulnerability of Malta's water resources and the potential consequences of different courses of action	Carefully targeted and structured awareness campaign for decision-makers at all levels Educational campaign in schools	Islandwide long-term impact on decision-making at all levels Higher levels of collective responsibility for the management of water resources
Improved access of all stakeholders to quality-controlled water-related information	Establishment and management of a common water-related information base including consensus building among stakeholders on the status of water resources	Islandwide long-term impact on decision-making all levels Improved stakeholder dialogue as using the same information as a basis for discussion
Improved policy-level water governance	Alignment of policies that have the potential to affect the supply of or demand for water resources Apolitical approach to long-term water resource planning Regulatory systems that have more independence from government	Islandwide impact at the policy level Policies that no longer promote groundwater use in excess of sustainable levels Emphasis on long-term planning
Improved strategic water governance	Alignment of planning processes that have the potential to affect the supply of or demand for water resources	Groundwater extraction will be reduced to and maintained at sustainable levels Introduction of EU WFD catchment-planning procedures
Establish water governance arrangements that facilitate greater involvement of stakeholders in water resources planning and management	Establish a stakeholder platform that includes representatives from all the main sectors and that holds regular meetings and consultations	Better involvement of stakeholders in decision-making processes Better ownership of plans, regulations, etc.
Immediate regulation of users of groundwater who are damaging the integrity of the sea-level aquifers	Identification of deep boreholes and/or boreholes from which there is a high rate of abstraction; fitting of meters and issuing of licences	Reduction in localized upconing of seawater into the sea-level aquifers Potential for slow recovery in the water quality of sea-level aquifers
Staged regulation of all groundwater users	Registration of all boreholes, issuing of licences, introduction of tariffs and other relevant demand-management instruments Costs of implementing the regulatory system are recovered	Reduction in groundwater use to sustainable levels Allocation of water to uses that have the highest social, environmental and economic value Promotion of efficient and beneficial use
Improved regulation of all activities that have the potential to pollute surface and groundwater resources	Identification of polluters and polluting activities Enforcement of polluter pays principle	Improvement in surface-water and groundwater quality
Establishment of a groundwater strategic reserve	Relaxing groundwater extraction for a period of time sufficient to allow a strategic groundwater reserve of acceptable quality to be established	This will reduce the risk of major disruption to the Maltese economy that might result from problems with RO production resulting from, say, a major pollution incident and shortage of energy for RO production
Pricing of TSE at an acceptable level, investment in infrastructure for better distribution of TSE and protection of aquifers from low-levels of pollution from TSE	Fixing the price of TSE at a level that will enable profitable production of high-value crops and profitable commercial use Construction of an appropriate reticulation system Use of precautionary principle when deciding on areas/aquifers to be supplied with TSE	Relaxation of the pressure on groundwater by providing groundwater users with a substitute TSE source Users of groundwater currently faced with deteriorating groundwater quality have the potential to stay in business
Increased water harvesting in urban areas. Also increased water harvesting in rural areas wherever there will not be negative downstream impacts	Increasing use of well-designed and well-constructed local solutions (including cisterns) for making better use of runoff particularly during years with good rainfall Provision of fiscal incentives where appropriate	Reduced pressure on groundwater Cost savings to users that substitute harvested rainwater for water supplied by the WSC

TABLE 15
Options and opportunities for improving water management (Continued)

Options/opportunities	Main components	Potential nature & scale of impact
Strict regulation of activities likely to increase the salinity levels of drainage water	Banning of hotel use of seawater in dual plumbing systems	This will improved the quality of sewage effluent and reduce treatment costs
	Banning of the dumping of brine from small RO plants in drainage systems	Leaks of sewage into aquifers will have a lower pollution risk
Regulating the sale of groundwater	Licensing and imposing a charge for tankers selling water	Reduced pressure on groundwater
		This will reduce the use of tankers as a means of avoiding regulation based on block tariffs
Long-term protection of aquatic ecosystems and rare habitats	Planning procedures that give a high priority to maintaining rare and important ecosystems	In addition to being the right policy, this will help Malta meet obligations under the EU WFD
Improvement in conveyance efficiency (i.e. leak reduction)	Continued efforts by WSC to reduce water lost in the form of leaks, illegal connections, etc.	Reduced pressure on groundwater
		Reduced risk of pollution
		Better and more economic service delivery
Improved water-use efficiency by agricultural users	Improved irrigation and cropping practices leading to a reduction in demand by individual farmers and the agriculture sector as a whole	Reduced pressure on groundwater
Increased recycling of water	Tariffs and incentives are used to encourage relevant industries to install the necessary equipment to recycle water	Reduction in pressure on groundwater and reduced risk of pollutants leaving the relevant industries
	Tariffs and incentives are used also to encourage household-level reuse of water	Reduced costs for users
Use of agro-environment funds aimed at protecting aquifers	Range of practices include funding set-aside strategies or a more permanent switch from irrigated agriculture to rainfed land uses	Reduced pressure on groundwater
		Improvements in biodiversity and in scenic and touristic value of islands
Hotels are encouraged to install RO plants to meet the demands of any increase in tourism	Tariffs and incentives are provided to hotels to install RO plants	Reduced pressure on groundwater and the supply infrastructure during the summer months
Sufficient resources allocated to enable water law to be implemented	Staff and equipment are in place so that a regulatory system can be operated effectively and efficiently	This is a precondition for the successful implementation of a regulatory system
	Confidence is built among stakeholders that an equitable and just approach is being taken to implementing the regulatory system	

