CONTENTS

TABLES

ANNEXES

LIST OF DRAWINGS

SOURCES (REFERENCES FOR THE BASIC MAPS)

EIA – D – 1	Base: British Maps. Produced by Military Survey, Ministry of Defence, U.K. 2000 Original Scale 1 : 50 000 Purchased by the Department of Town Planning and Housing
EIA – D – 2	As **EIA** –D – 1
EIA – D – 3	As **EIA** – D – 1
EIA – D – 4	Geological Map of Cyprus, compiled, designed and drawn by the geological survey department. Ministry of Agriculture, Natural Resources and the Environment, Cyprus 1995.
EIA – D – 5	As **EIA** – D – 4
EIA – D – 6	As **EIA** – D – 4
EIA – D – 7	Base as **EIA** – D – 1, Boundaries by SOGREAH CY
EIA – D – 8	Base as **EIA** – D – 1, Boundaries by SOGREAH CY
EIA – D – 9 (A)	Base as **EIA** – D – 1, Zones by SOGREAH CY
EIA – D – 9 (B)	Limassol Local Plan, Department of Town Planning and Housing
EIA – D – 9 (C)	Limassol Local Plan, Department of Town Planning and Housing
EIA – D – 10	Polis Chrysochous Local Plan, Department of Town Planning and Housing
EIA – D – 11	Satellite Images, SOGREAH CY

EXECUTIVE SUMMARY

As a member of the European Union, Cyprus must fulfill the EU requirements concerning the protection of the environment and therefore meet the obligations and requirements of Council Directive 91/271/EEC on urban wastewater treatment. The Directive concerns the collection, treatment and discharge of wastewater from sufficiently populated areas.

As a part of the "Implementation Programme of the Council Directive 91/271/EEC" and in the context of the Council Directive 91/271/EEC, a project was launched by the Water Development Department of the Ministry of Agriculture, Natural Resources and Environment to upgrade the sewage systems of communities with equivalent population of more than 2000, which are not already equipped with a centralised sewage collection and treatment system. The project includes 28 communities, which have been divided into 4 groups according to their district areas. This study concerns Limassol and Paphos communities of Group D. The Limassol Communities that are included in this Group are Ypsonas, Erimi, Episkopi, Kolossi and Trachoni: The only Paphos Community that is included in this Group is Polis Chrysochous.

PROJECT DESCRIPTION

The project includes the design and construction of the collection, conveyance and centralized treatment of the urban sewage effluents from the Limassol communities that are included in this Project, as well as from Polis Chrysochous. For this purpose, during the feasibility stage, a number of alternative schemes were evaluated based on technical, financial and environmental criteria and a final scheme was selected as the preferred alternative. This included the construction of one sewage treatment plant to the southeast of Episkopi, within the British Bases, for the connection of the communities of Episkopi, Erimi, Kolossi, Trachoni and Ypsonas. Polis Chrysochous was examined separately and will be served by its own Sewage Treatment Plant, which will be set to the east of the community and within the administrative boundaries of Pelathousa village.

Regarding the treatment process, the activated sludge process combined with tertiary treatment has been suggested. This is a proven and reliable process, which is currently in operation in three of the main treatment plants in Cyprus. Strict effluent quality standards will be applied for the design of the plant, which are a combination of the Cyprus and EU Standards for the quality of treated sewage waters. The main objective is the reuse of the treated water for irrigation purposes. For the long term storage of the treated effluents during the winter months, when the demand for water will be limited, a reservoir will be constructed at each plant site. Additionally, there will be a reservoir for the storage of untreated effluent in case of an emergency (e.g. an accident or a technical damage).

The main objective for the sludge that will be produced from the process is agricultural reuse, as a fertilizer. The selection of the treatment process will be based on this assumption. In addition, the main objective for the water that will be produced from the process is to be reused for the agricultural irrigation: Therefore, the selection of the treatment process will be based on this requirement as well. For this purpose, an independent study will be carried out by the Water Development Department.

IMPACT EVALUATION AND MITIGATION MEASURES

Following a description of the baseline environment of the area in which the two sewage treatment plants will be constructed, the environmental impacts that could result from the project have been identified and mitigation measures have been proposed to eliminate or minimize such impacts. Impacts have been examined in relation to project location and design, the project construction and operation phases and, in less detail, the reuse of treated sewage: The Water Development Department will carry out an independent study, which will analyze these impacts in detail; this study will list the possibilities of reuse, but will not analyze their impact.

The project impact and the mitigation measures are outlined in the table below: The expected impact is presented on the left column of the table below, whereas the proposed mitigation measures on the right. The table initially presents the impact connected to the project location, beginning with the sewage treatment plant of Episkopi and continuing with the Polis Chrysochous plant.

The environmental impact that could result from the project design and the mitigation measures proposed are presented in a subsequent stage. The impacts summarized in the table are generally expected to be similar for both treatment plants and therefore no distinction is made between the two. The same goes for the construction and operation stage of the two treatment plants. At the end of the table, a number of measures are presented concerning the reuse of the treated sewage for irrigation as well as the reuse of sludge as agricultural fertiliser.

ENVIRONMENTAL IMPACT AND MITIGATION MEASURES

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
IMPACTS RELATED TO PROJECT LOCATION	
Episkopi Sewage Treatment Plant	
Permanent Land Acquisition Permanent acquisition of private land for construction of the STP, the storage reservoirs and the pumping stations	Compensation for loss of land, agricultural trees and possible loss of income.
Impacts on Ecological Values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat (storage reservoir) and park in an otherwise degraded region.	No mitigation measures required.
Polis Chrysochous Sewage Treatment Plant	
Permanent Land Acquisition Permanent acquisition of private land for construction of the STP, the storage reservoirs and the pumping stations	Compensation for loss of land, agricultural trees and possible loss of income.
Impacts on Ecological Values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat (storage reservoir) and park in an otherwise degraded region.	No mitigation measures required.
IMPACTS RELATED TO PROJECT DESIGN	
No significant impacts are expected	➢ Treatment process is reliable and proven and effluent will meet the set performance

standards.

- Emergency storage will safeguard against problems in treatment process.
- Sludge treatment to be chosen will be effective in achieving required standards.

IMPACTS DURING THE CONSTRUCTION STAGE

Temporary Land Acquisition

Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.

- Compensation for the temporary use of land, loss of production, or inconvenience created.
- Design to minimize construction land requirements.
- Special obligation on contractor to minimize impacts on temporarily acquired agricultural land so that it can be put back to production quickly. Measures include the preservation of soil through profiling of the top and sub soil to the original level. Building material must be fenced and the land should be cleared after construction.
- Full rehabilitation of sites to be required form contractor.

Vegetation Clearing

Clearing of vegetation for construction of the sewage treatment plants, the emergency and the long term storage reservoirs, the pumping stations and the conveyance system.

- Compensation for the destruction of agriculture, particularly trees (permanent crops).
- Prior to construction a rapid survey of affected trees and vegetation should be carried out to clearly indicate the number of trees to be cleared.
- An equivalent number of trees and vegetation to be planted by contractor.

Soil Impacts

- Soil erosion: resulting from uncovered and unconsolidated materials during construction

- Strict clauses regarding earthworks management during construction to be imposed to the contractor.
- Careful design of construction operations, including the selection of haulage routes into the site and the location of stockpiles.
- Pipe construction should be divided into sub-sections, after excavating one section, backfilling it and clearing the area.
- Timely carry away discarded soil. The temporary deposits should be kept within barriers to prevent erosion.
- Avoid large scale excavations during rainfall or strong winds.
- Remove as little vegetation as possible during construction and revegetate bare areas as soon as possible after construction.
- Avoid creating large expanses of bare soil. If such expanses are created, then windbreaks may be required.

- Soil disaggregation

- Take the soil out in horizons and keep each horizon in a separate pile.

Soil compaction	- Use wide tires to spread the weight of vehicles. - Use a single or as few tracks as possible to bring vehicles to construction sites. - Until the area after compaction has taken place.

Dust, Fumes and Noise

- Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds.	- Frequent spraying of stockpiles and haulage roads with water. - Regular sweeping of access roads. - Covering of vehicles carrying materials. - Early planting of peripheral tree screens where they will be part of the development. - A system of monitoring site accesses and stockpiles should be implemented.
- Noise: from construction operations, machinery and vehicle movements.	- Use equipment with low noise outputs. - Where it is necessary for construction sites to operate at night, causing an impact on residents, it is required that noise reduction measures are taken so that reasonable noise levels are maintained. - Blasting and other operations with significant noise outputs should be restricted to certain hours of the day, while being prohibited at night. - A plan for the management of construction activities, to minimize noise impacts and ensure compliance with noise control measures to be imposed on contractor. - Construction operations must be carefully planned to minimize construction time.
Air Pollution: from car and truck traffic and from machinery.	- Plan routes to minimize vehicle movements as far as possible.
On-Site Safety	- Strict clauses imposed on contractor for the implementation of on-site health and safety measures and standards. - Regular maintenance of construction equipment, machinery and vehicles must be ensured. - Measures to ensure traffic security to be adopted. - Preparedness procedures in case of accidents and emergencies to be established.
Waste Management Construction waste, domestic solid waste.	- Contractors must make arrangements for the collection and transportation of domestic waste to official landfill sites. - The contractor must prepare a plan for the collection and appropriate disposal of construction waste and transportation plans must be made.

	- Transportation at peak hours must be avoided. - Spoil and wastes should be transported along specified routes and disposed of at designated sites. - Inspection should be carried out to ensure that the plans are properly implemented.
Pollution Air water and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.	- Strict clauses regarding the operation and maintenance of construction equipment to be imposed on contractor. - Regular monitoring of water and air quality near construction sites must be carried out. - Procedures must be taken for the containment of pollutants at storage sites. - Measures must be taken to avoid impacts from any accidental spillages; including the containment of storage tanks on concrete floors will walls to prevent the release of effluents on the soil. - Preparation and implementation of a management plan for the collection, storage and disposal of used oils and other pollutants.
Traffic As a result of increased vehicle movement and road excavations.	- The construction of the conveyance system should be phased and excavation, pipe laying and trench refilling should be completed as quickly as possible. - For busy roads, construction at peak hours should be avoided. - Spoil soils on roads under construction should be kept to a minimum so as not to affect local traffic. - Specific routing must be prepared for vehicles.
IMPACT DURING OPERATION	
Landscape Impacts Limited Impacts	Planting inside and outside of the site and preservation of the existing vegetation wherever possible.
Noise At STP sites and pumping stations. Impacts at STP sites are limited as they are at sufficient distance from residential areas; however, certain pumping stations are within urban areas.	- Enclose sources to insulate noise and incorporate specific acoustic features in the design of buildings. - Use low noise equipment. - Application of noise control equipment where necessary. - Use of noise screens, including tree plantings. - The noisiest sources should be monitored four times a year and noise measurements should be carried out near the plant and pumping stations two times a year during the day and night.
Odours	- Implement and observe the appropriate treatment procedures. - Cover the treatment areas and provide for sufficient air filtration. - Regularly observe the procedures and carry out all applicable chemical and biochemical

	analysis. - Regular unit and pump station maintenance - Use odour control systems at the designing of the treatment plants. - Design a suitable transportation system in order to avoid the creation of sulphur combinations.
Impacts on Groundwater Resources Positive impact: reduction in groundwater pumping because of the reuse of effluent, and reduction in nitrates released in the environment	No measures required.
Impacts from Sludge Production and Reuse	- Choice of treatment process to meet standards for reuse in agriculture. - Correct soil application methods according to the Code for the Use of Sewage Sludge in Agriculture. - Monitoring of sludge and soil quality in accordance with the Code.
Risk of System Overload Minimum risk: emergency storage available, design includes seasonal variations	No additional measures required.
Risk of Insufficient Treatment of Effluents	- Regular monitoring of effluent quality
Reuse of Treated Effluent for Irrigation	- Regular monitoring of effluent quality according to the Code of Practice for the Use of Treated Effluent for Irrigation. - Choice of irrigation methods according to the Code. - Crop selection to avoid adverse impacts on crop yields.
Urban Reuse of Treated Effluent	- Regular monitoring of effluent quality. - Labeling of pipes and use of signs in areas irrigated with treated effluent. - Choice of irrigation methods according to the Code of Practice.
Groundwater Recharge	- Monitoring of effluent and groundwater quality to avoid risk of aquifer pollution.

MITIGATION MEASURES FOR THE REUSE OF SLUDGE FOR AGRICULTURAL PURPOSES

Misuse of the agricultural value of sludge
Leaching of nitrates to groundwater

- Better knowledge of sludge content in terms of compounds of agricultural value
  - Adequate sampling procedures (frequency, number of samples, etc.)
  - Adequate analysis protocols
- Improve use of sludge agricultural value
  - Determination of the sludge agricultural value (N, P, K, content)
  - Planning and application adapted according to:
    - Plant needs
    - Other fertiliser sources
    - N remaining in the soil
    - Nutrient bioavailability
    - Adequate spreading periods according to agricultural and environmental constraints
  - Regular soil analyses to establish increase in nutrient content
  - Information from farmers about quantities spread

Soil contamination by heavy metals and organic pollutants

Determination of background levels in soil

Determination of pollutant content in sludge
Safe storage of sludge
- ❑ Safe storage to reduce leaching
- ❑ Sufficient storage capacity
- ❑ Reduction of storage duration in the field

Water contamination by heavy metals and organic contaminants

- ⇩ Forbid sludge spreading in sensitive areas, especially:
  - ❑ On sloping land
  - ❑ Near surface water
  - ❑ On wet areas
  - ❑ Within water resource protection areas
  - ❑ On sandy soils
  - ❑ On frozen grounds
  - ❑ In areas where the water table is near the surface
- ⇩ Encourage fast ploughing down in order to reduce the risk of runoff and the use of close-to-ground techniques in order to reduce the formation of aerosols
- ⇩ Safe storage of sludge

Crop contamination by heavy metals and organic pollutants

- ⇩ Reduce transfer in the food chain
  - ❑ Encourage sludge spreading before non-food crops
- ⇩ Limit plant uptake
  - ❑ Adapt sludge spreading to soil types (mainly according to pH and CEC)
  - ❑ Take into consideration heavy metal bioavailability in soil
  - ❑ Define a crop/sludge type matrix with specific recommendations
  - ❑ Prohibit sludge spreading on plant/crops which are known to accumulate heavy metals
- ⇩ Limit deposition on plant
  - ❑ Limit use of sludge on vegetable and certain fruit productions
- ⇩ Analyses of the metal level in crops and foodstuff

Animal contamination by heavy metals and organic pollutants

- ⇩ Limit pollutant transfer to animals
  - ❑ Tighten limits concerning quantity and quality of sludge which may be applied
  - ❑ Grazing land:
    - ⇨ Introduce a time period before harvesting
    - ⇨ Favor sludge ploughing down
  - ❑ Grassland:
    - ⇨ Allow spreading before sowing and after each cut
- ⇩ Control of the metal levels in foodstuff
  - ❑ Analysis of the pollutant levels in animal products

Human contamination

- ⇩ Limit pollutant transfer in the food chain
- ⇩ Protection of operating equipment
  - ❑ Ensure safe manipulation of sludge
  - ❑ Material cleaning and maintenance
  - ❑ Protective clothes

Contamination by pathogens

- ⇩ Animal contamination:
  - ❑ Grazing land: introduce a time period before grazing
  - ❑ Grassland: allow spreading before sowing and after each cut
  - ❑ Encourage fast ploughing down of sludge
- ⇩ Human contamination:
  - ❑ Prohibition of sludge spreading on products which are to be consumed raw
  - ❑ Safe transportation of sludge
  - ❑ Prohibition of sludge spreading in the vicinity of houses and near bathing water and drinking water supply areas

MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENTS FOR IRRIGATION PURPOSES

❑ Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality

- ⇨ Drafting of Reuse Management Plan, incorporating:

- ❑ Appropriate site identification
- ❑ Crop water requirements
- ❑ Crop selection
- ❑ Irrigation methods and scheduling
- ❑ Evaluation of nutrient and salt loading rates

❑ Nitrogen leaching to groundwater, accumulation in soil
- ⇨ Balance nitrogen loading rates with crop requirements.

❑ Phosphorous leaching to groundwater, accumulation in soil
- ⇨ Balance phosphorous loading rates with crop requirements

❑ Adverse impacts on soil productivity and risk of groundwater contamination
- ⇨ Determine salt loading rates
- ⇨ Ensure irrigation practices do not result in off-site run-off, appropriate leaching and drainage provisions

❑ Adverse impacts on crop yields and quality
- ⇨ Crop selection based on crop sensitivity to treated effluent constituents

❑ Adverse impacts on health
- ⇨ Timing of irrigation prior to harvesting
- ⇨ Correct irrigation practices
- ⇨ Minimize site access during irrigation periods
- ⇨ Use of signs specifying that treated effluent is used
- ⇨ Establishment of buffer zones around irrigated areas where necessary

❑ Quality considerations
- ⇨ Implement treated effluent quality monitoring programme to ensure compliance with the set standards
- ⇨ Implement soil quality monitoring programme
- ⇨ Monitoring of application rates of heavy metals, nutrients and slats.
- ⇨ Monitoring of irrigation methods and practices

ENVIRONMENTAL MANAGEMENT PROGRAM

An Environmental Management Program has been prepared outlining a set of mitigation measures and monitoring programmes, in relation to the project construction and operation, with the purpose of avoiding and controlling any adverse environmental impacts that might arise. As a result, many of the impacts that have been identified will be effectively mitigated limiting the projects resulting effect on the environment.

1. INTRODUCTION

As a member of the European Union, Cyprus must fulfill the EU requirements concerning the protection of the environment and therefore meet the obligations and requirements of Council Directive 91/271/EEC on the collection, treatment and discharge of wastewater from sufficiently populated areas.

The Water Development Department of the Ministry of Agriculture, Natural Resources and the Environment has elaborated an "Implementation Programme of the Council Directive 91/271/EEC" (a full compliance programme including projects' timetables and costs). The programme covers 32 communities of more than 2,000 population equivalent (p.e.), 4 greater urban areas (Nicosia, Larnaca, Limassol and Paphos) and 2 major summer resorts. It covers development in collection networks and treatment plants including technical studies, designs, tendering, construction and supervision. The financial needs of the Programme will be met through commercial loans guaranteed by the Government, which subsidizes part of the cost. The implementation of the Programme will assure conformity with the Directive's requirements in the year 2012. This implementation Programme has been submitted to the European Commission and derogation for Cyprus has been granted up to 2012.