Chapter 10
Water demand scenarios and possible water supply strategies

THE WATER MANAGEMENT VISION

Most national water policies would state that the primary goals of the policy are:

- safe and secure drinking-water supply for the population;
- reliable water supplies to support a sustainable economy;
- protection of the water-dependent environment.

This would certainly hold true for Malta, but Malta cannot afford a generic approach to water policy. If the country is to be serious about reversing trends and restoring the integrity of its natural resource systems to the point where the primary goals are likely to be met, it needs a much sharper, more focused vision of what is possible in the short to medium term. The first priority is to restore public water-supply aquifers and remove volatility in groundwater supply. The second is to maintain a strategic reserve and minimize social and economic risks to Malta's economy that are inherent in a water-supply policy based on imported energy. The third is to achieve "good" status linked to commitments to the EU.

In order to be effective in reversing current trends, that vision would have to set targets achievable by 2015 that at the very minimum comprise:

- levels of groundwater and surface-water use regulated according to sustainable abstraction levels;
- sea-level and perched aquifers restored to a status that represents a strategic reserve (a figure of the equivalent to 18 months of demand has been proposed);
- water quality of all aquifers restored to within permissible limits;
- widespread use of local and decentralized solutions (e.g. rainwater cisterns, grey-water recycling, and pollution control);
- high levels of collective responsibility at all levels for managing and protecting Malta's water resources.

Achieving this vision will call for a mix of economic and regulatory measures to be applied, some as a matter of urgency. This chapter discusses a set of water supply and demand scenarios that are based firmly on the analysis of current trends. At the same time, different strategies are considered for each scenario that have the potential to achieve the vision described above.

WATER DEMAND SCENARIOS

It is assumed that a combination of the options and opportunities listed in Chapter 9 will form the backbone of a new water policy. In this section, attention is given specifically to "demand" scenarios and the possible water supply strategies for each scenario.

Four "demand" scenarios have been selected on the basis of information presented in this report and discussions with key stakeholders. Table 16 presents the "demand" scenarios along with various "supply" strategies for each scenario. The logic is that each strategy will be analysed in full view of its potential to achieve the overall vision identified above. Table 16 also summarizes the potential socio-economic implications of each demand scenario and supply strategy.