As a part of the Programme, and in the context of the Council Directive 91/271/EEC, a project was launched by the Water Development Department of the Ministry of Agriculture, Natural Resources and Environment to upgrade the sewage systems of communities with equivalent population of more than 2000 which are not already equipped with a centralised collection and treatment system.
The number of these communities is 28. They have been split in 4 groups. These groups, which are related to district areas, are as follows:

- **Group A: Nicosia district**: Peristerona, Astromeritis, Palaiometocho, Kokkinotrimithia, Akaki and Lympia
- **Group B: Larnaca district**: Aradippou, Kiti, Perivolia, Dromolaxia/Meneou, Livadia and Athienou
- **Group C: Famagusta district**: Xylotymvou, Achna, Ormideia, Avgorou, Xylofagou, Agios Georgios Acheritou, Liopetri, Frenaros, Sotira and Deryneia
- **Group D: Limassol and Paphos districts**: Ypsonas, Kolossi, Episkopi, Trachoni, Erimi and Polis Chrysochous.

1.1. CONTRACT FOR ENGINEERING SERVICES

A contract for engineering services EuropeAid/113561/D/SV/CY was signed with the consortium SOGREAH, France and A.F.Modinos & S.A. Vrahimis, Cyprus.

The specific objective of engineering assignment is to provide technical and detailed studies for collection networks and appropriate treatment for the sewage system upgrading of the above mentioned communities.

The engineering services are composed of the following stages:

- Inception stage,
- Technical studies (feasibility studies, financial studies, EIA)
- Detailed studies.

1.2. PURPOSE OF STUDY

The purpose of the Environmental Impact Assessment Study for the Limassol district and the Polis Chrysochous Group is to evaluate the environmental impacts that will result from the proposed project and to propose mitigation measures and monitoring requirements through the Environmental Management Programme that has been drafted.

This study is only suggestively referring to the reuse of treated water for irrigation, as well as the reuse of sludge in agriculture based on information taken from complete studies on this issue.

2. INSTITUTIONAL FRAMEWORK FOR EIA

2.1. ENVIRONMENTAL ORGANISATION IN CYPRUS

2.1.1. CENTRAL GOVERNMENT LEVEL

In Cyprus, environmental policy is coordinated through the **Minister of Agriculture, Natural Resources and Environment (MANRE)**, although responsibilities for town and country planning issues rest with the **Minister of the Interior** and for air pollution control/air quality with the **Minister of Labor and Social Security**.

The **Council for the Protection of the Environment** which is an advisory body, chaired by MANRE, advises the Council of Ministers on issues, legislation and policy relating to the environment and sustainable development.

The **Environment Committee** chaired by the Permanent Secretary of MANRE and constituted of representatives from all the ministries and government services involved in environmental issues, is another authority. The Committee deals with the formulation and determination of the environmental policy objectives and assists in their co-ordination and implementation.

There are also two **Technical Committees** dealing with environmental issues, one responsible for evaluating the Environmental Impact Assessment (EIA) studies and the other for reviewing the Licensing of Discharges and the Registration of Processes under the laws for the Protection of Water and the Protection of Air. The Environment Committee and the Technical Committees are the main formal bodies through which the Government agencies communicate with each other, and through which inter-departmental issues are addressed.

The key Ministries and Agencies involved in Environmental Management in Cyprus are the following:

The **Ministry of Agriculture, Natural Resources and Environment (MANRE)** has prime responsibility for many different aspects of the environment. These responsibilities are distributed among the Environment Service and seven separate Departments.

The **Environment Service** is the coordinating agency for Government programmes for the protection of the environment. It heads the Technical Committee on the Environmental Impact Assessment (TCEIA) of projects, advises on environmental policy and is mandated to ensure the implementation of the environmental policy. Among its responsibilities, the ES is in charge of the co-ordination of the adoption of the EU environmental acquis in co-operation with the Planning Bureau of the Ministry of Finance. The **ES** is also in charge of the TCEIA (which responsibility is to review EIA studies for environmental clearance), and is responsible for the enforcement of the Law on the Control of Water Pollution, for the promotion of environmental awareness and training, and for the provision of support to the Environment Committee and the Council for the Environment. The **ES** acts as the National Focal Point for a wide range of international agreements, conventions and organisations related to biodiversity and environmental protection.

The **Water Development Department (WDD)** is the largest single department of MANRE, reflecting the critical importance of water resources in Cyprus. It is responsible for most aspects of the implementation of water policy and the management of water resources (supply and use). This includes hydrological and hydrogeological water resources, the planning, design, construction and operation of water supply infrastructure, sewerage and wastewater treatment (outside the major urban areas) and the monitoring of water resources quality and quantity.

The **Department of Agriculture (DoA)** is the second largest department of MANRE, after WDD. Aside from responsibilities in the general agricultural development sector, the DoA is particularly responsible for those components as wastewater reuse and utilisation of STP sludge for agricultural production.

The **Department of Forests (DoF)** of MANRE is responsible for the management and exploitation of state forests (which account for 19% of the area of Cyprus), including environmental aspects, and can declare nature reserves and national forest parks within those forests.

The **Ministry of Interior (MoI)** is responsible for town and country planning, including related environmental issues. The Department of Town Planning and Housing (DTPH) of the MoI is not only responsible for policy and legislation in this area but also acts as planning authority outside the four major conurbations of Nicosia, Larnaca, Limassol, and Paphos. It is responsible for imposing environmental conditions (based on recommendations of the ES and the EIA Technical Committee) through the planning permit, and participates in the EIA Technical Committee.

The **Ministry of Health (MoH)** also has an important role in relation to the environment in general and health impacts in particular. The State General Laboratory (SGL) of the MoH is the main government laboratory in Cyprus.

The **Public Health Service (PHS)** of the MoH has a large inspectorate and is responsible primarily for the monitoring of drinking water quality but also other environment-related aspects of public health. This includes the monitoring of groundwater quality (where this is used for drinking water), public health aspects of waste management (including, with ES and WDD, landfill site inspection), seawater quality (bathing beaches) and swimming pools.

2.1.2. LOCAL LEVEL

A total of 24 Municipalities cover the major conurbations and larger towns in Cyprus, with a further 9 in the area occupied by Turkey. Populations range from almost 90,000 (Limassol) to less than 1,000 (Lefkara), although the average is around 16,500. Nicosia is covered by seven different Municipalities representing a total population of some 170,000. The Municipalities are represented by the Union of Cyprus Municipalities.

Under the Municipalities Law, the Municipalities are nominally responsible for water supply, sewerage and wastewater treatment, rainwater drainage, street cleaning, refuse collection and disposal and the protection of the natural environment.

The major Municipalities (greater Nicosia, Limassol, Larnaca and Paphos) are also Town Planning Authorities, responsible for issuing permits for the construction and operation of new developments in their areas. The major Municipalities discharge their responsibilities for wastewater collection, treatment and disposal through Municipal Sewage Boards (MSBs), which are established as separate entities but linked to the Municipalities. The Municipalities also work together where appropriate (particularly in Nicosia) on joint projects, for example sewage treatment works and waste disposal sites.

In addition to these Municipalities, there are 352 Communities in the rural areas of Cyprus. These cover only about 40% of the population but 80% of the land area. The average population served by a Community is only around 750 and many are much smaller than this. They are represented by the Union of Cyprus Communities, and have a more limited role in relation to environmental issues. Like the Municipalities, the Communities also work together where appropriate.

In practice, neither the Municipalities nor the Communities have the financial resources or the staff to discharge their environmental responsibilities effectively. It follows that responsibility for infrastructure investment required by the local authorities generally falls to central government, as for example the Water Development Department of MANRE.

2.1.3. NON GOVERNMENTAL ORGANISATIONS

There are more than 30 purely environmental or environmentally-concerned NGOs in Cyprus, and their involvement in environmental policy formulation is actively encouraged. Under law 57(1) on EIA, the Federation of Environmental and Ecological Organizations participates as a member in the TCEIA.

Several NGOs are members of the Council for the Environment and of steering committees for protected areas. They are also invited to express their views during hearings at the Parliamentary Environment Committee. The awareness-raising activities of NGOs are supported by financial assistance from Government for specific actions.

2.2. CYPRUS NATIONAL LAW 57(I)/2001 ON EIA

2.2.1. OBLIGATION FOR EIA STUDY

According to Cyprus Law 57(1) of 2001, STPs with a capacity above 2,000 population equivalent are subject to full EIA study. This level is extremely low when compared to the same requirement of EU Directive 97/11/EC which is 150,000 equivalent-population, but understandable when considering the limited size and population of Cyprus. The Law, however, does not mention any environmental requirements specific to the construction of sewer networks.

What will be considered for the present EIA study is:

- Full EIA will be carried out for all the STPs proposed, as all the projects will serve more than 2,000 people each.
- For groups of villages to be connected to an existing STP, Preliminary Environmental Impact Assessment (PEIR) will be carried out, complemented by an Environmental Management Plan (EMP) focusing on mitigation and monitoring measures during the construction stage.
- In the Proposal of the Consultant, it was anticipated to carry out one EIA study for each group (cluster) of villages, or 4 EIAs. It is obvious that the splitting of some initial groups into two different systems will complicate the task. According to the Environment Service of MANRE, in such situation, one EIA report may still be maintained, considering that a two facilities scheme is the preferred alternative.

2.2.2. CYPRUS NATIONAL LAW 57(I)/2002 ON EIA

A significant part of the harmonization procedure of Cyprus with the EU 'acquis' has been the adoption of the Law for the Assessment of the Environmental Impacts from Certain Projects (No. 57(I)/2001, Gazette No. 3488 of April 12th, 2001), which is now fully implemented, with responsibilities resting primarily with the Environmental Service. The Law deals with the environmental impacts from projects and activities, and aims at minimizing these impacts taking into consideration the environmental parameters before the issuing of a permit for the execution of the project. The Law is based on the EU Directive 85/337/EEC, as amended by Directive 97/11/EEC. It has replaced the system of assessing the impacts to the environment that was applied based on a Council of Ministers Decision (No. 35/700, dated 20/6/1991).

According to this Law, the granting of a permit or approval for a project, including public projects, that may have significant environmental impacts, should be done only after assessing its potential impacts on the environment. This applies for every project that falls in the project categories of Annex I or II of the Law. The projects, which are included under Annex I are those that could potentially result in significant adverse impacts on the environment and must go through a full assessment of their impacts. Annex II projects do not necessarily and in all occasions have significant environmental impacts, and for this they are subject to a Preliminary Environmental Impact Report (PEIR). Following evaluation of the PEIR, it is decided whether a full environmental assessment is required. Therefore, when an application is submitted for a planning permit or project approval, an EIA must be submitted for Annex I projects, or a PEIR for Annex II projects. With regards to sewage treatment plants, those with a capacity above 2 000 population-equivalent are included in Annex I and are thus subject to a full EIA. (Articles 9 and 10, Law 57(I)/2001).

The EIA must contain the information specified in Annex III of the Law. It must identify, describe and evaluate the direct and indirect impacts likely to result from the project on a number of factors, including human beings; flora and fauna; the natural, as well as the historic and traditional man-made landscape; water, air and climate, and soils; material assets; the financial and social aspects and the architectural, cultural and archaeological heritage. (Article 12, Law 57(I)/2001)

Following the submission of the EIA, the developer (public or private authority) must publicize a Notification in two local daily newspapers announcing the submission of the EIA, the project and the area where it will be executed and the place where the study can be inspected. Any person can submit opinions or representations regarding the scope of the EIA or the possible environmental impacts of the project to the Environmental Authority (which is the Director of the Environment Service) within 30 days from the publication of the notification. (Article 20, Law 57(I)/2001)

The EIA is evaluated by the Environmental Authority who is advised by a permanent Committee (Committee for the Assessment of Environmental Impacts). This comprises representatives of all key Ministries and Departments related to the environment, as well as representatives of civil society. The Committee must take into consideration any justified opinions or representations made by any persons, organisation or authorities. It then makes recommendations to the Environmental Authority, which delivers a justified opinion to the planning authority proposing measures to be imposed with the permit or even that the project is not executed. (Article 13, Law 57(I)/2001). In issuing the permit, the opinion of the environmental authority must be taken into account as a fundamental factor in the decision-making. (Article 4, Law 57(I)/2001)

2.3. OTHER NATIONAL LAWS

A study financed by the European Investment Bank has been prepared, considering the options available (including for agricultural purposes) for the re-use of such sludge from the various treatment plants. The study indicates that the sludge produced could find use in agriculture and as an alternative low cost fuel in cement factories. A Code of Good Agricultural Practice (Use of

Sewage Sludge in Agriculture), used as a guide for the discharge consent terms, has been completed and adopted in the beginning of 2002, under the Water Pollution Control Law.

The Quality of Water Intended for Human Consumption Law was enacted in May 2001 (Law No.87 (I) 2001), which fully covers requirements to safeguard drinking water quality

The Law 106(I)/2002, "On controlling water and soil pollution" deals with the general protection of the water and the soil and includes particular provisions for a complete pollution control and prevention and describes the implementation procedures of the various provisions. The Law 13(I)/2004"On Water protection and management" deals with the surface and underground water condition, monitoring and safeguard.

2.4. EU ENVIRONMENTAL DIRECTIVES

2.4.1. EU DIRECTIVE 97/11/EC ON EIA

EIA is a procedure required under the terms of European Union Directive 85/337/EEC amended by **EU Directive 97/11/EC** on assessment of the effects of certain public and private projects on the environment. Article 2 of the Directives requires that *"Member States shall adopt all measures necessary to ensure that, before consent is given, projects likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location are made subject to a requirement for development consent and an assessment with regard to their effects."* Article 8 then requires that *"The results of consultations and information gathered pursuant to* [the EIA procedure] *must be taken into consideration in the development consent procedure"*. These requirements are elaborated further in the Directive and in the EIA system introduced in Cyprus (Law 57(1) of 2001).

The environmental information that developers are required to provide under the EIA procedure is defined in Article 5(3) and Annex IV of Directive 97/11/EC. Article 5(3) requires that the information must include "*at least*

- *A description of the project comprising information on the site, design and size,*
- *A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects,*
- *The data required to identify and assess the main effects which the project is likely to have on the environment,*
- *An outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects,*
- *A non technical summary of the information mentioned in the previous indents*".
- Article 5(1) provides that the developers must supply the information in Annex IV "*in an appropriate form (…) in so much as:*
- *The Member State considers that the information is relevant to a given stage of the consent procedure and to the specific characteristics of a particular project or type of project and of the environmental features likely to be affected;*
- *The Member State considers that a developer may reasonably be required to compile this information having regard to current knowledge and methods of assessment*."

In most Member States, as in Cyprus, the information is provided in the form of an Environmental Impact Statement or EIS.

2.4.2. OTHER EU DIRECTIVES

Council Directive 91/271/EEC of 21May 1991 on urban wastewater treatment;

Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture;

Birds Directive 79/409/EEC: This Directive was implemented in April 1981 and imposes strict legal obligations on European Union Member States to maintain populations of naturally occurring wild birds at levels corresponding to ecological requirements, to regulate trade in birds, to limit hunting to species able to sustain exploitation, and to prohibit certain methods of capture and killing. Article 1 applies to the conservation of birds and to their eggs, nests and habitats. Article 4 requires Member States to take special measures to conserve the habitat of certain listed threatened species through the designation of **Special Protection Areas** (SPAs).

Habitats Directive 92/43/EEC (Directive on the Conservation of Natural and Semi-natural Habitats and of Wild Fauna and Flora) aims to conserve fauna, flora and natural habitats of EU importance. The fundamental purpose of this directive is to establish a network of protected areas throughout the Community designed to maintain both the distribution and the abundance of threatened species and habitats, both terrestrial and marine. The network of **Special Areas of Conservation** (SAC) is called **Natura 2000**, and will include SPAs of the Birds Directive. Criteria for selection include priority habitats and species, as identified in its Annexes.

Under the Habitats Directive, **Natura 2000** is defined in Article 3(1) as a coherent European ecological network of special areas of conservation. This network, composed of sites hosting the natural habitat types listed in Annex I and habitats of species listed in Annex II, would enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range.

Based on the Bird and Habitat Directives, the network sets the minimum standard for biodiversity conservation in the Member States, encompassing a wide range of issues and containing a number of concrete obligations. This concept is strengthened by the Maastricht Treaty, according to which all Community policies and instruments must comply with the Community's environmental statutes, including the Habitats and Birds Directives.

In Cyprus, 38 Natura 2000 sites have already been proposed.

2.5. INTERNATIONAL AGREEMENTS AND CONVENTIONS

Several international conventions for the protection of the environment have also been ratified such as the Convention for the Conservation of the European Wildlife and Natural Habitats, the Convention on Biological Diversity, the Convention on the International Trade of Endangered Species (C.I.T.E.S.), the Convention for the Protection of the Mediterranean Sea Against Pollution and its four Protocols (MARPOL), the Global Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, the Vienna Convention and the Montreal Protocol on the Protection of the Ozone Layer, the Climate Change Convention, the Convention for Migratory Species, the Convention on EIA in a Transboundary Context, the Convention to Combat Desertification, and the Convention on Wetlands of International Importance (RAMSAR).

3. PROJECT DESCRIPTION

3.1. PROJECT JUSTIFICATION

. The Directive 91/271/EEC that Cyprus must fulfill on urban wastewater treatment concerns the collection, treatment and discharge of wastewater, including biodegradable industrial wastewater discharges, from sufficiently populated areas. It sets deadlines until 31 December 2005, to provide for collection systems and at least for secondary treatment for communities of different levels of populations, ranging from 2 000 population equivalent (p.e.) to more than 100 000 p.e. More advanced tertiary treatment is required for sensitive areas, including communities of less than 2 000 p.e. It also requires prior regulations and authorizations for all discharges of wastewater into the environment, for industrial discharges into urban wastewater systems and for the disposal of sewage sludge from biological treatment plants.

The current project involves the design of sewerage systems for the communities of the Limassol and Paphos areas (Group D), which include Episkopi, Ypsonas, Kolossi, Trachoni, Erimi and Polis Chrysochous. The sewage systems will consist of the collection and conveyance systems, and the central sewage treatment plants. For this purpose, during the feasibility study stage, a number of alternative schemes were evaluated, in connection with possible alternative sites for the construction of the sewage treatment plants, based on technical, financial and environmental criteria and a final scheme was selected as the preferred alternative. This includes the construction of a sewage treatment plant to the southeast of Episkopi, which will serve the communities of the Limassol district. Polis Chrysochous was studied separately because of its distance from the other communities and will be served by its own treatment plant, which, according to the chosen plan, will be constructed to the east – northeast of the community, within the administrative boundaries of Pelathousa village.

In this chapter, the project is presented giving information on the location of the plants and the features of the project. Both Treatment Units are expected to use the activated sludge process, which will be presented further on (3.3.2.4). In addition, a description of the sludge treatment and odour controlling is given. These descriptions refer to both treatment units that have been proposed for construction. The only information given separately is information on the efficiency and the various numbers (concerning the sewage treatment plant, the storage tanks etc) of the two plants.

3.2. PROJECT LOCATION

The proposed location for the construction of the sewage treatment plant which will service the communities of Episkopi, Ypsonas, Kolossi, Trachoni and Erimi, including the emergency and long term storage reservoirs, is presented in Drawing EIA – D – 1 (together with the alternative locations that will be presented further on in this study) The site is within the administrative boundaries of Episkopi, but still within the British Bases, at a distance of approximately 1.5 km away from the limit of the urban zone to the southeast of the community: This is an agricultural area.