TABLE 16
Demand scenarios and supply strategies

Water demand scenarios	Potential demand scenarios based on current trends	Water supply strategies	Strategies for meeting current and future demands (i.e. 2015)	Economic/social implications
I	Municipal demand* remains fairly constant at current values or increases at about 1–2%/year while agricultural demand increases reaching a maximum not exceeding 21 hm^3 as projected**.	I	Agriculture is given priority over the use of groundwater and, consequently, the urban supply is increasingly sourced from RO plants.	The WSC has to source its supply increasingly from RO plants, with resulting price increases on the urban sectors. The quality of the domestic supply will increase. However, the country will be fully dependent on RO plants for the production of potable water – leaving the country vulnerable to fluctuations in the energy sector, oil spills, etc. Significant price increases in the industrial and tourism sectors would be expected to reduce their economic competitivity.
		II	No action is taken and groundwater abstraction remains unregulated.	Overabstraction will result in an increase in the salinity of groundwater abstracted from the sea-level aquifers and in the drying-up of perched aquifers in the summer period. Degeneration in quality will make groundwater unsuitable for direct utilization, and extra treatment costs will be incurred by all sectors in the long-term as groundwater becomes progressively unusable for all sectors.
		III	A reduction in groundwater abstraction is implemented in order to achieve a sustainable abstraction strategy allowing the setting up of a strategic groundwater reserve. The available abstractable groundwater quota is then allocated on a 50/50 basis between the WSC and all other users. Options involving artificial recharge of groundwater and improved rainwater harvesting will also have to be implemented in order to augment groundwater availability. Agri-environment schemes and smart irrigation techniques are used to encourage low-water-using farming systems.	The WSC will have to reduce the proportion of abstracted groundwater; while agriculture and industry will have to substantially increase the amount of recycled water used. Tariffs for the domestic/ commercial sectors will be utilized to manage the sectoral demand. Agriculture will have to absorb a proportion of the cost of treating sewage effluent - possibly additional costs of desalination on the effluent treated to tertiary level. Groundwater will be viewed as a national strategic resource and a strategic reserve will be established in the long-term. Although there will be a potential negative impact on the livelihood of some agricultural users, these will be outweighed by the potential benefits to the economy as a whole. In the long term, better groundwater quality will result in decreasing treatment costs for all sectors.
II	Municipal demand remains fairly stable at current values or increases at about 1–2%/year while the agricultural demand decreases to pre-EU Accession levels (of 15 hm^3/year) driven mainly by market forces.	I	Agriculture is given priority over the use of groundwater with the potable supply being increasingly sourced from RO plants. Effluent from wastewater treatment plants viewed primarily as an option to supplement water supply to the agriculture/industrial sectors, thus, further reducing the pressures on groundwater.	The cost of the WSC supply will increase, in proportion to the increased dependence on RO water which will be required in order to maintain potable quality standards.

* Municipal demand refers to the domestic, industrial, commercial and tourism sector demand.
** The projected increase of 1 percent in urban demand is expected to be countered by a similar decrease in system demand (i.e. leakages) at least in the medium term. Therefore, for the period under consideration, the total WSC demand (inclusive of leakages) is projected to remain stable at 34 hm^3.

TABLE 16
Demand scenarios and supply strategies (Continued)

Water demand scenarios	Potential demand scenarios based on current trends	Water supply strategies	Strategies for meeting current and future demands (i.e. 2015)	Economic/social implications
III	Municipal demand decreases to about 27 hm^3 because of significant investment in local water conservation and reuse; while agricultural demand increases, reaching 21 hm^3 as projected.	I	Agriculture is given priority over the use of groundwater and, consequently, the urban supply is increasingly sourced from RO plants. Treated effluent is used in agriculture to address possible regional overexploitation of groundwater.	The WSC has to source its supply from RO plants with resulting unit price increases on the urban and economic sectors. Although the increased unit price of the supply will not be fully reflected in water bills owing to the smaller volumes consumed. The chemical quality of the domestic supply will also improve significantly. However, the country will be fully dependent on RO plants for the production of potable water. This strategy is the least dependent on groundwater.
		II	A cut-back in groundwater abstraction is implemented in order to achieve a sustainable abstraction strategy allowing the setting up of a strategic groundwater reserve. Available groundwater is then allocated between the WSC and all other users. Because of the projected decrease in treated effluent availability, the proportion of groundwater allotted to agriculture should exceed that allotted to the WSC. Options involving artificial recharge of groundwater and improved rainwater harvesting will also have to be implemented in order to augment groundwater availability.	Significant long-term savings will be made by the domestic/commercial sectors, while agriculture will have to absorb a proportion of the effluent treatment cost. A national strategic groundwater reserve is established.
IV	Municipal demand decreases because of significant investments in local water reuse, while agricultural demand decreases to pre-EU accession levels (of 15 hm^3), driven mainly by market forces.	I	A cut-back in groundwater abstraction is implemented in order to achieve a sustainable abstraction strategy allowing the setting up of a strategic groundwater reserve. Available groundwater is then allocated between the WSC and all other users.	The WSC will be in a position to decrease the amount of water produced from RO plants. Agriculture will have to absorb a proportion of the effluent treatment cost. Reduced abstraction of groundwater and eventual higher quality of domestic supply will reduce the salinity in the sewage, leading to lower effluent treatment costs in the long term.

* Municipal demand refers to the domestic, industrial, commercial and tourism sector demand.

** The projected increase of 1 percent in urban demand is expected to be countered by a similar decrease in system demand (i.e. leakages) at least in the medium term. Therefore, for the period under consideration, the total WSC demand (inclusive of leakages) is projected to remain stable at 34 hm^3.