The proposed location fort he construction of the sewage treatment plant which will service Polis Chrysochous is presented in Drawing EIA – D – 2 (together with the alternative location that will be presented further on in this study). The site is within the administrative boundaries of Pelathousa village, at a distance of approximately 2 km away from the urban zone to the northeast of the community and 1.5 km from the limit of the urban zone of Polis Chrysochous to the east – northeast of the community: This is an agricultural area as well.

3.3. PROJECT CHARACTERISTICS

3.3.1. SERVICED AREA

Table 3.1 lists the communities of Limassol district and Paphos (Group D) that are included in this project together with their respective number (d1 – d6).

TABLE 3.1: COMMUNITIES OF LIMASSOL DISTRICT AND PAPHOS (GROUP D)

COMMUNITY NUMBER	COMMUNITY
d1	Polis Chrysochous
d2	Episkopi
d3	Erimi
d4	Kolossi
d5	Ypsonas
d6	Trahoni

The sewage treatment plant proposed to be constructed in Polis Chrysochous will service the community itself. In the planning however, the connection of the communities Argakas, Agia Marina, Goudi as well as the costal community (more specifically the costal road) Neo Chorio in the Paphos District is foreseen.

The Episkopi treatment plant will service the Limassol communities, Episkopi, Trachoni, Ypsonas, Erimi and Kolossi, thus the communities d2 – d6 in the above table.

Consequently, in order for the service of the communities to be feasible, the water consumption must be established, since it will lead to the estimation of the sewage produced by those communities. The water demand of its community are summarised in the table below. As the titles of the two columns point out, the average water demand for 2005 is presented, whereas in the brackets is given the demand including the summer consumption.

TABLE 3.2: WATER DEMAND

COMMUNITIES	AVERAGE WATER DEMAND FOR 2005 (INCLUDING SUMMER CONSUMPTION) m^3/day	AVERAGE WATER DEMAND FOR 2030 (INCLUDING SUMMER CONSUMPTION) m^3/day
Polis Chrysochous	280 (1 120)	604 (2 363)
Episkopi	436 (436)	649 (649)
Erimi	206 (206)	334 (334)
Kolossi	539 (539)	874 (874)
Ypsonas	926 (926)	1 513 (1 513)
Trachoni	460 (460)	619 (619)

3.3.2. SEWAGE TREATMENT PLANTS

After the water demand has been established, then, according to the right estimations, the capacity of both treatment plants can be established as well. The quantities that have been estimated for the flow and for the pollutant load and in greater detail for the BOD are provided below. Further, on, the treatment method is presented that is expected to be used in the plants. In addition, a description of the technologies used for the treatment of the produced sludge as well as the technologies used for the odour control is provided.

3.3.2.1. EXPECTED CAPACITY

Wastewater production was derived from the data on water demand taking into account:

- The return rate from the water supply to the sewers
- The corresponding flow from the summer houses
- A peak day factor
- A peak hour factor
- Groundwater Infiltration

Concerning the return of water to the wastewater system, studies made for the Greater Nicosia Sanitary System indicate that approximately 85% of domestic consumption could enter into the sewerage system, assuming a connection existed. Such a figure is in the range of those encountered elsewhere and was used in this study.

In the communities, in which the tourist sector expands, there will be substantial seasonal variation in the drained quantities. This fact was taken into consideration in the hydraulic planning because of the additional demand for summer houses.

According to the obtained data groundwater levels in the study area are generally lower that invert levels of the collection system except for the groundwater in the communities of Polis Chrysochous and Ypsonas. In the case of these two communities, an infiltration in the conveyance system is possible, specifically in gravity pipes where water leaks into the system through joints, cracks and other defects. Furthermore, infiltration is likely to occur in winter months when water consumption is low and the groundwater levels are higher. In case a part of the system is estimated to be below the groundwater level during winter months, infiltration is calculated based on an infiltration rate per day and per conveyor km (30m^3/day/km) and length of the system expected to be below groundwater level. The values for the estimated infiltration are presented in Appendix 2 of this study.
The average dry weather flow (ADWF) was calculated as a sum of domestic, non domestic and additional summer houses and hotel flow. In addition, infiltration is added as a provision. Peak factors in sewerage systems correlate to a certain extent to those in water supply. In the GNSS project, the peak water consumption was 1.4 times the average water consumption. This factor has been used to derive a Maximum Dry Weather flow (MDWF). The factor is not applied to the infiltration flow. The estimated wastewater production is given in Table 3.3 for the years 2005, 2015 and 2030.

TABLE 3.3: WASTEWATER FLOW

COMMUNITIES	20052005 ANNUAL PRODUCTION IN m^3/year	2005 MAXIMUM DRY WEATHER FLOW IN m^3/day	2015 ANNUAL PRODUCTION IN m^3/year	2015 MAXIMUM DRY WEATHER FLOW IN m^3/day	2030 ANNUAL PRODUCTION IN M^3/YEAR	2030 MAXIMUM DRY WEATHER FLOW IN m^3/day
Polis Chrysochous	220 313	2 485	314 875	3 747	476 157	5 499
Episkopi	135 269	519	157 607	605	201 352	772
Erimi	63 912	245	76 942	295	103 624	397
Kolossi	167 225	641	201 352	772	271 159	1 040
Ypsonas	292 152	1 264	361 440	1 816	488 848	2 448
Trachoni	142 715	547	159 779	613	192 045	737
TOTAL	**1 021 584**	**5 701**	**1 271 994**	**7 848**	**1 733 184**	**10 894**

Dry weather flow varies during the day with a major peak typically occurring in the early morning. The hourly flow was calculated with the assistance based on a factor, the "hourly factor", which gives the hourly rate when multiplied with the average daily rate. The peak factor for the maximum hour varies for different consumers (domestic and industrial). On average, the Peak hour factor is approximately 2.00, while for industries it rises to 3.8, relative to average day flow. Annex 2 presents the values calculated for the maximum hourly flow as well as other intermediary calculations that led to the calculation of the final flow as it is presented on table 3.3.

The Episkopi Treatment Plant capacity was calculated on the sum of the MDWF that was calculated for Episkopi, Erimi, Kolossi, Ypsonas and Trachoni for the year 2030. The Polis Chrysochous Treatment Plant capacity is the MDWF that was calculated for the same community for the year 2030. It should be mentioned that the flow calculated for Polis Chrysochous includes the expected flows from additional communities. These are the communities of Goudi, Argaka, Agia Marina and the coast area of Neo Chorio.

The table below shows the capacity estimated for both plants as well as the land usage in the location proposed for the construction of the Treatment Plants.

TABLE 3.4. SEWAGE TREATMENT PLANTS

LOCATION		CAPACITY (m^3/day)
Sewage Treatment Plant	Urban / Rural / Government Land	
Episkopi	Rural	5 395
Polis Chrysochous	Rural	5 499
TOTAL		**10 894**

The area requirements for the sewage treatment plants have been estimated to be 1.6 m^2/m^3/day, assuming a unit wastewater flow of 145 l/cap/day, or 0.3 m^2/population equivalent.

The land requirements for the sewage treatment plants will be as follows:

TABLE 3.5: LAND REQUIREMENTS FOR THE SEWAGE TREATMENT PLANTS

SEWAGE TREATMENT PLANT	AREA REQUIREMENTS FOR SEWAGE TREATMENT PLANT	AREA REQUIREMENTS INCLUDING NEEDS FOR SLUDGE STORAGE, PARKING SPACE, OFFICES, BUFFER ZONE, ETC.
Episkopi Plant	8 632 m^2	8 700 m^2
Polis Chrysochous Plant	8 798 m^2	8 900 m^2

3.3.3.1. ESTIMATED POLLUTANT LOAD

There is no data available on the quality of the wastewater for the villages and it is difficult to characterize wastewater from a few spot analyses. Therefore, the wastewater pollution loadings have been estimated using per capita loading rates in accordance with the EU Directive 91/271/EEC. The following unit loading rates have been used:

TABLE 3.6: PROPOSED WASTEWATER POLLUTION UNIT LOADING RATES

BOD g/cap/d	COD g/cap/d	SS g/cap/d	TKN g/cap/d	P g/cap/d	Total coli MPN/cap/d	Faecal coli MPN/cap/d
60	135	75	12	4	10^8	10^7

BOD refers to Biological Oxygen Demand, **COD** to Chemical Oxygen Demand, **SS** to Suspended Solids, **TKN** to Total Kjeldahl Nitrogen, **P** to Phosphorous, **Total coli** to Total coliform bacteria and **Faecal coli** to Faecal coliform bacteria.

BOD is the basic design parameter for a Treatment Plant. The average and peak daily BOD load for the years 2005, 2015 and 2030 are given in the table below. BOD concentrations vary between 500–525 mg/L, which is within the frame of what has been observed in Treatment Plants in Cyprus.

TABLE 3.7: WASTEWATER POLLUTANT LOAD ESTIMATES (BOD)

COMMUNITY	2005 ANNUAL LOAD KG BOD/YR	2005 PEAK DAILY LOAD KG BOD/DAY	2015 ANNUAL LOAD KG BOD/YR	2015 PEAK DAILY LOAD kg BOD/day	2030 ANNUAL LOAD kg BOD/yr	2030 PEAK DAILY LOAD kg BOD/day
Polis Chrysochous	65 423	738	91 664	1 091	136 403	1 575
Episkopi	71 243	273	81 944	314	101 083	388
Erimi	33 619	129	40 003	153	51 922	199
Kolossi	87 958	337	104 766	402	136 188	522
Ypsonas	151 294	655	180 674	908	235 779	1 181
Trachoni	75 093	288	83 020	318	96 506	370
TOTAL	**484 630**	**2 420**	**582 071**	**3 187**	**757 882**	**4 236**

3.3.2.3. EXPECTED QUALITY OF THE TREATED EFFLUENT

A combination of the standards specified by both the EU Directive 91/271/EEC and the Cyprus Codes of Practice for the disposal or reuse of treated effluents (Law 106(I)/2002 on the Control of Water and Soil Pollution) will be used (Appendix 1), and the most stringent values will be applied for the design of the wastewater treatment plant. Removal of nitrogen and phosphorus will be governed by the EU standards, whereas the limits for BOD, Suspended Solids (SS) and micro-organisms will follow the Cyprus Standards.

According to the EU Directive, the effluent discharged to sensitive areas should have concentrations of Nitrogen and Phosphorus not exceeding 15 mg/l (N) and 2 mg/l (P) respectively. However, the Government of Cyprus has requested deviation from the EU Directive in the case of phosphorus removal when the treated effluent will be used for irrigation purposes. In light of this, it has been suggested that the treatment plant should be designed in a way as to ensure that the nitrogen concentration of the treated effluent does not exceed 15 mg/l, while with regards to phosphorus removal only provision for future installation shall be provided for in the plant.

When the study has been carried out in order to establish the appropriate agricultural land and crops where the treated effluent can be reused for irrigation or aquifer recharge purposes, the risk of groundwater or soil pollution can also be established as well as the appropriate inhibitory measures.

Table 3.8 outlines the proposed limit values for the treated effluent as compared with the EU and Cyprus Standards.

TABLE 3.8: SUGGESTED DISCHARGE STANDARDS

PARAMETER	EU STANDARDS	CYPRUS REGULATION 517/2002 (FOR IRRIGATION OF ALL CROPS	PROPOSED LIMIT VALUES
BOD_5	25 mg/l	10 mg/l	10 mg/l
COD	90 mg/l	< 125 mg/l	90 mg/l
Suspended Solids	35 mg/l	10 mg/l	10 mg/l
Total N	15 mg/l	–	15 mg/l
Faecal coliforms	–	▪ 5 units/100 ml (in 80% of samples) ▪ 15 units/100 ml (maximum)	▪ 5 units/100 ml (in 80% of samples) ▪ 15 units/100 ml (maximum)
Intestinal worms	–	Nil	Nil
Total P	2 mg/l	–	2 mg/l

3.3.2.4. TYPE OF TREATMENT PROCESS: ACTIVATED SLUDGE PROCESS

The preliminary selection of the various treatment technologies available is presented in Chapter 7. The treatment method that is appropriate for the sewage treatment in order for the sewage to have the desired quality is the activated sludge process followed by sand filtration and disinfection by chlorine. The activated-sludge process is one of the most common treatment processes and is currently in operation in three of the main treatment plants in Cyprus (Paralimni, Limassol and Larnaca). The process can be designed in many modified forms, including: selection of the reactor type, oxygen requirements and transfer, and types of settling tanks, but fundamentally the theoretical aspects of the process are similar:

- Wastewater is introduced into a reactor (aeration basin) where an aerobic bacterial culture is maintained in suspension. The reactor contents are referred to as the “mixed liquor”. In the reactor, the bacterial culture carries out the conversion of the organic matter into biological solids (biological cells).
- The aerobic environment in the reactor is achieved by the use of diffused or mechanical aeration, which also serves to maintain the mixed liquor in a completely mixed regime.
- After a specific period of time, the mixture of biological solids is passed into a settling tank, where some of the settled sludge is recycled to maintain the desired concentration of organisms in the reactor and the remainder is removed from the system.
- The level at which the biological mass in the reactor should be kept (mean cell - residence time) depends on the desired treatment efficiency and other considerations, including the nature of the wastewater, and the local environmental conditions.

Different parameters can be used for the design of the activated-sludge process:

- The food to micro-organism ratio or mass loading defined as the mass of BOD applied per day to the treatment system divided by the mass of mixed liquor suspended solids (MLSS) in the aeration tank.
- The mean cell-residence time or sludge age that is the ratio of the mass of MSS in the aeration tank to the mass of sludge removed per day from the system.
- The volume loading defined as the mass of BOD applied per day to the treatment system divided by the aeration tank volume.

The activated sludge process was initially designed for removal of dissolved organic pollution (expressed as BOD, COD and SS), where removal rates up to 90%-95% can be expected depending on the design parameters. In the later years, the removal of nitrogen by biological nitrification and denitrification has been largely developed, requiring an increase of the sludge age in the tank and specific mixing, aeration and recycling arrangements. It has also been shown that biological phosphorus reduction can be achieved if an anaerobic tank is added at the inlet of the biological reactor and this development is now gaining more and more interest.

Aeration equipment for injecting oxygen into the MLSS can consist of mechanical aerators or diffused air systems that blow air into the MLSS.

Final settling tanks are used to separate the biological solids produced in activated sludge from the treated wastewater. Settling tanks are mainly designed on the basis of an overflow rate. Overflow rates may range from 0.5 to 0.7 m/h at peak flows.

It should be pointed out that an activated-sludge process does not provide any significant reduction in coliform counts (only 10%). Where coliform reduction is required, as the case is here, a tertiary treatment should be added to the treatment train, most often consisting in sand filtration and disinfection by chlorine or UV radiation.

Provided with tertiary treatment, the activated sludge process would meet the set performance requirements. However, due to the space requirements, the process could be difficult to locate where little land is available and leads to high costs if the plant should be covered and odour treated.

3.3.2.5. SLUDGE TREATMENT AND DISPOSAL

The production was calculated on the basis of the BOD load and the conservative assumption that 1 kg BOD can be transformed into 1 kg DS (Dry Solids) sludge.

Information concerning the BOD load and the respective sludge production was requested from the existing Treatment Plants in Larnaca, Limassol and Ayia Napa/Paralimni. The answers received (only from Larnaca Treatment Pant) are presented in Appendix 16.

The expected sludge production for the years 2005, 2015 and 2030 as calculated on the basis of the above assumption is outlined in Table 3.9.

TABLE 3.9: EXPECTED SLUDGE PRODUCTION

COMMUNITY	ANNUAL DRY SOLIDS PRODUCTION, kg DS/YEAR		
	2005	2015	2030
Polis Chrysochous Sewage Treatment Plant			
Polis Chrysochous	*65 423*	*91 664*	*136 403*
Total Sludge Volume at 30% DS Content	216 m³/year	302 m³/year	450 m³/year
Episkopi Sewage Treatment Plant			
Episkopi	71 243	81 944	101 083
Erimi	33 619	40 003	51 922
Kolossi	87 958	104 766	136 188
Ypsonas	151 294	180 674	235 779
Trachoni	75 093	83 020	96 506
Total	*419 207*	*490 407*	*757 882*
Total Sludge Volume at 30% DS Content	1 383 m³/year	1 618 m³/year	2 051 m³/year
Total quantities			
Total Sludge Volume at 30% DS Content	1 600 m³/year	1 920 m³/year	2 501 m³/year

The experience from other wastewater treatment plants in Cyprus shows that sludge can easily be reused in agriculture and, due to the low rate of industrial wastewater of the total, that the sludge meets EU requirements for agricultural use without problems. It is therefore anticipated that the sludge from the treatment plant will be used as soil amendment in agriculture in accordance with the Code of Practice for the Use of Sludge for Agricultural Purposes (Law 106(I)/2002) and the standards imposed by it. The process selection for the sludge treatment will be based on this assumption.

Nevertheless, a significant percentage of the sludge produced will be disposed in landfills despite objectives for reuse, particularly during the first years of operation of the STP. Disposal must take place in an official controlled landfill site appropriate for the disposal of such wastes, which will incur additional costs for the transport of sludge.

Three different terraces in the sludge treatment can normally be distinguished: thickening, stabilization and dewatering. Sometimes, thickening and dewatering can be combined or stabilization be omitted. An additional drying stage could also sometimes be required.

⇩ SLUDGE THICKENING

The excess sludge, which is withdrawn from the secondary clarifier, has a dry solids (DS) content of around 8 g/l and, in consequence, a water content of 99.2%. The sludge at this stage is thus liquid, "dirty water". The purpose of sludge thickening is to concentrate the solids to a solids content of around 30 g/l or 3%. The sludge is after thickening still a liquid but with the volume reduced to around ¼ of the initial volume. Sludge thickening is generally carried out either by gravity thickeners, air flotation or drainage screens.

Gravity thickener: it is the most common type of sludge thickening device. It gives excellent results on primary sludge and acceptable results on digested secondary sludge. The principle and the operation are simple and robust. Gravity thickeners cannot be used if biological phosphorus removal is used, since anaerobic conditions will appear in the thickener with subsequent phosphorus release as a result.

Dissolved air flotation: it is used when the sludge is light and difficult to settle, typically for unstabilised activated sludge or sludge from biofilters. It is also a preferred option when biological phosphorus removal is used. The process is however more complicated to operate and more costly in operation and maintenance.

Drainage screens: they are mainly used in small treatment facilities and can be an interesting and space saving option.

⇩ SLUDGE STABILIZATION

The purpose of the sludge stabilization is to reduce the content of organic matter in the sludge and thereby reduce the potential for further fermentation or putrefaction and, in the same time, eliminate offensive odours. The stabilization will also reduce pathogens in the sludge to some extent. The processes used are:

- ⇨ anaerobic digestion
- ⇨ aerobic digestion
- ⇨ lime stabilization
- ⇨ thermal treatment

Anaerobic digestion: by methane fermentation is a powerful means of removing substantial quantities of organic matter. The process most generally used is mesophilic digestion at 35°C. For normal wastewater treatment sludge, a reduction of 45 to 50% of the organic matter content can be expected. The digestion is producing biogas, mainly consisting of methane and carbon dioxide. A part of the produced biogas is used for the heating of the digestor and the surplus can be used for heating other facilities or for producing electricity for the aerators of the plant.

Aerobic stabilization: it is usually employed in open-air units provided with air diffusers or surface aerators. The aerobic stabilization is rather energy consuming and is therefore rarely used as a specific unit. However, in an extended aeration activated sludge process, sludge is partly aerobically stabilised within the treatment process.

The advantages and disadvantages of aerobic and anaerobic stabilization are compared in the following table (from Degrémont Water Treatment Handbook):

TABLE 3.10: ADVANTAGES AND DISADVANTAGES OF AEROBIC AND ANAEROBIC STABILISATION

	AEROBIC STABILIZATION	ANAEROBIC STABILIZATION
Products	CO_2 H_2O NO_3^-	CH_4 CO_2 H_2O NH_4^+
Energy released in liquid medium per g of organic matter removed	20 kJ	0.8 kJ
Energy generated in gas form per g of organic matter removed	0	20.9 kJ
Rate of breakdown	+	-
Final reduction of organic matter	-	+
BOD_5	30-50 mg/l	200-400 mg/l
Resistance to inhibitors	+	-
Long-term storability	-	+
Sludge filterability	-	+

Stabilization with lime treatment: The fermenting capacity of sludge can be temporarily reduced by adding chemical agents in bacteriostatic dosages. Lime is the most widely used reagent because it is cheap, offers the right alkalinity and enhances the physical structure of the sludge. Lime can be added to the liquid sludge or to the dewatered sludge. The advantage of lime treatment is the absence of heavy investments in civil works and equipment, but this saving should be seen in the light of the relatively high operating costs.

Thermal treatment: is principally used for the conditioning of the sludge by release of bound water in the cells and for deactivation of pathogenic agents.

As a matter of fact, in many cases it is a combination of these processes that are used. In an extended aeration process, sludge is first partly stabilised in the aeration tank, thus aerobic digestion, before undergoing anaerobic digestion. The digested sludge is then often treated with lime in order to improve the physical properties and to ensure that the sludge could be stored for long periods without any renewed fermentation.

⇩ SLUDGE DEWATERING

The purpose of the dewatering process is to further reduce the moisture content in the sludge, thereby also reducing the volume. Typically, dewatered sludge has a dry solids content between 20% and 40% depending on the process, which means a tenfold reduction of the volume. The degree of dewatering depends on the type of equipment being used and it should be selected depending on the final destination of the sludge. Where sludge should be transported over long distances, additional drying up to 60% or even 90% DS could be considered in order to reduce the transportation costs.

Some kind of chemical conditioning is most often required to improve the dewatering characteristics of the sludge. Various types of chemicals are used: metal salts such as ferric chloride and aluminium sulphate, polymers (very commonly used) and lime. The most commonly used dewatering devices and their performances are given in the following table:

TABLE 3.11: DEWATERING TECHNIQUES AND THEIR EFFICIENCY

DEVICE	PERFORMANCE FOR STABILISED BIOLOGICAL SLUDGE	ENERGY CONSUMPTION
Centrifuge	20% - 30%	55-70 kWh/ton dry matter
Belt filter	18% - 26%	40 kWh/ton dry matter
Plate filter press	30% - 40%	30-40 kWh/ton dry matter

Dewatering of sludge on drying beds is a very inexpensive solution, but is limited to small treatment plants due to the large surface areas required. About 0.25 m² of land per population equivalent is required, which would double the required surface for an activated sludge plant

3.3.2.6. ODOUR CONTROL

Generally, three types of odour removal systems are used in applications related to wastewater conveyance and treatment:

- ⇨ Chemical scrubbers
- ⇨ biological filters
- ⇨ activated carbon filters

Chemical scrubbers, including three (or two) scrubber towers and using acid, alkaline and oxidising agents are able to remove satisfactorily all odorous compounds in the air. The system requires daily verification but not any complicated operation procedures. The chemicals used need to be renewed at intervals.

Biological filters are now being developed more and more for odour treatment. Until recently, the biological filter consisted of an organic filter media, normally made up by peat and ligneous fibres, which needed to be replaced every five years. However, mineral filter media are now being developed that do not need replacement. Sprinkling with fertiliser is required at intervals to maintain the biological activity on the filter. The biological filters are being more and more efficient with the recent development and can now remove most odorous components, but with reduced efficiency on nitrogen components.

Activated carbon filters can be used to adsorb some odorous compounds. The type of odorous compounds to be removed depends on the treatment of the activated carbon. Hydrogen sulphide (H_2S) can be well removed, but nitrogen compounds are difficult to remove by this system. The activated carbon filter media gets saturated and needs to be replaced from time to time. The design life depends on the applied load, but does generally not exceed six months.

Chemical scrubbers is the system used in a large majority of odour removal systems for wastewater treatment plants and pumping stations in France because of the high efficiency and the relatively low operation costs. Biological filters tend also to be used more frequently. The use of activated carbon filters is limited to very small installations with low air flows and with a temporary operation, e.g. for odour control of a rainwater holding tank, where the air treatment is only operated 10 to 20 days per year.

In normal cases, odour treatment is applied to the facilities that generate the most odours, i.e. pre-treatment and sludge treatment. In some particularly sensitive cases, where the treatment plant is close to housing areas, the whole plant could be covered and the air treated.

3.3.3. STORAGE RESERVOIR

Two storage reservoirs will be installed in the Treatment Plants: A long term storage reservoir and an emergency storage reservoir. The installation of an emergency storage reservoir is a measure taken in Cyprus in order to preserve untreated wastewater, so that they will not have to be discharged in surface waters or elsewhere. The long term storage reservoir is necessary for the preservation of treated effluent that will be reused.

The extent and the areas that these reservoirs are expected to occupy, are presented in the following subchapters. The final tank sizes will be established after the completion of the study for the reuse of treated effluent and after a preliminary design has taken place, taking into account details concerning the geomorphology of the locations as well as the appropriate raw material for those reservoirs. Therefore, the numbers presented for the land requirements are only indicative, since the geomorphology and the appropriate design will contribute to the reduction of the land required for those two reservoirs. The long term storage reservoir might be better to be installed outside the plant site, close to the crops that will be irrigated by the treated effluent, if the result of the study for the reuse suggests so. For the purpose of this study, it is assumed that it will be installed within the plant site.

3.3.3.1 EMERGENCY STORAGE RESERVOIR

An emergency storage reservoir will be constructed for each of the two sewage treatment plants, to provide for the storage of the untreated effluents in case of problems in the treatment process. The reservoirs will provide emergency storage for 7 days. The depth of the reservoirs will be 5 m, which is a usual depth but on the conservative assumption that the construction will be parallelepiped with a resulting area requirement of 1.4 m^2/m^3/day. The following table shows the capacity of each tank as well as the land requirements at the plant location.

TABLE 3.12: EMERGENCY STORAGE RESERVOIRS

LOCATION		VOLUME (m^3)
Sewage Treatment Plant	Urban / Rural / Government Land	
Episkopi Treatment Plant	Rural	37 760
Polis Treatment Plant	Rural	38 490

On the assumption that the tanks will have a depth of 5 meters, the land requirements for the emergency storage reservoirs will be as follows:

TABLE 3.13: LAND REQUIREMENTS FOR THE EMERGENCY STORAGE RESERVOIRS

SEWAGE TREATMENT PLANT	AREA REQUIREMENTS FOR THE EMERGENCY STORAGE RESERVOIR
Episkopi Treatment Plant	7 550 m^2
Polis Treatment Plant	7 700 m^2

3.3.3.2 LONG-TERM STORAGE RESERVOIRS

Provisions must be made for the long term storage of the treated effluents, which will be a necessity, particularly during the winter months when the demand for irrigation will be low. Each reservoir will provide storage for 120 days, and, having a depth of 5 m, the resulting area requirement will be 24m^2/m^3/day. This depth is within the usual frame for such storage tanks; here however, the assumption is made that the tank is a parallelepiped construction. In addition, all scales are calculated on the basis of the Maximum Dry Weather Flow, which is also a conservative assumption.

TABLE 3.14: LONG TERM STORAGE RESERVOIRS

LOCATION		VOLUME REQUIRED (m^3)
Sewage Treatment Plant	Urban / Rural / Government Land	
Episkopi Plant	Rural	647 390
Polis Chrysochous Plant	Rural	659 840

The land requirements for each long term storage reservoir, based on the 5-meter depth assumption, are as follows:

TABLE 3.15: LAND REQUIREMENTS FOR THE LONG TERM STORAGE RESERVOIRS

SEWAGE TREATMENT PLANT	LAND REQUIREMENTS FOR THE LONG TERM STORAGE RESERVOIR
Episkopi Plant	129 480 m^2
Polis Chrysochous Plant	131 970 m^2

3.3.4. SEWERS AND PUMPING STATIONS

Sewers and pumping stations are necessary factors for the perfection of the project. Specific information about the pipes that will be used, e.g. the pipe diameter, the appropriate material for their construction as well as their length is given in this part of the study together with information about the pumping stations.

These numbers are based on a preliminary study with suggestions concerning the characteristics of the pump stations; it is, however, possible that they will change when the constructor (Construction Company) that will undertake the project makes the final planning. Fact is, however, that no big change is expected, especially with regard to the pumping pipe length, which is the most interesting part from an environmental point of view for reasons that are explained in the following subchapters.

3.3.5.1. SEWERAGE COLLECTION SYSTEMS

The sewerage collection networks for each community will be completed in two Phases. Phase A covers the areas to be presently connected to the network, while Phase B includes the areas to be connected in the future and its boundaries are in most cases the same as the water supply boundaries. Drawing EIA – D – 11 presents these two phases with the data received from the Water Development Department.

For the gravity pipes in the collection system the PVC pipes will be used while for the force mains the HDPE (High-density Polyethylene) are predicted. For the detailed design of the collection system the following criteria will be used:

- Minimum pipe diameter: 100 mm
- minimum depth from cover to the top of the pipe: 1.6 m
- Pipe design is based on the maximum hourly flow (at this flow rate the water depth in the pipes will be equal to the pipe diameter; this way 100% of the pipe capacity will be used)

The estimated total length of the sewerage collection networks is given in the following Table.

TABLE 3.16: CALCULATED LENGTH OF THE COLLECTION NETWORK

COMMUNITY	LENGTH (m)	MIN GROUND ELEVATION (masl)	MAX GROUND ELEVATION (masl)
Polis Chrysochous	36 000	2.00	55.00
Episkopi	29 800	28.00	138.00
Erimi	21 900	55.00	150.00
Kolossi	34 300	40.00	115.00
Ypsonas	76 700	43.00	200.00
Trachoni	26 600	7.00	55.00
TOTAL	**225 120**		

3.3.5.2. CONVEYANCE SYSTEM AND PUMPING FACILITIES

Pipelines are divided in two categories depending on the way the water is forced to flow. If the water flows by gravity, the pipelines are gravity sewers. If the flow is pushed by pumps, the pipelines are forcemains.

In forcemains, the wastewater is in a closed environment without the presence of air. Formation of sulphides, which causes creation of unpleasant odours, is possible in case of long transfer of water without aeration, which lasts a few hours – approximately 6 hours. With appropriate standard design, no problem of creation of sulphides, and therefore unpleasant odours, is anticipated for lengths of forcemain below 10 km, which corresponds to a transfer time of approximately 3 hours.

The proposed scheme includes one sewage treatment plant that will be constructed near Episkopi and will service all communities of Limassol District that are included in this project. The preliminary layout of the system and the respective system flows are presented in Drawing EIA – D – 3.

The communities of Limassol District will be connected to the sewage treatment plant, which will be constructed in Episkopi. The sewage will be transferred from Episkopi mainly by gravity, while only a small part of the conveyance pipe will be a forcemain to the connection with the pipeline from Erimi. The connection from Erimi will be in part gravity and in part forcemain. Near the treatment plant there will be the connection with the pipeline, which will transfer the wastewater from the other communities of the project. The wastewater from Ypsonas will be transferred with gravity to Kolossi and then to the connection of the pumping pipeline from Trachoni. From this connection, the wastewater will be pumped to the connection with the pipeline from Erimi and Episkopi. From this point on the wastewater will be transferred to the Episkopi Sewage Treatment Plant.

The conveyance system for the Limassol communities to the treatment plant that is suggested for the specific location (Drawing EIA – D – 1) will consist of:

- ⇨ The total length of the gravity pipes is 10.7 km and will have a diameter ranging between 200 mm and 500 mm.
- ⇨ The total length of the forcemains is 5.6 km, with a diameter ranging between 100 mm and 300 mm.
- ⇨ Four pumping stations have been estimated, with the discharge capacity varying from 5.0 l/s to 58.0 l/s and installed power from 1.0 kW to 40.0 kW.

The conveyance system for the community of Polis Chrysochous for the proposed location (Drawing EIA – D – 2) will consist of:

- ⇨ The total length of the gravity pipes is 600 m and the diameter is 500 mm.
- ⇨ The total length of the forcemains is 2.7 km and the diameter is 300 mm.
- ⇨ A pumping station with discharge capacity of 64 l/s and installed power of 61.5 kW.

Table 3.17 gives the position of the pumping stations for both the communities of Limassol and Polis Chrysochous with regard to the land usage.

TABLE 3.17 : LOCATION OF PUMPING STATIONS

PUMPING STATION	COMMUNITY	LOCATION
PS Episkopi	Episkopi	Within the residential area
PS Kolossi	Kolossi	Within the British Bases, away from the residential area
PS Trachoni	Trachoni	Within the residential area
PS Polis	Polis Chrysochous	Within the residential area

The area required for each pumping station will be 500 m^2 (0.05 ha), with a total area of 2 500 m^2 (0.25 ha) for all five pump stations.
The preliminary locations for the pumping stations are included in Appendix 3.

3.4. IMPLEMENTATION SCHEDULE

The project schedule is outlined in the Project Implementation Programme (Appendix 4).

4. LIMASSOL AREA: DESCRIPTION OF THE ENVIRONMENTAL BASELINE

4.1. MAIN FEATURES OF THE PROJECT AREA

As mentioned before, the communities of the Limassol area that will be included in the project are five and are given once again in the following Table together with the respective population (2001) and the lowest and highest ground level within their community boundaries. The following table also shows the total population of the communities.

Community	Population according to the 2001 Census	Indicative Ground Level of the Urban Area: Lowest and Highest (masl)
Episkopi	3 500	28 – 138
Erimi	1 850	55 – 150
Kolossi	5 800	40 – 115
Ypsonas	7 000	43 – 200
Trachoni	5 287	7 – 55
Total	23 437	

These five communities are situated on the west of Limassol. Episkopi, the community that is situated far away from Limassol, is 15 km from the Limassol city centre. It is placed to the north of the British Bases of Akrotiri, together with the communities of Erimi, Kolossi, and Ypsonas. Kolossi is 10 km to the west of Limassol whereas Ypsonas is 5 km away from the beach and the commercial area of Limassol. Trachoni lies south of Kolossi and is surrounded by the area of the British Bases.

4.2. PHYSICAL ENVIRONMENT

4.2.1. TOPOGRAPHY, GEOLOGY AND SOILS

Drawings EIA – A – 4 provides the geological map of the plant project area and the project communities.

4.2.1.1. GENERAL GEOLOGICAL ENVIRONMENT

❑ YPSONAS, KOLOSSI, ERIMI AND EPISKOPI AREAS

The ground covered by the communities of Ypsonas, Kolossi, Erimi and Episkopi is part of the west – east marine terrace, which developed in the area in older geological years and tend to a general south direction. The lowest and most recent terrace is the one of Akrotiri – Limassol, which begins almost at the sea level and amounts to a ground level of 40-45 meters. It slopes to the south with a slight inclination. To the north, it is followed by an older marine terrace, which slopes to the south with a bigger inclination (ca. 2^o). This older terrace merges with the Akrotiri terrace to the east between Ypsonas and Limassol, but in many points further east the two terraces are separated by a ground strip with a scarp, which builds the old coastline. This second terrace seems to be elevated to a ground level of ca. 120 meters. Above this point, the ground inclination rises again, suggesting a possible additional inclination into a third, even older terrace.

The biggest part of the area of the above communities falls into the area of the second marine terrace and only the small parts of land to the south and north edges come under the lowest (Akrotiri terrace) or the highest marine terrace respectively. The lowest ground levels in the communities' area are observed in Episkopi where the ground level falls to 28-30 meters at the far south edge of the village, which is obviously part of the lowest marine terrace (Akrotiri). Some higher ground levels are observed to the south of Kolossi and to the southeast of Ypsonas, where again the two lower terraces seem to merge. The northern ground levels of the communities' area rise from ca. 110 m in Kolossi to 200 m in Ypsonas and have in between ground levels of ca. 140 m in the two other communities of Erimi and Episkopi.

Many rills cross through the project area with a general south direction. All of them are small, beside the Kourris River that flows between Erimi and Episkopi and has created a valley with some hundred meters width. A number of River terraces have developed at the two sides of the valley at various levels.

The ground analysis in the area presents the following picture beginning with the surface:

The whole of the communities' area is covered by a reddish brown soil of sandy silt with clay and rock fractions. In the southern area it seems to be better developed and thick (up to 0.5 m), while it is more uneven or absent at the highest ground level, where the mother rock appears at the surface without being covered by any surface layer. In some places, e.g. Kolossi, it is followed by terra rossa, which consists of reddish brown soil with clay, has a thickness up to 1.0 m and seems to represent palaeosoil, thus soil that was created in earlier geological periods.
In all communities, the soil layer rests on a horizon of secondary limestone, which consists of havara, which is covered by kafkalla in certain parts. The kafkalla layer is usually very hard and its thickness ranges between a few centimeters up to 0.5 m. Its appearance in the area is restricted and it seems to develop better in the north, on havara or other rocks that carry calcium carbonate of the Pachna Formation, such as chalks, biocalcerenites, sandstones or limestone. The havara horizon is an enrichment zone for the calcium carbonate, but, unlike kafkalla, it has a lower concentration level. Its thickness varies and depends on the nature of the lower mother rock, while it seems to reach 4-5 m in the area.

The kafkalla and havara horizons that represent the land deposits are followed by deposits of the sea or river terrace. The extensive deposits of the marine terrace constitute a layer on top of the terraces described above. They consist of mud and sand with sandstone and clay. They seem to reach a maximum thickness of 15 m on top of the second terrace on which the biggest part of the communities lies. To the south, at the boundaries with the lowest terrace of Akrotiri, the thickness of these deposits increases. At the southeast edge of Ypsonas, they reach a thickness of 30 m, which increases to 60-70 m to the south of the south boundaries of Kolossi, Erimi and Episkopi. These sea deposits are slightly thick. They belong to the Pliocene-Pleistocene period.