Groundwater abstraction is currently about 32 hm^3. Water-balance data indicate that the sea-level aquifers are being overabstracted by about 5 hm^3 and the perched aquifers by 2 hm^3. Thus, the potentially abstractable groundwater from all the groundwater bodies in the Maltese Islands is about 25 hm^3. Any abstraction above this figure will lead to overabstraction with the consequential degrading in the quantitative and qualitative status of the groundwater bodies. Apart from harming the aquifer systems and limiting future uses of groundwater in Malta, this situation would also lead the country to be in violation of agreed EU environmental obligations. The re-establishment of the sea-level aquifers is estimated to require a further 10-percent cut-back in groundwater abstraction from these aquifers, thereby reducing the annual recommended abstraction volume to 23 hm^3.

The situation described above is an oversimplification of the way the aquifer systems in Malta function. Further in-depth management actions must be taken in order to distribute the abstractable volumes among the different aquifers, where the different geological and storage characteristics lead to a very diverse spectrum of groundwater availability. Furthermore, the calculations do not take into account any reduction in both natural recharge (arising from increased urbanization) and artificial recharge (resulting from the municipal supply leakage-reduction programmes). Thus, periodic adjustments to these calculations to reflect changing recharge patterns will have to be implemented.

The following sections present a detailed analysis of the demand scenarios presented in Table 16 and discuss the possible supply strategies required in order to meet the projected demand. The technical feasibility of each strategy is then analysed from a socio-environmental perspective in order to assess the possible implications of each strategy.

SCENARIO I

Scenario I considers a stable or slightly increasing urban/commercial demand accompanied by a significant increase in agricultural demand, which will be assumed to attain but not exceed the projected 21 hm^3 by 2010. It is expected that projected increasing urban demand will be dampened by the planned/expected reductions in the distribution system demand (leakages), thus contributing to an overall stable WSC production requirement of 34 hm^3.

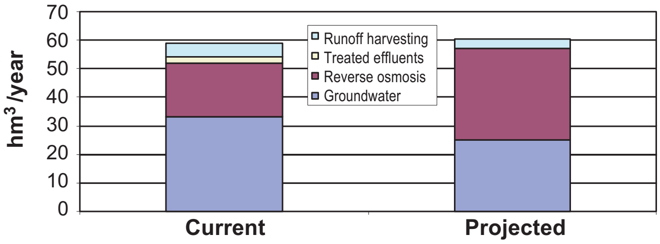
The first strategy considered (Figure 48) assumes that the agriculture/economic sectors will be given priority over the use of groundwater, subject to the provision that the global abstracted volume does not exceed recharge. The WSC will then be obliged to source its supply increasingly from RO plants as it reduces its abstraction quota in response to increases in agricultural demand. The quality of the potable water supplied by the WSC will increase as the RO product will not be blended with groundwater.

However, urban demand is expected to be quite close to the WSC's nominal RO production capacity (about 35 hm^3/year). This may require additional investment in RO facilities in order for the WSC to be in a position to operate effectively. Further constraints relate to the water supply situation on the island of Gozo, which currently depends almost exclusively on groundwater. As this strategy would almost certainly lead to an increase in the WSC's production costs, the unit price of water is likely to rise and be highly sensitive to fluctuations in the price of energy.

The demand of the agriculture and commercial sectors would in this case be catered for from the aquifers without the need for overabstraction. However, the demand is quite close to the calculated sustainable yield of the aquifer systems in the Maltese Islands. Agricultural demand would be managed primarily by introducing a licensing system, by water pricing, and by the use of macroeconomic instruments.

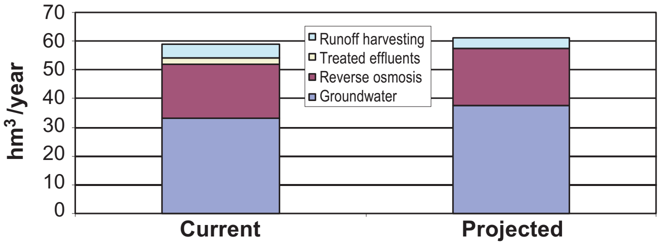
No further investments would be required in the management of sewage, which would be treated to secondary level and discharged to the sea. However, with the municipal supply increasingly dependent on RO water, the chloride levels in sewage would be expected to decrease considerably, thus reducing any treatment costs constraining reuse. Options relating to the reuse of treated effluent could also be considered in order to reduce the pressure on groundwater and possibly opening up the possibility of fulfilling the strategic obligation of augmenting groundwater storage through this option. The use of TSE is an option that gives greater flexibility to the strategy.

FIGURE 48
Redistribution of supply under Strategy 1 for Scenario I



This strategy can be seen to result in consumers having to meet increasing water bills in order to sustain the agriculture sector. Apart from that, given that energy costs constitute about two-thirds of the cost of producing desalinated water, this strategy would expose water users, taxpayers and the Maltese economy to potential further increases in energy costs. The country's water supply would also be more vulnerable to disasters such as oil spills or political crises that might interrupt energy supplies.