Alluvial deposits are mainly deposits of the river terrace in the Kourris River and appear along the valley at different levels to the west of Erimi and to the east of Episkopi. At the present riverbed, their thickness is more than 50 m but on top of the terraces, they seem to reach a thickness of 10-15 m. They consist of coarse gravels and sand with boulders containing mud and clay. Alluvial and colluvial deposits exist also in a smaller scale in Ypsonas and Kolossi in narrow, shallow valleys and topographical concavities. They mainly represent the products of erosion of nearby geological formations including the marine terrace deposits and sediments of the Formation of Pachna, and their thickness attains a few meters.

The rocky sub-layer in the area, on which the lithological formations described above are based, consists of sediments of the Pachna Formation from the Middle Miocene period. It consists of chalks, marls, chalky marls, marl chalks, biocalcerenites, limestone, mainly in a form of alternating layers having a total thickness of some hundred meters. In the far southern part of Ypsonas, it is also possible to find plaster on top of the Pachna Formation. The sediments of Pachna are usually covered by alluvial deposits or marine terrace deposits with changing thickness, but that are exposed on the hills between the first and the second marine terrace, as for example to the south of the old village of Kolossi and at Episkopi as well as on the highest ground at the far north part of Ypsonas.

- AREA OF TRACHONI

Community of Trachoni lies on a west – east lengthwise hill in the middle of the Akrotiri peninsula, some kilometers to the south of the rest four communities. The area around the hill is flat with a slight inclination to the south – southeast and forms a part of the Akrotiri – Limassol marine terrace. The lowest ground level is on the southeast edge of the village having an altitude a little bit less than 8 m, which increases to 26 m in the southwest side. The top of the hill attains its highest level of 52 m on the west side and fall on the east side to ca. 36 m. On the north side of the hill, the ground lowers to 40 m to the west and to 20 m to the east and starts rising slightly to the north.

Studies of the area have shown until now the following geological picture beginning from the surface downwards:

A reddish brown soil appears in some parts of the area and consists mainly of clay mud with sand. This soil layer leans on a horizon of secondary limestone consisting of havara and kafkalla. The kafkalla layer that represents the highest hardened part of the secondary limestone seems to have an uneven development and it might not exist in certain parts. Its thickness ranges between a few centimeters and ca. 0.5 m. The kafkalla layer can develop directly on top of the biocalcerenites rocky layer of the area or it can cross down through softer havara. This last layer consists mainly of slightly or medium dense limestone mud and reaches a thickness of ca. 4 m. The adhesion ability reduces with the depth.

The above horizons lean mainly on limestone, which forms the rocky sub-layer in the biggest part of the area. This limestone, which belongs to the Athalassa Formation of the Upper Pliocene – Pleistocene age, reaches a thickness of more than 40 m and can be bestrewed with layers of marl limestone. It is a medium grained biocalcerenites of slight to medium density. Limestone leans on a marl horizon, possibly of the Pliocene age (Nicosia Formation) and is followed by sediments of Pachna that consist of marl chalks, marl and plaster in some parts, and extend to several hundred of meters depth.

In the south – central part of the area the sediments of the Akrotiri marine terrace, which consist of sand and sandy silt with clay, overtop the limestone. The thickness of these deposits is only a few meters in the area but it increases substantially to the south to more than 100 m, resulting in the creation of the Akrotiri Aquifer.

4.2.1.2. SOIL CHARACTERISTICS AND PRESENT SANITARY SITUATION

Table 4.1 gives the soil characteristics and the current sanitary situation in each community. The present sewerage system in the project communities consists of septic tanks and absorption pits; however, the soil conditions in some cases are not appropriate for such a sanitation system. This results in serious absorption problems and health hazards. Therefore, the construction of centralised sewage collection and treatment systems is judged as a necessity.

TABLE 4.1 : SOIL CHARACTERISTICS AND PRESENT SANITARY SITUATION IN THE PROJECT COMMUNITIES

COMMUNITIES	SOIL CHARACTERISTICS	PRESENT SANITARY SITUATION
Episkopi	Light brown surface soil – grey mud with sandy silt, with a thickness of 0.2 – 0.4 m, seems to cover the whole area. In the north part, it leans on havara and kafkalla, which have a total thickness of more than 3.5 m, or directly on deposits of the marine and river terrace to the	There is an increasing problem with the absorbency of the ground as well as overflow problems. The absorption pits are emptied once a month in some areas and every two

COMMUNITIES	SOIL CHARACTERISTICS	PRESENT SANITARY SITUATION
	south and east. Marine terrace deposits consist of mud and sand with some gravel, while the deposits of the river terrace consist of mud, sand, gravels with boulders. They have a thickness ranging between 1 and at least 4 m. This sequence leans on a rocky sub-layer of the Pachna Formation, which consists of marl chalks, chalky marls and limestone, eroded on its top, which extends to some hundred meters depth. The groundwater level is deeper than 4 m. The permeability of the surface layer is low to moderate, but the alluvial deposit layer to the east is probably higher.	months in other areas.
Erimi	A layer of surface soil from grey – light brown sand and mud, with a thickness of 0.2 – 0.3 m, extends over the whole area and leans on a layer of light brown, muddy sand – sandy mud, with a thickness to up to 3 m, or leans directly on havara in some spots. It is followed by a) marine terrace deposits in the east part of the area (east part of the Kourris River valley), which consist of sand and gravels with boulders, with a minimum thickness of at least 10 m, and b) a havara layer, which consists of a slightly or medium dense white to reddish brown sand and mud, with a thickness of more than 2 m. The havara layer crosses through marine terrace deposits, which consist of sand and mud and extend to depths deeper than 4 m in the biggest part of the area. The above layers lean on a rocky sub-layer of chalky marls in a depth of 2-3 m to the north and deeper in the rest of the area. The permeability of the marine terrace deposits and of the sub-layer is mainly low or medium but the permeability of the alluvial deposits to the west of the area is high.	There is an increasing problem with the absorbency of the ground as well as overflow problems. The absorption pits are emptied once a month in some areas and every two months in other areas.
Kolossi	Surface soil of light brown mad and sand with some gravel and a thickness of 0.2 – 0.4 m, leans on a number of different lithological horizons, including a) one horizon of light brown muddy, clay mud, b) a horizon of terra rossa consisting of reddish brown mud and sand with clay and thickness of 0.3 – 0.9 m, c) a horizon of secondary limestone consisting mainly of havara and less kafkalla. Kafkalla is very uneven, has a thickness of 0.1 – 0.2 m and is very hard. The above succession of land and sea deposits leans on a rocky sub-base of Pachna sediments, consisting of chalks, chalky marls and limestone. The sub-layer depth is in some parts low up to 0.6 m. The thickness of the surface layer is at least 4 m, but in some spots, it can reach 10-15 m. The permeability of	There is an increasing problem with the absorbency of the ground as well as overflow problems. The absorption pits are emptied once a month in some areas and every two months in other areas.

COMMUNITIES	SOIL CHARACTERISTICS	PRESENT SANITARY SITUATION
	the surface layer and sub-layer is moderate to low.	
Ypsonas	Reddish brown surface soil consisting of clay mud with sand and stone, with a thickness of up to 0.5 m, covers the biggest part of the area but is uneven or absent in the northern part. It leans mainly on a hard kafkalla and a softer havara layer with a maximum thickness of ca. 5 m, which seems to be very common in the area. It is followed by marine terrace deposits and some alluvial deposits consisting of mud and clay with sand and some gravel. These are very thin to the north but reach a thickness to the south and southeast of more than 30 m. This succession of the surface deposits leans on a rocky sub-layer of Pachna sediments consisting of chalks, marls, limestone and plaster and has a thickness of several hundred meters. No groundwater has been discovered in up to 4 m depth. The permeability of the surface layer and sub-layer is low to moderate, but probably high to the southeast.	The soil absorbability worsens and results in the overflow of the pits. The absorption pits are emptied every two months.
Trachoni	Light brown mud and sand surface soil, with a thickness of 0.2-0.5 m leans on hard kafkalla, with a thickness of 0.5 m, followed by softer havara that extends to a depth of at least 4 m and consists of slightly or moderately dense mud with sand. This succession is followed mainly by limestone rocks that constitute the sub-layer in the biggest part of the area and have a thickness of ca. 40 m. The permeability of the surface deposits and of the sub-layer is low to moderate.	There is an increasing problem with the absorbency of the ground as well as overflow problems. The absorption pits are emptied once a month in some areas and every two months in other areas.

4.2.2. CLIMATE

In terms of climate, the year in Cyprus can be divided in two seasons: the winter period, between October to March, and the summer period, between April to September. During the winter period, there are significant fluctuations in the climatic conditions, with large variations in temperature and pressure, and frequent alterations in wind directions and speed. In contrast, during the summer period climatic conditions are largely stable.

4.1.2.1. TEMPERATURE

The mean annual temperatures for the periods 1981 – 1990 and 1991 – 2000 in the greater project area were as follows:

Akrotiri Meteorological Station		
1981 – 1990	Mean annual temperature	19.2 °C
	Mean daily temperature range	12.4 °C (January) – 26.6 °C (August)
1991 – 2000	Mean annual temperature	19.2 °C
	Mean daily temperature range	11.9 °C (February) – 27.0°C (August)
Limassol Meteorological Station		
1981 – 1990	Mean annual temperature	19.6 °C
	Mean daily temperature range	12.4 °C (January) – 27.1 °C (August)
1991 – 2000	Mean annual temperature	20.2 °C
	Mean daily temperature range	12.8 °C (January/February) – 27.9 °C (August)

4.1.2.2. PRECIPITATION

The mean annual precipitation in the Akrotiri region for the period 1991 – 2000 was 371.4 mm, and for the Limassol region 404.7 mm with the normal mean annual precipitation (1961-1990) being 406.9 mm and 435.1 mm for the two regions respectively. The average monthly precipitation (1991-2000) for the same period was in the range of 0.0 mm for July and August, up to 88.1 mm for December in the Akrotiri region; in Limassol region it was 0.0 mm in July and August up to 94.9 mm in December. The normal precipitation (1960-1990) ranged between 0.0 mm in July and August and 98.1 mm in December, and 0.5 mm in August up to 102.0 mm in December in the two areas respectively.

Average precipitation values for the area are as follows:

Akrotiri Meteorological Station		
1991 – 2000	Mean monthly precipitation range	0.0 mm (June, August) – 88.1 mm (December)
	Mean annual precipitation	371.4 mm
1961 – 1990	Normal monthly precipitation range	0.0 mm (July) – 98.1 mm (December)
	Normal annual precipitation	406.9 mm
Limassol Meteorological Station		
1991 – 2000	Mean monthly precipitation range	0.0 mm (July, August) – 94.9 mm (December)
	Mean annual precipitation	404.7 mm
1961 – 1990	Normal monthly precipitation range	0.5 mm (August) – 102.0 mm (December)
	Normal annual precipitation	435.1 mm

The mean annual number of rainy days (which are established with regard to the precipitation as the days with $\geq$ 0.2 mm of rain) for the area of Limassol in the years 1961-1990 was 62 and the mean number of humid days (established as the days with $\geq$ 1.0 mm rain) was 50.

4.2.2.1. RELATIVE HUMIDITY (RH)

The mean annual RH, in the Akrotiri area and the Limassol area, at 08:00 hrs LST, during the periods 1981 – 1990 was 67%. The mean monthly relative humidity ranged between 62% in September and October up to 74.0% in December and January for the area of Akrotiri, whereas for the area of Limassol it ranged between 62.0% in April and 76.0% in January. In the same period, the mean annual relative humidity at 13:00 LST in Limassol area was 55% and the mean monthly values ranged between 53% during May, June, August, September and October, up to 59% during December, January and March.

During the period 1991-2000 the mean annual relative humidity at 08:00 LST was 67.0% in the area of Akrotiri and 71.0% in the area of Limassol. The mean monthly values ranged between 58.0% in October up to 77.0% in December in Akrotiri and from 67.0% during April and September, up to 81% in December in Limassol.

The mean values of Relative Humidity are outlined in the following table:

Akrotiri Meteorological Station		
1981 – 1990	Mean monthly RH range at 08:00 LST	62.0% (September, October) – 74.0% (December, January)
	Mean annual RH at 08:00 LST	67.0%
1991 – 2000	Mean monthly RH range at 08:00 LST	58.0% (October) – 77.0% (December)
	Mean annual RH at 08:00 LST	67.0%
Limassol Meteorological Station		
1981 – 1990	Mean monthly RH range at 08:00 LST	62.0% (April) – 76.0% (January)
	Mean annual RH at 08:00 LST	67.0%
	Mean monthly RH range at 13:00 LST	53.0% (May, June, August, September, October) – 59.0% (December, January, March)
	Mean annual RH at 13:00 LST	55.0 %
1991 – 2000	Mean monthly RH range at 08:00 LST	67.0% (April, September) – 81.0% (December)
	Mean annual RH at 08:00 LST	71.0 %

4.2.2.2. WIND DIRECTION

Measurements regarding the wind direction in the area are available at the meteorological stations of Limassol and Kourris dam.

- KOURRIS DAM METEOROLOGICAL STATION

  October to March the prevailing winds in the area have a north to northeast direction, with angles between 0^o and 30^o. The winds with a southwest direction with angle 210^o have also high percentage of occurrence during the months October, February and March; similarly, the winds with northwest direction with angle 300^o prevail during December and February.
  For the months between April, May, August and September the prevailing winds are those with north and northeast directions, with angles of 0^o and 30^o and winds with southwest directions with angle 210^o. In April and May, the winds with high percentage of occurrence are those with northwest directions with angle 210^o as well as those with north to northwest directions and angles 0^o to 30^o.

- LIMASSOL METEOROLOGICAL STATION

  From October until March, the prevailing winds are those with west to northwest directions, with angles between 270^o and 330^o. Winds with north directions and angles 0^o, from October until February, those with northeast directions, with angle 60^o, from December until March, as well as those with southwest directions and angle 240^o during October and March are also winds with high percentage of occurrence.
  From April until September the prevailing winds have southwest to west directions with angles between 240^o and 270^o. In September winds with northwest and north directions and angles between 300^o and 0^o have high percentage of occurrence as well.

In conclusion, comparing the measurements by the two meteorological stations, it is expected that in the project area the prevailing winds during October to March will have northwest and northeast directions, with angles between 300^o and 30^o. Between April and September, the prevailing winds will have southwest directions, with angles between 210^o and 240^o.

The meteorological data for the area are included analytically in Appendix 5.

4.2.3. SURFACE WATER RESOURCES

4.2.3.1. NATURAL STREAMS AND SURFACE WATER BODIES

The location proposed for the construction of the Episkopi Sewage Treatment Plant is at a distance of ca. 200 m from Kourris River. The outflow sink of Kourris River covers an area of ca. 300 km^2 and provides most of the surface water that is channeled to the Southern Conveyor Project. The water users in the outflow sink are many and their water rights differ accordingly. In the upper parts of the sink, the agricultural users pump groundwater and divert the surface water for irrigation purposes under a common property agreement. In the lower parts of the sink, water is diverted to the dams in order to be distributed to the main urban centers and other irrigation networks through the southern conveyor. In the lowest parts of the sink, surface water is channeled to the coast wetland habitats, which provide a home for endemic and migratory birds.

Diverting the surface river flow to the upper parts of the sink reduces the water quantities that are available in the lower parts. In addition, the surface water flow is connected with the ground water and up to 60% of the surface flow consists of the underground flow and springs. Under these circumstances, water pumping in the upper parts of the sink influences the water flow in lower parts as well.

4.1.3.1. EXISTING RESERVOIRS

There are no existing dams near the site of the location proposed for the construction of the sewage treatment plant; therefore, it is necessary to construct a long term storage reservoir for treated effluent, especially during winter months, when the water demands for irrigation will be restricted. It is most possible that the tank will be constructed within the plant site, which is suggested in Drawing EIA – D – 1.

4.2.4. GROUNDWATER RESOURCES

The sand depositions of the first marine terrace in the project area created an important aquifer, the Akrotiri aquifer, which has a thickness of more than 100 m to the north of the area of salt marsh. Because of the extensive pumping in the last decades, the water levels have been reduced significantly and the sea water has entered into the aquifer accessing Episkopi and Trachoni according to measurements by the Water Development Department in March 2003. At the south boundaries of Trachoni, the water levels are a little bit higher than 0 m a.s.l. and at the south boundaries of Episkopi ca. 4 m a.s.l. Water levels in the rest of the area are much higher.

The Akrotiri aquifer covers an area of ca. 60 km^2, while its thickness ranges between a few meters at the foothill of the mountain in the north, up to 100 m in the south, close to the coast. Under normal conditions, groundwater moves with south direction and outflows into the Akrotiri lake and the sea. Especially in the area of Akrotiri where the water levels are lower than the sea levels for a long distance, the conical depressions that exist close to pumping points change the natural water flow. This has led to penetration of the sea water with increased chlorides (500 – 700 mg/l), 2 – 4 km from the coast. An enrichment of the aquifer takes place with the infiltration of rainwater and irrigation water. The extensive pumping led to the penetration of saltwater into the aquifer, while the use of nitrate-containing fertilizers led to an increase of the nitrate concentration up to 200 mg/l NO_3.

The potential of the second marine terrace, which includes the biggest part of the area, regarding the aquifer layer, is significantly restricted to the one of the Akrotiri aquifer. Smaller water quantities exist in the sediments of Pachna and the water level is usually several meters below surface. The Akrotiri aquifer together with the aquifer of the Kourris River covers only a small part of the project area communities. Although the aquifers in the area have a hydraulic connection among them, it seems that the existing situation regarding the discharging of urban wastewater in the ground of the five communities has not influenced significantly the Akrotiri aquifer.

The last result report on the study on the water protection from the pollution caused by nitrates from agricultural sources according to the Directive 91/676/EEC establishes the aquifer as Nitrate Sensitive Zone. This zone is defined as an area, in which groundwater contains more than 50 mg/l NO_3 or that could contain more than 50 mg/l NO_3 if the appropriate measures are not taken. In the case of the Akrotiri aquifer, there are concentrations higher than 50 mg/l NO_3, while all five project communities lie within the defined zone.

4.3. ECOLOGICAL ENVIRONMENT

4.3.1. VEGETATION

The area proposed for the construction of the Episkopi sewage treatment plant is used as agricultural land. The biggest part of the area is used for the cultivation of temporary plants, and mainly cereal. To the northwest of the site, there are gardens with permanent plants, such as fruit-bearing trees. These gardens are surrounded by cypress tufts.

4.3.2. WILD LIFE

The proposed location for the construction of the Episkopi sewage treatment plant is within an agricultural area, which is of no particular ecological interest and where only the most common fauna species are observed.

4.4. PLANNING ZONES AND LAND USE

4.4.1. ADMINISTRATIVE BOUNDARIES

The location proposed for the construction of the sewage treatment plant, which will service the communities of Episkopi, Erimi, Kolossi, Trachoni and Ypsonas is in Episkopi, to the southeast of the village, near the boundaries with Kolossi and the area of Akrotiri, and within the administrative boundaries of the British Bases. The community of Episkopi covers an area of 24 km², of which 17 km² fall into the area of the base. The administrative boundaries of the project communities and the position of the plant are shown in Drawing EIA – D – 7.

4.4.2. PLANNING ZONES

Although the location, in which the sewage treatment plant will be constructed, is in an agricultural land, the area is within the administrative boundaries of the British Bases, where there are no defined planning zones. The planning zones and the British Bases in the project area are presented in Drawing EIA – D – 9(α). In Drawing EIA – D – 9(b) the planning zones for the area of Ypsonas are presented and in EIA – D – 9(c) the Local Communities Plan.

4.4.3. EXISTING INFRASTRUCTURE

A track road provides access from the main Trachoni-Episkopi road to the location where the Episkopi sewage treatment plant will be constructed. The nearest electricity transmission line (66kV), is at a distance of approximately 0.8 km from the proposed location

4.4.4. LAND OWNERSHIP

EPISKOPI SEWAGE TREATMENT PLANT

The land requirements for the construction of the Episkopi sewage treatment plant are as follows:

Sewage Treatment Plant	8 700 m^2
Emergency storage reservoir	7 550 m^2
Long term storage reservoir	129 480 m^2

The total area of land that will be taken up for the construction of the STP and the storage reservoirs is approximately 172 330 m^2 (17.2 ha), including the land that will be taken up for the construction of roads, parking places, landscaping and planting around the treatment plant and storage reservoirs, sludge storage etc. The lands proposed for the construction of the station constitute Turkish-Cypriot property under the supervision of the Minister of the Interiors. This constitutes a problem, since the Minister decided that no Turkish-Cypriot land will be disposed for development and the Water Development Department is trying to secure those lands.

PUMPING STATIONS

For the wastewater conveyance system from the communities to the treatment plant 4 pumping stations will be required. Each of the four pumping stations will cover a maximum area of approximately 500 m^2, and the maximum total land requirements for their construction will be 2 000 m^2. The exact locations of the pumping stations will be determined during the detailed design of the conveyance system, therefore it cannot be assessed at this stage which plots will be acquired and whether the land will be governmental or privately owned.

4.4.5. LAND USE

- EPISKOPI SEWAGE TREATMENT PLANT

The location proposed for the construction of the Episkopi sewage treatment plant is in an agricultural area. The biggest part of the site that has been established for the project is cultivated with temporary plants, mainly cereals. To the northwest of the site, there are gardens with permanent cultivations, mainly fruit-bearing trees. The gardens are surrounded with cypress tufts. During the planning of the treatment plant efforts will be made to install the units in the area with the temporary cultivations in order to avoid destroying the permanent cultivations. The cypress tufts will be maintained as part of the decoration of the plant.

PUMPING STATIONS

The pumping stations for the wastewater conveyance will be located mainly within the urban areas of the communities.

4.4.6. BUILD UP PROPERTIES

EPISKOPI SEWAGE TREATMENT PLANT

There are no other developments or constructions in the areas that will be used for the construction of the sewage treatment plant and the emergency and long term reservoir, therefore no private property will be affected by the project.

PUMPING STATIONS

The pumping stations will be sited in plots where there are no other developments or constructions present, therefore their constructions will not result in the destruction of any other existing structures or build-up property.

4.5. SOCIO-ECONOMIC ENVIRONMENT

4.5.1. POPULATION DISTRIBUTION

4.5.1.1. POPULATION PROFILE

A summary of the population distribution in the project communities, according to the 2001 Census of Population, is given in Table 4.2. The population is presented in connection to the households, the housing units and institutions in the respective communities. The table also shows the total population of each community in the right column.

The table below outlines the information given in Annex 6 (Communities Description).

TABLE 4.2 : POPULATION FIGURES IN EACH COMMUNITY (HOUSING UNITS, HOUSEHOLDS, INSTITUTIONS)

COMMUNITY	HOUSING UNITS			HOUSEHOLDS		INSTITUTIONS		TOTAL POPULATION
	Total	Used as Usual Residence	Vacant or Temporary Residence	Number	Population	Number	Population	
Episkopi	1 001	923	78	923	3 045	1	31	3 076
Erimi	528	453	75	453	1 432			1 432
Kolossi	1 198	1 084	114	1 084	3 722	1	25	3 294
Ypsonas	2 034	1 823	211	1 823	6 435			6 435
Trachoni	947	897	50	897	3 269	1	25	3 294
TOTAL	5 708	5 180	528	5 180	17 903	4	79	17 982

4.5.1.2. POPULATION PROJECTIONS

TABLE 4.3 : POPULATION PROJECTION BY COMMUNITY

COMMUNITY	2001	2010	2020	2030
Episkopi	3076	3489	4008	4614
Erimi	1432	1749	2034	2371
Kolossi	3745	4588	5305	6219
Ypsonas	6435	7909	9965	10766
Trachoni	3294	3641	4005	4407
TOTAL	**17 982**	**21 376**	**25 352**	**27 858**

TOTAL 4.4 : POPULATION – PERMANENT AND TEMPORARY

COMMUNITY	2010			2020			2030		
	Permanent	Summer	Total	Permanent	Summer	Total	Permanent	Summer	Total
Episkopi	3489	0	3489	4008	0	4008	4614	0	4614
Erimi	1749	0	1749	2034	0	2034	2371	0	2371
Kolossi	4588	0	4588	5305	0	5305	6219	0	6219
Ypsonas	7909	0	7909	9965	0	9965	10766	0	10766
Trachoni	3641	0	3641	4005	0	4005	4407	0	4407
TOTAL	**21 376**	**0**	**21 376**	**25 352**	**0**	**25 352**	**27 858**	**0**	**27 858**

4.5.2. SOCIO-ECONOMIC INDICATORS

4.5.2.1. AGRICULTURAL LAND IN THE REGION

The only available data regarding the agricultural land in the project region are from the 1994 Census of Agriculture. Therefore, this section outlines information regarding only the total cultivated area, the types of crops and the land uses in the area, as these were recorded in 1994. More detailed data from the Census, including the areas reported as irrigated on non-irrigated agricultural land, are provided in Appendix 7.

- AGRICULTURAL LAND BY COMMUNITY

TABLE 4.5: AGRICULTURAL LAND BY COMMUNITY (1994)

COMMUNITY	Total Area (donums)
Episkopi	5 350
Erimi	2 062
Kolossi	2 821
Trachoni	1 203
Ypsonas	10 153
TOTAL	**21 589**

TABLE 4.6: AGRICULTURAL LAND USE BY COMMUNITY (1994)

COMMUNITY	TEMPORARY CROPS		PERMANENT ROPS		FALLOW LAND		UNCULTIVATED FOREST AND SCRUB LAND	
	Donums	%	Donums	%	Donums	%	Donums	%
Episkopi	2 851	53 %	972	18 %	361	7 %	1 167	22 %
Erimi	422	20 %	632	31 %	202	10 %	806	39 %
Kolossi	631	22 %	1 664	59 %	207	7 %	319	11 %
Trachoni	152	13 %	984	82 %	26	2 %	42	3 %
Ypsonas	1 903	19 %	2 933	29 %	630	6 %	4 688	46 %
TOTAL	**5 959**	**28 %**	**7 185**	**33 %**	**1 426**	**7 %**	**7 022**	**33 %**

TABLE 4.7: TEMPORARY CULTIVATIONS BY COMMUNITY (1994)

COMMUNITY	CEREALS (Donums)	PULSES (Donums)	INDUSTRIAL (Donums)	FODDERS (Donums)	POTATOES (Donums)	VEGETABLES (Donums)
Episkopi	42 %	4 %	0.07 %	34 %	13 %	8 %
Erimi	40 %	3 %	0 %	41 %	13 %	2 %
Kolossi	34 %	3 %	0 %	52 %	7 %	4 %
Trachoni	29 %	1 %	0 %	32 %	2 %	37 %
Ypsonas	42 %	2 %	0 %	44 %	6 %	6 %
TOTAL	**41 %**	**3 %**	**0.03 %**	**39 %**	**10 %**	**7 %**

TABLE 4.8: PERMANENT CULTIVATION BY COMMUNITIES (1994)

COMMUNITY	VINEYARDS *(% of Permanent Crops Area)*	CITRUS	FRUIT	DRY NUTS	OLIVES	CAROBS
		% of total number of trees				
Episkopi	*27 %*	75 %	9 %	0.4 %	9 %	6 %
Erimi	*1 %*	59 %	6 %	6 %	10 %	19 %
Kolossi	*31 %*	90 %	3 %	1 %	6 %	1 %
Trachoni	*26 %*	96 %	1 %	0.3 %	3 %	0.1 %
Ypsonas	*32 %*	65 %	6 %	2 %	13 %	13 %
TOTAL	***28 %***	**77 %**	**5 %**	**2 %**	**9 %**	**8 %**

	Main cultivation		Second main cultivation

Most of the agricultural land in the Episkopi community is used for the cultivation of temporary crops, and mainly cereal. On the contrary, in the communities of Erimi, Kolossi, Trachoni and Ypsonas the biggest part of the agricultural land is used for permanent crops, especially citrus and vineyards. Temporary crops are usually fodders and cereals.
Regarding the reuse of the treated sewage effluents, all temporary cultivations, with the exception of vegetables, can be irrigated, as well as all permanent cultivations. The suggested effluent standards allow, according to the Code of Practice, for the irrigation of all crops, except leafy vegetables. It is, however, recommended that the irrigation of vegetables is altogether avoided, particularly in the case of those vegetables eaten raw, so as to avoid any risk of health hazards that could arise from the misuse of the treated effluent.

Table 4.9 includes data regarding the total agricultural land in the project communities that is irrigated with water from the Southern Conveyor:

TABLE 4.9: SOUTHERN CONVEYOR PROJECT – IRRIGATION AREAS (2000, WDD)

COMMUNITY	IRRIGATION AREAS	
	Hectares	Donums
Episkopi	155	1 159
Erimi	540	4 037
Kolossi	318	2 377
Ypsonas	303	2 265

Assuming that the total agricultural area has not change significantly since the 1994 Agricultural Census and assuming that this area in the project communities is ca 21.500 donums (Table 4.7), then around 46% of the agricultural land in the area fall under the irrigation network and the irrigation demand is covered with water provided by Kourris dam as part of the Southern Conveyor Project. Treated wastewater from the Episkopi plant can be used for the irrigation of areas that are outside the irrigation network and cover their water demands by pumping groundwater.

- IRRIGATION DEMAND PER CROP

TABLE 4.10: WATER DEMAND PER CROP (m^3/m^2/YEAR, 2001)

CROPS	TRACHONI	FASSOURI
Permanent Crops		
Citrus	870	870
Deciduous	870	870
Olives	522	522
Table grapes	334	334
Fodders	1 472	1 472
Almonds	535	535
Temporary Crops		
Tomatoes GH[1]	1 070	1 070
Cucumbers GH	1 070	1 070
Beans GH	736	736
Peppers GH	1 070	1 070
Melons GH	736	736
Strawberries GH	870	870
Flowers GH	1 204	1 204
Potatoes	334	334
Tomatoes OF[2]	736	736
Cucumbers OF	736	736
Beans OF	736	736
Squash	401	401
Onions	535	535
Peppers OF	736	736
Groundnuts	669	669
Cabbage	535	535
Parsley	936	936
Carnation	1 137	1 137
Artichoke	870	870
Kolokassi	2 649	2 649
Spices	401	401
Carrots	535	535
Beets	268	268
Watermelons	535	535
Broad Beans	67	67
*OF: Open Field, GH: Greenhouse		

4.5.2.2. LIVESTOCK PRODUCTION

TABLE 4.11: NUMBER OF ANIMALS BY COMMUNITY (1994)

COMMUNITY	SHEEP	GOATS	CATTLE	PIGS	CHICKEN
Episkopi	4 661	1 164	432	3	2 667
Erimi	598	797	0	2	450
Kolossi	2 111	735	213	1 620	15 057
Trachoni	287	190	29	0	300
Ypsonas	2 301	481	25	2 586	68 961
TOTAL	**9 958**	**3 367**	**699**	**4 211**	**87 435**

TABLE 4.12: NUMBER OF ANIMALS BY COMMUNITY (2001)

COMMUNITY	CATTLE	PIGS	SHEEP	GOATS	SHEEP AND GOATS	CHICKEN
Erimi	56	0	613	813	1 191	–
Kolossi	149	1 376	2 644	3 910	2 653	4 416
Trachoni	–	–	325	698	495	–
Ypsonas	–	1 582	736	1 351	1 689	–
TOTAL	**205**	**2 958**	**4 318**	**6 772**	**6 028**	**4 416**

4.5.2.3. EMPLOYMENT IN AGRICULTURE

TABLE 4.13: EMPLOYMENT IN AGRICULTURE AND LIVESTOCK PRODUCTION (1994) (EQUIVALENT OF FULL EMPLOYMENT)

	HOLDERS OF AGRICULTURAL LAND	EMPLOYEES (PERMANENT AND TEMPORARY)	TOTAL
Episkopi			
Men	118	21	139
Women	59	10	69
TOTAL	**177**	**31**	**208**
Erimi			
Men	31	1	32
Women	15	6	21
TOTAL	**46**	**7**	**53**
Kolossi			
Men	67	7	74
Women	36	5	41
TOTAL	**103**	**12**	**115**

	HOLDERS OF AGRICULTURAL LAND	EMPLOYEES (PERMANENT AND TEMPORARY)	TOTAL
Trachoni			
Men	35	4	39
Women	15	5	20
TOTAL	**50**	**9**	**59**
Ypsonas			
Men	126	28	154
Women	91	34	125
TOTAL	**217**	**62**	**279**

4.5.3. CULTURAL AND ARCHAEOLOGICAL VALUES

There are no archaeological or historic sites near the location proposed for the construction of the Episkopi STP.

5. POLIS CHRYSOCHOUS: DESCRIPTION OF THE ENVIRONMENTAL BASELINE

5.1. INTRODUCTION

Community	Population according to the 2001 Census	Indicative Ground Level of the Urban Area: Lowest and Highest (masl)
Polis Chrysochous	1 847	2 – 55

Polis Chrysochous is a picturesque city, built on a hill and located in the tourist area of the northwest coast of Cyprus, 25 km away from Paphos.

Polis is a developing tourist resort and a very popular area for summer houses. There is an extendable costal zone from Polis up to Latsi to the east and up to the boundaries with Neo Chorio to the west.

5.2. NATURAL ENVIRONMENT

5.2.1. TOPOGRAPHY, GEOLOGY AND SOIL

Drawing EIA – D – 5 presents the geological map of the plant and the community area.

5.1.1.1. GENERAL GEOLOGICAL ENVIRONMENT IN POLIS CHRYSOCHOUS AREA

The area forms part of the terrace that extends from the Baths of Aphrodite in the west, from Prodromi and Polis, to the Lake in the east. The area is characterized by marine terraces with northwest inclinations, crossed through by rills, most important of which is Chrysochous River that flows between Polis Chrysochous and Prodromi.

At least two marine terraces distinguish in the area and are separated by a precipitous hill in many spots. The lowest terrace, which is the most recent one, is apparent in Latsi and to the east of Polis towards the Lake. It has an altitude that increases from the sea level to up to 8 m. The highest terrace exists in the area between the Baths of Aphrodite and the road to Neo Chorio with ground levels of 14 30 m, as well as to the west and south of Prodromi and in Polis.

The geological formations that are found in the area are the following, beginning from the surface downwards:

A surface soil layer of brown clay and sandy mud with some gravel and thickness of 0.2 – 0.5 m seems to extend on top of the biggest part of the area covering the terrace and the alluvial deposits.

Alluvial deposits consist of gravels with boulders, sand, mud and clay. In the Chrysochous River valley, these deposits reach a thickness of ca. 60 m, but in the rest of the area, the thickness reduces to ca. 10 m.

The sea marine terrace deposits consist of mud and sand with gravels that can be slightly to medium dense with biocalcerates on top. These deposits have only a few meters of thickness in the area west of Latsi but their thickness increases to the east. It seems to be ca. 15 m to the west of Polis but to the east, near the Lake they reach a thickness of 30 m.

The above succession of the surface deposits lean on a rocky sub-layer that consists of various formations and lithological types. For 2.6 km to the west of Venus Baths, the sublayer is Mamonia Melange from the Middle Cretaceous age and consists of broken biocalcerenites, mud and pieces of limestone. This is followed to the east by a strip of chalky Lefkara and red limestone of the Lower Eocene – Lower Miocene age that extends to the crossroad in the direction of Neo Chorio. To the east, in the area of Latsi and to Prodromi the rocky sub-layer changes to chalks, marls and limestone of the Pachna Formation of the Middle Miocene age. From Prodromi to the Lake the sub-layer changes again to Pliocene – Lower Pliocene marls with limestone, chalks and shingles.

SOIL CHARACTERISTICS IN THE AREA OF POLIS CHRYSOCHOUS

A surface soil of brown clay, sandy mud with some gravel and thickness of 0.2 – 0.5 m extends over the biggest part of the area and leans on a) loose alluvial deposits that consist of sand and gravels, boulders, mud and clay, having a thickness of 10 – 60 m and b) marine terrace deposits consisting of slightly or medium dense mud and sand with gravels and thickness of 30 m. This succession leans on a rocky sub-layer that from the west to the east varies between Mamonia Melange in Baths of Aphrodite and Lefkara chalks, red limestone and Pachna chalks, marls and limestone and finally Pliocene – Pleistocene marls with limestone, chalks and shingles in the Polis area.
The permeability of the marine terrace deposits is medium or low and the permeability of the alluvial deposits is medium to high. Most of the sub-layer formations are impermeable, beside the limestone that has low to medium permeability. The water level is shallow in the costal areas of Latsi and Lake but deepens in the rest of the area. In the Chrysochous River valley, the water level differs from season to season and is shallower in the end of the winter and the beginning of spring.

The current sewerage system consists of septic tanks and absorption pits; however, the soil conditions in some cases are not appropriate for such a sanitation system. This results in serious absorption problems and health hazards. Therefore, the construction of centralised sewage collection and treatment systems is judged as a necessity.

5.1.2. CLIMATE

TEMPERATURE

The mean temperatures in Polis Chrysochous for the periods 1981 – 1990 and 1991 – 2000 were as follows:

Polis Chrysochous Meteorological Station		
1981 – 1990	Mean annual temperature	18.6 °C
	Mean monthly temperature range	11.6 °C (February) – 26.7 °C (August)
1991 – 2000	Mean annual temperature	18.9 °C
	Mean monthly temperature range	11.4 °C (February) – 27.4 °C (August)

PRECIPITATION

The mean annual precipitation in the area for the period 1991 – 2000 was 399.2 mm, while the normal precipitation (1961 – 1990) was 474.1 mm. The mean monthly precipitation, during the same period, ranged between 0.0 mm in August, and 92.1 mm in December, while the normal mean monthly precipitation ranges between 0.7 mm in August and 99.7 mm in December.