FIGURE 49
Redistribution of supply under Strategy 2 for Scenario I



The second strategy (Figure 49) assumes that no regulatory action is taken by the MRA to control groundwater abstraction. Under this strategy, no quotas/allotments will be set for any sector.

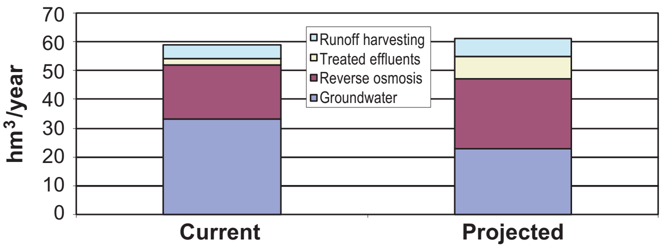
It is assumed that the WSC will keep its current groundwater abstraction levels at 15 hm^3/year, possibly reducing or further treating this volume as the quality deteriorates. The agriculture sector will also derive most of its demand from groundwater while no significant further investment would be made in the new sewage treatment plants in order to treat the effluent above the secondary level prescribed in EU legislation, making the effluent practically unusable for agriculture.

This supply strategy is heavily dependent on groundwater and would ultimately lead to the gradual deterioration in quality of the sea-level aquifers from overabstraction, making groundwater practically unusable for direct utilization by all sectors. The relatively smaller perched aquifers would be significantly threatened from a quantitative point of view, possibly even effectively drying up in the summer months.

In the long term, this strategy would lead to increased treatment costs to ensure the usability of groundwater, thereby resulting in higher costs for urban consumers and significant added costs to the agriculture and economic sectors, which would seriously threaten their competitivity. It would move away from harmonization with the environmental *acquis* of the EU.

The third strategy (Figure 50) considers a further cut-back of 10 percent in groundwater abstraction from the sea-level aquifers over and

FIGURE 50
Redistribution of supply under Strategy 3 for Scenario I



above WFD requirements as necessary in order to reduce seawater intrusion, restore the system, and establish a national groundwater reserve. Detailed monitoring would be needed to assess whether this cut-back is sufficient or excessive.

Information currently available indicates that a total reduction in groundwater abstraction of about 9 hm^3 from current values would be necessary for a "sustainable" situation to be reached. Thus, under this strategy, groundwater abstraction must not exceed 23 hm^3/year.

Therefore, the immediate question relates to the eventual distribution of these 23 hm^3 among the different demand sectors. The strategy here assumes a quasi-50/50 division of this potentially abstractable groundwater between the WSC and the private sector (including agriculture).

This would see the WSC being allotted an annual groundwater abstraction quota of about 11 hm^3. Then, all the other sectors would be left with an annual abstraction quota of about 12 hm^3, where these other sectors comprise agriculture (irrigation and animal husbandry), industry, tourism, commercial entities and private domestic usage. Currently, the water demand of these sectors from sources other than the public distribution network is estimated at 24 hm^3. Mainly owing to increases in the agriculture sector, this demand is estimated to reach as much as 27 hm^3 by 2010.

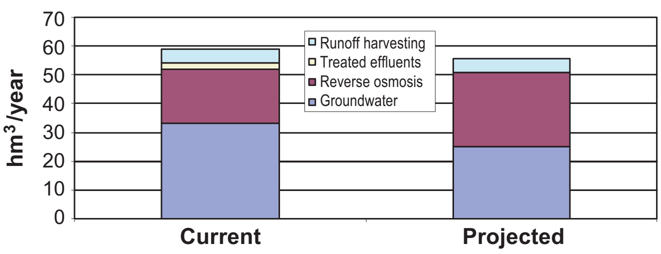
In order to replace groundwater abstraction, it is envisaged that increased investment would be required to harness alternative water sources such as the harvesting of rainwater runoff and the treatment of sewage effluent. This would introduce added costs on the sectors utilizing this water as it is expected that some form of cost recovery would be required for any treatment over and above the secondary treatment required by legislation. This measure would affect mostly the agriculture sector as it is the sector most dependent on groundwater and one that is not giving enough consideration to the cost of water in its production costs. Moreover, for this strategy to be feasible, the treated effluent produced would have to be made available to the agriculture/industrial sectors at the point of use.

SCENARIO II

Scenario II considers a stable or slightly increasing urban/commercial demand accompanied by a significant decrease in agricultural demand, which will be assumed to revert to pre-EU accession demand levels of about 15 hm^3, a change driven mainly by market forces.