Average precipitation values for the Polis Chrysochous area are as follows:

Polis Chrysochous Meteorological Station		
1991 – 2000	Mean annual precipitation	1.6 mm (August) – 79.4 mm (December)
	Mean monthly precipitation range	347.4 mm
1961 – 1990	Normal mean annual precipitation	2.5 mm (August) – 59.8 mm (December)
	Normal mean monthly precipitation range	309.8 mm

RELATIVE HUMIDITY (RH)

The mean annual relative humidity at 08:00 LST in Polis Chrysochous for the period 1981 – 1990 was 64.0%, while the mean monthly values ranged between 54.0% in July and 76.0% in January. The mean annual relative humidity at 13:00 LST during the same period was 57.0%, while the mean monthly values ranged between 52.0% in July and 62.0% in March.

For the period 1991 – 2000, the mean relative humidity at 08:00 LST was 66.0%. The mean monthly relative humidity ranged between 55.0% in July and 79.0% in December and January. The mean annual relative humidity at 13:00 LST was 59.0%, while the mean monthly values ranged between 54.0% in July and 63.0% in April and May.

The mean values for the Polis Chrysochous area are the following:

Polis Chrysochous Meteorological Station			
1981 – 1990	08:00 LST	Mean annual RH	64.0%
		Mean monthly RH range	54.0% (July) – 76.0% (January)

	13:00 LST	Mean annual RH	57.0%
		Mean monthly RH range	52.0% (July) – 62.0% (March)
1991 – 2000	08:00 LST	Mean annual RH	66.0%
		Mean monthly RH range	55.0% (July) – 79.0% (December, January)
	13:00 LST	Mean annual RH	59.0%
		Mean monthly RH range	54.0% (July) – 63.0% (April, May)

EVAPORATION

The mean daily evaporation for the period 1991 – 2000 ranged between 1.4 mm in January, and 7.7 mm in July, while the mean annual evaporation was 4.2 mm.

The mean values for the area of Polis Chrysochous for the period 1991 – 2000 are the following:

	POLIS CHRYSOCHOUS METEOROLOGICAL STATION
Mean annual evaporation	4.2 mm
Mean daily evaporation	1.4 mm (January) – 7.7 mm (July)

WIND DIRECTION

During the whole year, the prevailing winds in the area have south directions with angle 180^{o}. Between April and October north, winds with angle 0^{o}, as well as west winds with angle 270^{o} between June and August also have a high percentage of occurrences.

5.1.3. SURFACE WATER RESOURCES

5.1.3.1. NATURAL STREAMS AND SURFACE WATER BODIES

The area in which the Polis Chrysochous sewage treatment plant will be constructed is crossed by the Hortini rill, which is ca. 400 m away from Limni rill, which is bigger and flows into the sea. Both rills are seasonal.

5.1.3.2. EXISTING RESERVOIRS

There are no existing reservoirs near the site proposed for the Polis Chrysochous sewage treatment plant, therefore it will be necessary to construct a long term storage reservoir for the treated effluents, especially in winter months, when the irrigation demands will be restricted. Nevertheless, the reservoir will be located within the area of the old quarry, which is suitable in terms of geomorphology for its construction.

5.1.4. GROUNDWATER RESOURCES

The alluvial deposits of the Chrysochous River valley constitute an important aquifer, which provides the irrigation and drinking water of the area. Several drills in the past few years provide the

Chrysochous Irrigation Network with water. The alluvial and river terrace deposits to the south of Polis form the local aquifers that cover some of the irrigation needs in the costal plain.

The aquifer of the Chrysochous River covers an area of 6 km² and flows to the north along the valley. The aquifer is being used by 70 drills that pump 1.3 MCM/year in average over the past 10 years. In the same period, the natural enrichment was 2.8 MCM/year. The low precipitation levels in the last years have led to an excessive pumping of the aquifer, while the use of nitrate-containing fertilizers leads to an increase of nitrate concentrations.

The costal Chrysochous – Pomou (Yialia) aquifer covers an area of 27 km² and the water flows into the sea. Its being used by ca. 200 drills and the pumping average during 1991 – 2000 was 0.6 MCM/year, while the natural enrichment was 2.1 MCM/year. In the last years, the enrichment reduction and the pumping increase have led to the intrusion of the sea water into some areas. In addition, the agricultural activity in the last few years has led to an increase of the nitrate concentrations.

The last result report on the study on the water protection from the pollution caused by nitrates from agricultural sources according to the Directive 91/676/EEC establishes the aquifer as Nitrate Sensitive Zone. This zone is defined as an area, in which groundwater contains more than 50 mg/l NO_3 or that could contain more than 50 mg/l NO_3 if the appropriate measures are not taken. Although the Chrysochous – Pomou aquifer does not present concentrations higher than 25 mg/l NO_3, there is still danger of pollution and therefore, it is observed as a Nitrate Sensitive Zone. Polis Chrysochous falls under the defined zone.

5.2. ECOLOGICAL ENVIRONMENT

5.2.1. VEGETATION

The location proposed for the construction of the plant consists of agricultural land, which is used for temporary crops including cereals and fodders. Beside the temporary crops, some single olive trees and some natural vegetation exist in the location.

5.2.2. WILD LIFE

The proposed location is within an agricultural area, which is of no particular ecological interest. Because of the nature and its character in the area, only the most common fauna species are observed.

5.3. PLANNING ZONES AND LAND USE

5.3.1. ADMINISTRATIVE BOUNDARIES

The location proposed for the construction of the sewage treatment plant, which will service the community of Polis Chrysochous lies within the administrative boundaries of Pelathousa, in the northwest of the village, close to the boundaries with Polis. The community of Pelathousa covers a total area of 7.2 km² and Polis Chrysochous an area of 18.5 km². The administrative boundaries of the communities and the position of the plant are shown in Drawing EIA – D – 8.

5.3.2. PLANNING ZONES

The location proposed for the construction of the Polis Chrysochous sewage treatment plant falls under the Agricultural Zone. In this zone, apply the following planning provisions:

Maximum Construction Coefficient	0.15 : 1
Maximum Number of Floors	2
Maximum Height	8.30 m
Maximum Percentage of Coverage	0.10 : 1

5.3.3. EXISTING INFRASTRUCTURE

Access to the location for the construction of Polis Chrysochous sewage treatment plant will be provided by a truck road from the main Polis – Pomou road. The nearest electricity transmission line (66kV) is at a distance of approximately 300 m from the proposed location.

5.3.4. LAND OWNERSHIP

POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

The land needed for the construction of the Polis Chrysochous Sewage Treatment Plant is the following:

Sewage Treatment Plant	8 900 m^2
Emergency Storage Reservoir	7 700 m^2
Long Term Reservoir	131 970 m^2

The total area of land that will be taken up for the construction of the STP and the storage reservoirs is approximately 148 600 m^2 (14.7 ha), including the land that will be taken up for the construction of roads, parking places, landscaping and planting around the treatment plant and storage reservoirs, sludge storage etc. The lands proposed for the construction of the station constitute Turkish-Cypriot property under the supervision of the Minister of the Interiors. This constitutes a problem, since the Minister decided that no Turkish-Cypriot land will be disposed for development and the Water Development Department is trying to secure those lands.
The areas that are presented here are expected to be reduced after the programming of the reuse of treated effluent for irrigation has taken place.

PUMPING STATIONS

For the wastewater conveyance system from the community to the treatment plant a pumping station will be required that will cover a maximum area of approximately 500 m^2. The exact location of the pumping station will be determined during the detailed design of the conveyance system, therefore it cannot be assessed at this stage which plots will be acquired and whether the land will be governmental or privately owned.

5.3.5. LAND USE

POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

The location proposed for the construction of the Polis Chrysochous Sewage Treatment Plant is in an agricultural area. The site determined for the project is cultivated with temporary crops and more specifically cereals.

PUMPING STATIONS

The pumping station that will pump the wastewater from Polis to the site of the future treatment plant is expected to be within the urban area of Polis, although, as already mentioned, the exact plot has not been yet determined.

5.3.6. BUILD UP PROPERTIES

POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

There are no other developments or constructions in the area that will be used for the construction of the sewage treatment plant and the emergency and long term reservoir. If it is decided to place the long term storage reservoir in the same location, neither the construction of the emergency reservoir, nor that of the long term storage reservoir will affect directly any private property.

PUMPING STATIONS

The pumping station will be located in plots, in which there is no other development and therefore, its construction will not affect directly other existing buildings or units.

5.4. SOCIO-ECONOMIC ENVIRONMENT

5.4.1. POPULATION

5.4.1.1. POPULATION DISTRIBUTION

A summary of the population distribution in the project community of Polis Chrysochous, according to the 2001 Census of Population, is given in Table 5.2.

TABLE 5.1 : POPULATION IN POLIS CHRYSOCHOUS COMMUNITY

COMMUNITY	HOUSING UNITS			HOUSEHOLDS		INSTITUTIONS		TOTAL POPULATION
	Total	Used as Usual Residence	Vacant or Temporary Residence	Number	Population	Number	Population	
Polis Chrysochous	1 264	623	641	623	1 847	0	0	1 847

5.4.1.2. POPULATION PROJECTIONS

TABLE 5.2 : POPULATION PROJECTION FOR THE COMMUNITY OF POLIS CHRYSOCHOUS

COMMUNITY	2001	2010	2020	2030
Polis Chrysochous	1 847	2 400	3 212	4 300

TABLE 5.3: HOUSEHOLD PROJECTIONS FOR POLIS CHRYSOCHOUS

		NUMBER OF HOUSEHOLDS
2010	Permanent Population	2 400
	Seasonal Population	880
	Total	*3 280*
2020	Permanent Population	3 212
	Seasonal Population	1 130
	Total	*4 342*
2030	Permanent Population	4 300
	Seasonal Population	1 450
	Total	*5 750*

5.4.2. SOCIO-ECONOMIC INDICATORS

5.4.2.1. AGRICULTURAL LAND IN THE COMMUNITY OF POLIS CHRYSOCHOUS

The data regarding the agricultural land in Polis Chrysochous, regarding the total cultivated area, the types of crops and the land uses in the area according to the 1994 Census of Agriculture are included in Annex 7. The following Tables provide information regarding the total agricultural land and percentages regarding the crop type for comparison purposes.

TABLE 5.4: AGRICULTURAL LAND IN POLIS CHRYSOCHOUS (1994)

COMMUNITY	TOTAL AREA (DONUMS)
Polis Chrysochous	8 431

TABLE 5.5: USE OF AGRICULTURAL LAND IN POLIS CHRYSOCHOUS (1994)

	DONUMS	PERCENTAGE OF TOTAL AGRICULTURAL LAND (%)
Temporary Crops	4 318	51 %
Permanent Crops	1 713	20 %
Fallow land	940	11 %
Uncultivated, Forest and Scrub Land	1 460	17 %
TOTAL	**8 431**	**100.0 %**

TABLE 5.6: PERCENTAGE OF TEMPORARY CROPS IN POLIS CHRYSOCHOUS (1994)

COMMUNITY	CEREALS (DONUMS)	PULSES (DONUMS)	INDUSTRIAL (DONUMS)	FODDERS (DONUMS)	POTATOES (DONUMS)	VEGETABLES (DONUMS)
Polis Chrysochous	67 %	5 %	8 %	11 %	3 %	6 %

TABLE 5.7: PERMANENT CROPS BY COMMUNITY (1994)

COMMUNITY	VINEYARDS *(% of the Area of permanent crops)*	CITRUS	FRUIT	DRY NUTS	OLIVES	CAROBS
		% of Total Number of Trees				
Polis Chrysochous	*6 %*	68 %	7 %	15 %	10 %	1 %

(dark shading) Main cultivation	(light shading) Second main cultivation

Most of the agricultural land in the Polis Chrysochous community is used for the cultivation of temporary crops, and mainly cereal and fodders. The permanent crops are mainly citrus.
Regarding the reuse of the treated sewage effluents, all temporary cultivations, with the exception of vegetables, can be irrigated, as well as all permanent cultivations. The suggested effluent standards allow, according to the Code of Practice, for the irrigation of all crops, except leafy vegetables. It is, however, recommended that the irrigation of vegetables is altogether avoided, particularly in the

case of those vegetables eaten raw, so as to avoid any risk of health hazards that could arise from the misuse of the treated effluent.

The treated effluent from the Polis Chrysochous treatment plant will be reused for the irrigation of the agricultural areas that are outside the existing governmental irrigation networks.

5.4.2.2. LIVESTOCK PRODUCTION

TABLE 5.8: NUMBER OF ANIMALS IN POLIS CHRYSOCHOUS (1994)

COMMUNITY	SHEEP	GOATS	CATTLE	PIGS	CHICKEN
Polis Chrysochous	501	580	0	7	6 278

TABLE 5.9: NUMBER OF ANIMALS IN POLIS CHRYSOCHOUS (2001)

	POLIS CHRYSOCHOUS
Cattle	–
Pigs	–
Sheep	896
Goats	1 154
Sheep and Goats	2 041
Chicken	–
TOTAL	**4 091**

5.4.2.3. EMPLOYMENT

TABLE 5.10: EMPLOYMENT IN CROP AND LIVESTOCK IN POLIS CHRYSOCHOUS (1994) (EQUIVALENT OF FULL EMPLOYMENT)

	HOLDERS OF AGRICULTURAL	EMPLOYEES (PERMANENT AND CASUAL)	TOTAL
Men	87	2	89
Women	48	11	59
TOTAL	**135**	**13**	**148**

5.4.3. CULTURAL AND ARCHAEOLOGICAL VALUES

There are no historical or archaeological sites near the location proposed for the construction of the Polis Chrysochous sewage treatment plant.

6. ENVIRONMENTAL IMPACT ANALYSIS

6.1. IMPACT SCREENING

A screening of the impacts that could potentially result from the development was carried out in relation to project location and design, and the construction and operational phases. Table 6.1 outlines the probable impacts that have been identified.

TABLE 6.1 : ENVIRONMENTAL IMPACTS FROM THE PROJECT

	ENVIRONMENTAL IMPACTS
Impacts due to Project Location	*Permanent land acquisition* Permanent acquisition of land for construction of the STP, the storage reservoirs and the pumping stations.
	Impacts on surface water hydrology Positive impacts: additional surface water body.
	Ecological impacts No significant impacts are expected. Positive impacts from the creation of new wetland habitats with the construction of long term storage reservoirs.
Impacts due to Project Design	*No significant impacts are expected* - Treatment process is proven to be reliable and effluent will meet the set performance standards. - Emergency storage reservoir will safeguard against problems in treatment process. - Sludge treatment to be chosen will be effective in achieving required process. - There will be valve connections connecting the various treatment units to the stations and allowing the continuance of the station's operation in case one unit dysfunctions, offering the possibility to by-pass the specific unit and to smoothly continue the treatment.
Impacts during the Construction	*Temporary land acquisition* Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.
	Vegetation clearing Clearing of vegetation for construction of the STPs, the storage reservoirs, the pumping stations and the conveyance system.
	Soil impacts - Soil erosion: resulting from uncovered and unconsolidated materials during construction procedure - Soil disaggregation - Soil compaction

	ENVIRONMENTAL IMPACTS
	Dust, fumes and noise • Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds. • Noise: from construction operations, machinery and vehicle movements. • Fumes: from vehicle movements and machinery.
	On-site safety Risk of accidents at construction sites
	Waste management Construction waste, domestic solid waste
	Pollution Air, water, and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.
	Traffic. Off-site public safety and inconvenience As a result of increased vehicle movement and road excavations.
Impacts Related to Operation	*Landscape impacts* Limited adverse impacts
	Noise Impacts At STP sites and pumping stations. Limited impacts as the STP sites are at a considerable distance from residential areas. Some of the pumping stations however are within urban areas or near tourist areas.
	Odour impacts At STP sites and pumping stations. Limited impacts as the STP sites are at a considerable distance from residential areas. Some of the pumping stations however are within urban areas or near tourist areas.
	Impacts on groundwater resources. Positive impacts: decrease of water pumping and reduction of the nitrics released in the environment.
	Impacts from sludge production and reuse
	Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations
	Risk of insufficient treatment of effluents
	Impacts from the reuse of the treated effluents in agriculture Possible impacts on agricultural production, the soil and groundwater, plants and animals.
	Urban reuse of treated effluents Possibility of inappropriate use of treated water and impacts on public health

	ENVIRONMENTAL IMPACTS
	Groundwater recharge Possibility of aquifer contamination

6.2. ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

6.2.1. IMPACTS DUE TO PROJECT LOCATION

6.2.1.1. PERMANENT LAND ACQUISITION

- PROCESS FOR THE ACQUISITION OF LAND

Subject to the provisions of Article 23 of the Constitution and of the Compulsory Acquisition of Property Law 15/62, any property may be acquired compulsorily for a purpose, which is to the public benefit.

When immovable property needs to be acquired compulsorily the acquiring authority:

1. Shall publish a notice of the intended acquisition in the Official Gazette of the Republic.
2. Shall serve a copy of the notice of the intended acquisition to any interested person. In case the affected party cannot be found and the serving is therefore impossible and after a relevant confirmation from the local authority, an announcement is published in two daily newspapers.
3. Shall invite any interested person to submit to the acquiring authority any objections within 30 days from the date of service of the notice.
4. Will proceed to the examination of any objections to the acquisition made. The acquisition must be confirmed with the publication of an order of acquisition within 12 months from the date of publication of the notice. If an order is not published, the procedure is deemed to have been abandoned.
5. Shall, within fourteen months from the date of publication of the notice, send a written offer relating to the compensation payable for the property to be acquired.

Upon receipt of the offer, any interested person may:

1. Accept the compensation for full and final settlement of any claims relating to the acquisition of the property.
2. Accept the amount offered reserving the right to apply to Court for the fixing of the final amount of compensation.
3. Refuse or ignore the offer, in which case either the acquiring authority or the interested person may apply to the Court for the determination of the final compensation.

Where the whole property is subject to compulsory acquisition, the amount of the compensation shall be assessed with reference to the market value of the property as at the date of publication of the notice of acquisition. Where only part of the property is acquired, the compensation is also assessed with reference to the market value of that part of the property as at the date of publication of the notice. In these cases, the Law provided the set-off of betterment and compensation for injurious affection/severance, trade disturbance, reinstatement and any other damages or losses sustained by the owner. Finally, it provides that an interest of 9% should be added to the amount of compensation starting from the date of publication of the notice to the date of payment.