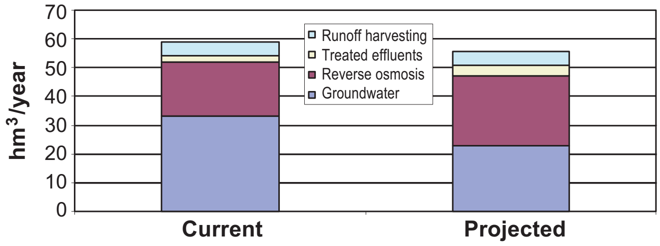
The first supply strategy analysed (Figure 51) proposes that agriculture should be given priority over the use of groundwater with the urban supply being increasingly sourced from RO plants. However, in this case, the decreased agricultural demand would enable the WSC to maintain a significant abstraction quota of groundwater. The price of water for urban consumers would thus be expected to rise reflecting the proportion of RO-produced water in the supply blend.

FIGURE 51
Redistribution of supply under Strategy 1 for Scenario II



Therefore, this strategy would require the full exploitation of the estimated abstractable annual groundwater yield (25 hm^3) in order to keep RO production low and, consequently, keep prices for urban consumers down as RO water costs more than groundwater to produce. There should be no added costs for the agriculture sector as the demand would be met from the groundwater supply. This strategy sees no use for treated effluent, and it considers groundwater

FIGURE 52
Redistribution of supply under Strategy 2 for Scenario II



as a more reliable and higher quality supply for the agriculture sector. Consequently, sewage would be treated only to secondary level and discharged to the sea. Treating sewage effluent could be considered as an option to tackle possible increases in agricultural demand or utilized in order to reduce the pressure on groundwater

The second supply strategy (Figure 52) is based on a further cut-back in the abstraction from the sea-level aquifers over and above WFD requirements in order to establish a national groundwater strategic reserve. In fact, a cut-back of 10 percent of the current abstraction from these aquifers is implemented in the calculations underlying this strategy. This cut-back was recommended by BRGM in 1990 as a measure for improving the status of the aquifers. The remaining abstractable groundwater resources (23 hm^3) would then be allotted almost equally between the WSC (the urban water service provider) and agriculture together with the other commercial sectors.

In this strategy, the WSC would have a fixed abstraction quota of 11 hm^3, with the remaining 12 hm^3 being reserved for the other sectors. Thus, the WSC would have to fill the gap between the demand and the abstraction quota from RO sources. As the agriculture sector has now a fixed quota of groundwater, the volume of which is smaller than its demand, increasing use would have to be made of alternative sources such as treated effluent and rainwater harvesting. In fact, the strategy envisages that sewage will be treated up to irrigable quality and supplied to farmers at the point of use.

Therefore, this strategy foresees the need for significant investments in effluent treatment, part of which would have to be borne by the sectors utilizing this water. However, by establishing a national groundwater reserve, the strategy aims at improving both the qualitative and the quantitative status of the aquifers. In the long term, this would result in reduced costs in treatment from which all users would be expected to benefit.

SCENARIO III

Scenario III considers a decrease in the urban/commercial demand fuelled by significant investments in local water conservation and reuse against a backdrop of increasing demand from the agriculture sector, which would reach the 21 hm^3 as projected in previous chapters.

This scenario suggests that local/household systems are introduced for the local recycling of grey-waters (water from baths, showers, washing machines, dishwashers, etc.) and its eventual reuse in lavatories and for the irrigation of gardens. Such a system has been adopted in Cyprus, where it is reported that more than 33 percent of household water was saved by such recycling initiatives. However, for the purpose of this study, a more conservative reduction of about 15 percent in WSC demand will be assumed to result from the introduction of such initiatives. This assumption takes into consideration that such initiatives will also be introduced in commercial concerns. Fiscal measures could also be considered in order to make these changes more cost-effective for the user. Another issue concerns urban/commercial rainwater harvesting. Here, the scenario assumes that the storage potential will be doubled, mainly because of increased eco-environmental awareness as well as through the enforcement of existing planning guidance and legislation. This would lead to a total reduction of 7 hm^3 from the WSC demand; which would thus decrease to about 27 hm^3.

FIGURE 53
Redistribution of supply under Strategy 1 for Scenario III

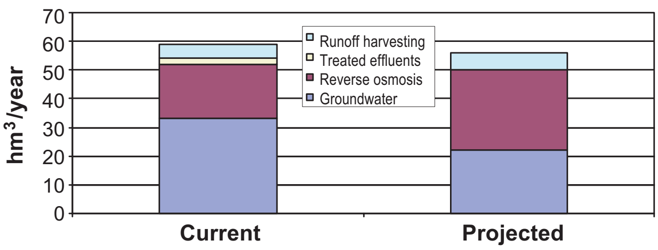
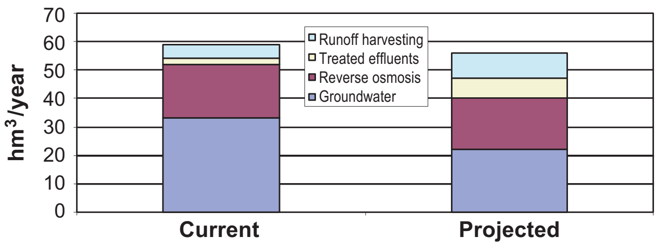


FIGURE 54
Redistribution of supply under Strategy 2 for Scenario III



The first supply strategy (Figure 53) for this scenario envisages that groundwater is written off as a source of potable water, with the agriculture and other economic sectors being given exclusive rights for its exploitation. The reduction in WSC demand would enable the corporation to meet all the urban/commercial demand from RO production (the WSC has a nominal RO production capacity of about 35 hm^3). This situation would also enable the WSC to reduce its operating costs significantly.

The total demand for groundwater with this strategy amounts to 22 hm^3, which is less than the estimated abstractable potential of groundwater in Malta. Thus, it fulfils the requirements for the establishment of a national reserve and the subsequent restoration of the aquifers. This strategy can be seen as taxing the urban consumers. These would have to construct water-treatment devices (which could be aided through the introduction of fiscal incentives) and at the same time meet higher water supply bills owing to the fact that the supply would be sourced exclusively from RO plants. However, the quality of the potable supply would increase considerably and the increase in the water supply bills would be dampened by the reduced consumption.

The second option (Figure 54) envisages strategically pre-fixing the abstractable quantity of groundwater at 23 hm^3 in order to restore the status of the aquifers and establish a national groundwater reserve. This quota is then subdivided almost equally between the WSC and the agriculture/economic sectors.

According to the estimates backing this strategy, the WSC would thus continue to blend RO and groundwater in the provision of the potable supply, the quality of which would be expected to increase in the long term as the groundwater status is restored. However, the quota allotted to the agriculture sector does not satisfy the projected sectoral demand. This would be achieved only through significant investment in sewage effluent treatment (the availability of which would be expected to decrease in response to the reduced urban consumption) and in rainwater-harvesting facilities. Investments in distribution facilities for the treated effluent produced would also be needed for this strategy to be implemented effectively.

SCENARIO IV

The fourth scenario maintains the decrease projections for the urban sectors and envisages a corresponding decrease in the demand of the agriculture sector to about 14 hm^3.

The strategy for this scenario (Figure 55) envisages that the abstractable groundwater quota is pre-set to 23 hm^3 in order to allow for the relaxing of the aquifers and the attainment of good status. This quota is then subdivided between the WSC and the agriculture/economic sectors. The WSC will supplement the abstracted groundwater (11 hm^3) with RO production (16 hm^3) in order to meet the urban demand (27 hm^3). No major changes in supply patterns are envisaged for sectors such as tourism and industry.

On the other hand, the agriculture sector would have to meet its demand by supplementing the abstracted groundwater (of which the sector would have a quota of 9 hm³) with other sources of water such as harvested rainwater runoff and treated effluent. Various options could be considered in order to meet this demand, which would involve striking a realistic cost-effective balance between the supply of treated effluent and the storage of runoff. As with similar strategies, it is envisaged that distribution facilities will be constructed so that the TSE produced will be supplied to farmers at the point of use.

FIGURE 55
Redistribution of supply under Strategy 1 for Scenario IV

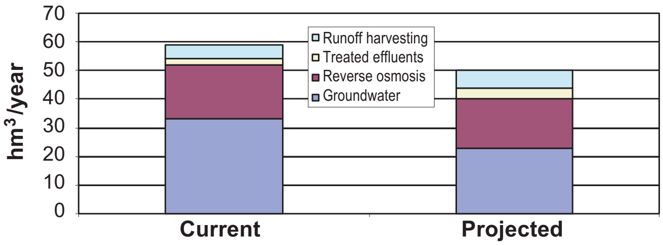
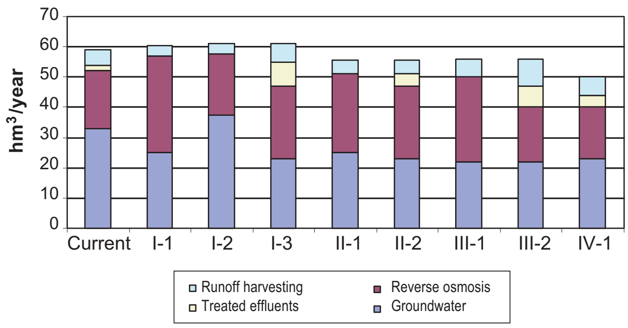


Figure 56 provides an overview of the results for each of the three scenarios and their respective strategies, and compares them with the current situation.

FIGURE 56
Comparison of redistribution of supply for all scenarios and strategies



SCENARIO ASSESSMENT AND STRATEGY IMPLEMENTATION

The above four scenarios cover the most probable limits of demand based on current trends and projections of the main water-using sectors. For each of the scenarios, there is one or more strategies for achieving the overall vision of the proposed water-policy. Table 17 presents the overall potential of each strategy for achieving this vision. However, each strategy will result in changes in Malta's water governance. Each strategy has a different level of risk associated with it and, as such, each strategy will have different impacts on users and the Maltese economy as a whole.

Thus, the implementation of each strategy will need clear political and economic decisions to be taken that will direct the country's socio-economic and environmental development in the coming years. These decisions cannot be postponed in favour of the

TABLE 17
Strategies with the potential to achieve all or part of the vision as stated in the water policy statement

Scenario		I			II		III	IV
Strategy	1	2	3	1	2	1	2	1
Levels of groundwater and surface-water use regulated according to sustainable abstraction levels	√	X	√	√	√	√	√	√
Sea-level and perched aquifers restored to a status that represents a strategic reserve equivalent to 18 months of demand	X	X	√	X	√	√	√	√
Water quality of all aquifers within permissible limits	X	X	√	X	√	√	√	√
Widespread use of local solutions (e.g. cisterns, pollution control)	X	X	√	X	√	√	√	√
High levels of collective responsibility (at all levels) for managing and protecting Malta's water resources	X	X	√	X	√	X	√	√
Potential to achieve all aspects of the vision	X	X	√	X	√	?	√	√

X - No
√ - Yes

"business as usual" demand scenario. The "business as usual" scenario is unacceptable because it is impossible to identify a supply strategy that is consistent with the vision (at least as described in this report).

The way in which these decisions are implemented and their impact on users will also depend on what happens to water demand as this is the main driving force behind each scenario. However, the overall strategic vision adopted will be reliant on the enactment of new legal provisions. It is anticipated that the new regulations to be introduced will require the inclusion of measures for:

- raising awareness of the poor condition of the sea-level aquifers and the potential consequences of continued mismanagement;
- the regulation of existing water users and sources in such a way that respects the hydrogeological integrity of the aquifers;
- the introduction and allocation of water supplies to users for purposes considered as beneficial to the economic development of the country;
- the recognition of sectoral priorities in groundwater use based on the social, economic and environmental benefits to be derived from such use;
- the introduction of cost-recovery mechanisms that take into consideration the environmental benefits derived from water using activities.

Chapter 11
Next steps

Malta's groundwater resources are poor and threatened by overexploitation and pollution. Reversing this trend requires a clear understanding of the situation that can guide policy decisions and help in setting up the necessary legal, institutional and implementation mechanisms. This report is an attempt to provide a clear picture of the situation and trends in Malta's water resources, and to identify the challenges that lie ahead. Time is of the essence. The process of putting policy into practice has to start as soon as possible if current trends are to be reversed and Malta's overall water-resource base brought to a position from which long-term sustainability can be assured.

The preparation and publication of this report are parts of the review and consultation process that were initiated in the framework of FAO's assistance to the MRA in the preparation of a comprehensive set of groundwater legislation. This report is the culmination of a round of collective and individual consultations with key stakeholders.

What is now needed is the vigorous support of all Maltese to promote a national water policy. A policy document has been prepared in parallel with this report in support of a national water policy consultation. Once endorsed by all stakeholders, it will serve as the basis for the development of a set of legal, institutional and operational instruments and programmes aiming at guaranteeing a sustainable supply of groundwater for the benefit of the Maltese community as a whole.

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Sustainable water resources are vital to Malta's long-term prosperity. Every sector of the economy depends on secure and sustainable access to water. A comprehensive review of Malta's water resources was carried out in 2004 by the Malta Resources Authority with the collaboration of the Food and Agriculture Organization of the United Nations. The Malta Water Resource Review is intended to provide a strong and objective factual knowledge base on the status of the islands' water resources and trends in water use. It is hoped that it will serve as a platform for discussion among stakeholders and contribute to the development of both a national water policy and a groundwater management strategy for Malta.