The exchange of state land with property or part of a property, which has been acquired compulsorily, is also possible where:

1. The compensation for the acquisition of the property has been finally determined.
2. Such acquisition deprives the applicant of the whole or part of his property which was used either:
   i) As a dwelling-house or was intended for the construction of a dwelling-house for use by the applicant or his family,
   ii) For the carry-on of any business, trade, profession or vocation,
   iii) The applicant's financial situation is considered to be poor, and
   iv) The state land that is to be exchanged:
      (a) Is situated in the same district and preferably in the same area as the acquired property.
      (b) Is suitable for the purposes for which the property was also used and
      (c) Is of an almost equal value with the compensation finally determined.

❑ LAND ACQUISITION FOR THE CONSTRUCTION OF THE SEWAGE TREATMENT PLANTS

The following table summarises the land requirements for the construction of the sewage treatment plants in Episkopi and in Polis Chrysochous, and the pumping stations for the conveyance system. The figures given take into account the additional land that is required for sludge storage, parking spaces, offices, and for landscaping and planting around the installations and the storage reservoirs.

TABLE 6.2 : LAND REQUIREMENTS FOR THE EPISKOPI STP

Sewage treatment plant		8 700 m^2
Emergency storage reservoir		7 550 m^2
Long term storage reservoir		129 480 m^2
Pumping stations	Each pumping station	500 m^2
	Total area	2 000 m^2
Total Area		147 730 m^2

TABLE 6.3 : LAND REQUIREMENTS FOR THE POLIS CHRYSOCHOUS STP

Sewage treatment plant	8 900 m^2
Emergency storage reservoir	7 700 m^2
Long term storage reservoir	131 970 m^2
Pumping stations	500 m^2

⇩ Episkopi Sewage Treatment Plant

The total land requirements for the construction of the sewage treatment plant in Episkopi and the emergency and long term storage reservoirs will be approximately 147 730 m^2, which includes the areas that will be required for sludge storage, offices, parking lots and for landscaping and planting around the installations.

The sewage treatment plant, including the emergency and long term storage reservoirs, will be constructed within a rural district. The pieces suggested for the plant construction are Turkish Cypriot property, which will be granted on approval of the Minister of Internal Affairs.

The land suggested for the project is an area is agriculturally used for the cultivation of annual plants like grain, and a part of it is under permanent crops, mainly of fruit-bearing trees. During the land acquisition, the necessary compensations must be provided to the farmers for any loss of income and for the destruction of cultivations, especially of the permanent crops.

- Polis Chrysochous Sewage Treatment Plant

The total land requirements for the construction of the sewage treatment plant and the emergency and long term storage reservoirs will be approximately 149 070 m^2, which includes the areas that will be required for sludge storage, offices, parking lots and for landscaping and planting around the installations.

The sewage treatment plant, including the emergency and long term storage reservoirs, will be constructed within an agricultural area, as in the case of the Episkopi plant. The pieces suggested for the plant construction are Turkish Cypriot property, which will be granted only on approval of the Minister of Internal Affairs.

The land suggested for the project is an area is agriculturally used for the cultivation of annual plants like grain. During the land acquisition, the necessary compensations must be provided to the farmers for any loss of income and for the destruction of their crops.

- Pumping Stations

The sewage conveyance system from the communities of Episkopi, Erimi, Kolossi, Trachoni and Ypsonas to the Episkopi treatment plant contains four pumping stations, while the sewage conveyance system from Polis Chrysochous to the treatment plant, one pumping station.

The total land requirements for each pumping station will depend on its drain potential and it is estimated to reach up to 500 m^2, the maximum, including the land required for landscaping. The maximum total land, which will be acquired for the pumping stations will be about 1 500 m^2 for the sewage conveyance system for the Limassol communities and 500 m^2 for the conveyance system for Polis Chrysochous.

The locations of the pumping stations will be determined during the detailed design of the conveyance system. Where these pumping stations will be located on private land the necessary compensation will be paid to the owners for the acquisition, as well as for any possible loss of income that might be incurred as a result.

6.2.1.2. IMPACTS ON ECOLOGY

- EPISKOPI AND POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

Due to the nature and character of the proposed location, no significant negative impacts are expected on ecology, or any destruction of natural habitats as a result of the construction of the sewage treatment plant.

The Episkopi sewage treatment plant site is within an agricultural area, as the one of the Polis Chrysochous plant. These two areas present no particular ecological interest, and most of the fauna and flora species there are common and found extensively in the regions. At the same time, both land areas where the plants will be constructed are of agricultural usage and more specifically for the cultivation of annual plants, like grain, and in Episkopi for permanent crops, mainly fruit-bearing trees, as well. Therefore, the destruction of the natural vegetation will be limited.

In the contrary, the construction of the long term storage reservoir for the treated effluents could possibly have a positive influence through the creation of wetland habitat in the area, which could have the potential of attractive bird and other fauna and flora species, especially in Episkopi due to the proximity of the site to the Akrotiri salt-pan, thus enhancing the biodiversity in the region.

- PUMPING STATIONS

Although the positions of the pumping stations are still preliminary and will be defined during the detail design of the conveyance system, these will not be constructed in ecologically sensitive areas, therefore no significant adverse impacts are expected.

6.2.2. IMPACTS RELATED TO PROJECT DESIGN

No significant impacts are anticipated in relation to the design of the STPs and the conveyance systems. The activated sludge process that has been proposed for the treatment of sewage is a proven and reliable process and, as it will be provided with tertiary treatment, the treated effluent will meet the set performance standards. With the activated sludge, process there will be stable performances despite variations in the hydraulic road. The process will ensure the removal of dissolved organic pollution (BOD, COD and SS), while the tertiary treatment will reduce the coliform counts, in accordance with the specified standards. Additionally, the process will be configured to achieve nitrogen reduction, thus reducing the nutrient levels of the receiving waters and soil. Therefore, the process will ensure the adequate treatment of wastewaters, thus minimizing the risk of any impacts arising as a result of insufficient treatment of the effluents.

The design of the sewage treatment plants includes the construction of an emergency storage reservoir to address the possibility of emergency problems in the treatment process. The reservoir of each plant will provide storage for 7 days, thus reducing the risk of any negative impacts resulting from emergency conditions.

The treatment of sludge is covered in chapters 3.3.2 and 6.2.5. The selection of the method of treatment of sludge will be based on the assumption that the treated sludge will be used as manure in agriculture, according to the specifications set.

The design of the conveyance systems will ensure that there will be no problem of creation of sulphides along the forcemains. The forcemains will be of the appropriate length, which, combined with the potentiality of the pumping stations, will help avoid odour production.

6.2.3. IMPACTS DURING THE CONSTRUCTION STAGE

6.2.3.1. TEMPORARY LAND ACQUISITION

During the construction phase, additional land will be required for the temporary construction facilities, which include worker camps, workshops, and storage and disposal areas. This could potentially lead to the temporary take up of additional land.

Where it is necessary to acquire additional land, measures should be taken up to ensure that such sites are limited to the minimum possible area required and are within the plant area. Later on, they will be planted and used for landscaping and planting reasons around the installations. Following the construction stage, all land, which was acquired temporarily, must be rehabilitated.

6.2.3.2. VEGETATION CLEARING

- EPISKOPI SEWAGE TREATMENT PLANT

The Episkopi sewage treatment plant will be constructed in an agricultural area, which is mainly used for annual crops as those of grain. In the northwest of the area, there are orchards with permanent crops, mainly fruit-bearing trees, which are surrounded by clumps of cypresses. During the design and the area division of the plant and the reservoirs, efforts will be made for the facilities to be located in the land where there are annual crops, to avoid the destruction of the permanent crops, while the clumps of cypresses will be kept as a part of the landscaping of the plant area.

Following the completion of the project, the plant site will be landscaped and various plant and tree species will be planted, thus compensating for any small losses in vegetation that will result from construction.

- POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

In the case of the Polis Chrysochous sewage treatment plant, the impacts will be comparatively more limited. The area where the treatment plant and most probably the storage reservoirs will be constructed contains of agricultural land, cultivated with annual plants, like grain and green fodder, while there are no permanent crops, except of some single trees, thus reducing the extend of the impact caused due to the destruction of the existing vegetation.

Following the completion of the project, the plant site will be landscaped and various plant and tree species will be planted, thus compensating for any small losses in vegetation that will result from construction.

- SEWAGE CONVEYANCE SYSTEM

During the construction of the conveyance systems, it is possible that vegetation, including cultivations, trees and natural vegetation, along the pipe routes will need to be cleared. In most cases, this will only be temporary, and the vegetation can be restored following the pipe laying phase. In the case of the pumping stations, the extent of vegetation destruction that will result from construction will be limited as most of the pumping stations will be within the urban or agricultural areas.
Where crop cultivations are destroyed compensation will be paid to the owners for any loss of income that might result from the destruction of crop yields and trees.

6.2.3.3. SOIL IMPACTS

Impacts on the soil of the site and along the conveyance routes could arise during the construction phase if appropriate measures are not implemented. Such impacts mainly include the erosion, disaggregation and compaction of the soil.

- Soil Erosion: This concerns mainly earthworks and spoil areas and is usually caused by rainfall, and mainly be wind. To prevent soil erosion it must be ensured that the earth piles are correctly shaped (e.g. with gentle gradients) and protected against erosion by protective walls. The creation of large expanses of bare soil must be avoided and the removal of vegetation must be reduced to the minimum possible. Additionally, the construction of the pipe network should be done by segmentation in order to minimize the spoil production.

- Soil Disaggregation: This is the mixing up of soils and arises particularly when soil is removed from one location to another. Soil disaggregation can be prevented by removing the soil in order of horizons and keeping each horizon in a separate pile.

- Soil Compaction: This is an inevitable impact during the construction stage, resulting from the movement of vehicles over soil, as well as the storage of soil heaps or other materials. A number of mitigation measures can be taken to reduce soil compaction, including the use of only a single or a few tracks by vehicles; the use of wider tires, which will spread the weight of vehicles; or by tilling the area once compaction has occurred.

Generally, during the construction phase, the topsoil must be effectively preserved for eventual use, i.e. for agricultural purposes.

6.2.3.4. DUST, FUMES AND NOISE

- IMPACTS ON AIR QUALITY DURING CONSTRUCTION

During the construction phase of the sewage treatment plants and the collection and conveyance systems, the main sources of air pollution will be the machines and vehicles through the burning of fuel, as well as the generation of dust from construction activities and vehicle movement.

To minimize the impacts the construction field and any access roads, which are not asphalted, will be watered several times a day, particularly during the summer, to reduce the amount of dust produced, while the regular maintenance of machinery and vehicles should be ensured. Provided that dust control and site management measures are adopted, the impacts will be localized, temporary and are not expected to be significant.

- NOISE DURING THE CONSTRUCTION STAGE

During the construction phase, the levels of noise to be generally anticipated are in the range 92 – 95 dB (A) at 5m. More specifically, it will vary between the different stages of the construction process, including:

- Site clearance
- Foundation work
- Building construction
- Road construction
- Pipe laying

The main sources of noise will be the operation of construction machines, the vehicles transporting materials and personnel, and the vibration caused by activities such as blasting and excavations.

TABLE 6.4: TYPICAL MAXIMUM NOISE LEVELS PERMITTED AT CONSTRUCTION SITES

MACHINES AND VEHICLES	dB(A)
Lorries	85
Bulldozer	120
Diesel mechanical shovel	110
Diesel earth excavator	105
Concrete breaker	110
Diesel winch	105
Dumper trucks	100
Diesel ground compactor	110
Concrete mixer	115
Concrete pump	115
Tractor	120
Soil grader	120
Pneumatic drill	125
Fixed compressor	115
Loader	115
Electric motor (300HP)	105
Electric pump (300HP)	120
Car	75
Bus	85

TABLE 6.5: NOISE LEVELS FROM MACHINERY USED DURING CONSTRUCTION

	EQUIPMENT	15 m	30 m	50 m	100 m	200 m
1.	Excavator	78	72	67	61	53
2.	Bulldozer	78	72	67	61	53
3.	Drilling machine	89	83	78	72	66
4.	Air compressor	75	69	64	58	52
5.	Vibrator	76	70	65	59	53
6.	Mixer	75	69	64	58	52
7.	Truck	76	70	65	59	53

Noise impacts during the construction phase will arise mainly from the construction of the collection systems, as works will take place within the residential areas, and partly from construction of the conveyance systems. In the case of the STPs, there will be no noise impacts on the resident population as all three sites are at a sufficient distance from housing areas.

Although during the construction phase noise control measures can be incorporated in the contract with the constructors, construction takes place in the open with the use of heavy machinery and often within residential areas. Therefore, the feasible noise control measures are rather restricted.

Mitigation measures to be adopted include:

- The use of low noise compressors, engines and equipment.
- A specification on the hours when construction will commence, while construction during the night hours when background noise levels are low should be strictly controlled to minimize impacts.

To ensure the effective adoption of mitigation measures these will be incorporated in the environmental specifications of the constructor as part of the contract.

6.2.3.5. ON-SITE SAFETY

The contractor, to ensure the avoidance of accidents in relation to the work force and the environment, must implement health and safety measures on the construction sites. The construction equipment and machinery, and all vehicles must undergo regular maintenance, while measures to ensure traffic security must be adopted and applied at all times. Regarding the work force, personal protective equipment must be provided and used at all times, medical assistance should be readily available, and preparedness procedures in case of accidents or emergency situations must be established.

6.2.3.6. WASTE MANAGEMENT

Waste is expected to arise as a result of construction activities, including construction waste and domestic solid waste from the workers' facilities. Domestic waste should be collected and transported to the appropriate official landfill site. In the case of construction waste, where these cannot be reused elsewhere, they should also be disposed at an official landfill site. Measures must also be taken for the handling of effluents from workers' sanitary facilities to prevent any risk of effluent runoffs.

6.2.3.7. POLLUTION

During the construction phase, there is the possibility of soil or water pollution as a result of effluents from camps, oils from engines, effluents from concrete production, or from other building materials used. Such effluents pose a risk for soil pollution and, potentially, aquifer pollution if the aquifer is near the surface. The risk for surface water pollution is lower, unless there is water runoff leading to the transport of pollutants into surface water bodies. Where the release of effluents is considered to pose a serious threat of soil pollution or when there is a possibility for runoff, procedures must be taken for the containment of pollutants.

Pollution, and particularly soil pollution, may also be the result of accidental spillages on construction sites, particularly in the case of storage tanks or on-site pumps. Measures must be taken to minimize the impacts of any accidental spillages, including the containment of such tanks on concrete floors with walls to prevent the release of effluents on the soil in case of a spillage.

6.2.3.8. OFF-SITE PUBLIC SAFETY AND INCONVENIENCE

During the construction of the sewage treatment plants there will be increased vehicle movement to and from the sites for the transportation of materials, equipment and personnel. This could potentially lead to driver delays along these roads, as well as increased risk of road traffic accidents.

The impacts during the construction of the collection and conveyance systems, however, will be more significant. The proposed collection and conveyance systems will, in most cases, be constructed along main roads, often within the community residential areas, which will cause inconveniences for the resident population. The opening of trenches and the partial or total closing of roads during the excavation and pipe-laying stages will lead to traffic congestions, and increase the risk of car accidents.

Mitigation measures are rather restricted. In the case of vehicle movements, these should be restricted to avoid hours of peak traffic. The necessary marking should also be provided along the roads where the pipe laying will take place, in order to avoid accidents and to make things easier for the public. Good site management during the construction stage and the adoption and adherence to road safety measures will minimize these impacts.

6.2.4. IMPACTS DURING PROJECT OPERATION

6.2.4.1. LANDSCAPE IMPACTS

- EPISKOPI SEWAGE TREATMENT PLANT

The landscape and visual impacts that will result from the construction of the Episkopi sewage treatment plant will be limited. Although this is a flat area and the site will be seen from the surrounding areas, the impacts minimize due to the distance of the plant location from the main roads and due to the cover offered by the existing permanent crops and clumps of cypresses.

Additionally, measures will be taken for the further minimization of any negative impacts. The site of the plant will be landscaped, and the trees and other plant species will be planted, so the area will have the appearance of a park. Furthermore, there will be appropriate architectural design of the installations to ensure that the plant will be in line with the built and natural environment of the wider region.

- POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

The landscape and visual impacts that will result from the construction of the Polis Chrysochous sewage treatment plant will be limited as well. The proposed site is located in an agricultural area of little value with regards to the landscape, which is distanced and isolated from main roads, residential areas and recreation places. Therefore, the impacts of the project will be limited.

Additionally, measures will be taken for the further minimization of any negative impacts. The site of the plant will be landscaped, and the trees and other plant species will be planted, so the area will have the appearance of a park or a green area. Furthermore, there will be appropriate architectural design of the installations to ensure that the plant will be in line with the built and natural environment of the wider region.

- PUMPING STATIONS

Any landscape or visual impacts that may result from the construction of the pumping stations will be minimized through the landscaping of the areas that will be carried, and the appropriate architectural design of the installations.

6.2.4.2. IMPACTS ON THE QUALITY OF LIFE

- EPISKOPI SEWAGE TREATMENT PLANT

No significant impacts are expected as a result of noise or odours on the residents of the community from the operation of the Episkopi sewage treatment plant. The location that is proposed for the construction of the plant is at a sufficient distance from the housing area, thus ensuring that there will be no risk or impacts. The site is at a distance of approximately 1.5 km from the boundary of the Episkopi residential zone, and 2 km in the case of Kolossi.

Regarding the wind direction in the project wider area, during the months October to March the prevailing winds are expected to have northwest to northeast directions, with angles between 300^o and 30^o. From April until September the prevailing winds will mainly have southwest directions, with angles between 210^o and 240^o. Although the prevailing winds during the period from April to September are in the direction of the Kolossi housing area, the distance of the proposed site from the residential zone ensures the avoidance of any odour risks.

- POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

No significant impacts are expected as a result of noise or odours on the residents of the community from the operation of the sewage treatment plant in Polis Chrysochous as well. The location that is proposed for the construction of the plant is at a sufficient distance from the housing area, thus ensuring that there will be no risk or impacts. The site is at a distance of approximately 1.5 km from the boundary of the Polis Chrysochous residential zone, and 2 km from the residential zone of Pelathousa community.

Regarding wind direction, throughout the year the prevailing winds have south directions, with angles of 180^o. Also winds having north directions, with angles of 0^o occur often from April to October, as winds having west directions, with angles of 270^o during the months June until August. Generally, the prevailing winds of the area are not in the direction of the housing areas of the neighbouring communities, thus further minimizing the risk of any impacts on their lives due to odours.

Additional to the sufficient distance of the site from the communities, with regards to odours, the plant design will ensure the effective control of odours as it will incorporate an odour removal system. These two factors, and the wind direction as well, will be suspending factors regarding the odour transport towards the residential area of the communities.

Moreover, noise impacts are also addressed by the Environmental Management Programme through the introduction of a noise monitoring programme and mitigation measures to ensure the avoidance of any negative impacts that could arise.

In conclusion, the plant design and the Environmental Management Programme, in conjunction with the distance of the STP site from residential areas ensure that there will be no adverse impacts on the quality of life for the concerned communities.

- NOISE IMPACTS DURING THE OPERATION OF THE SEWAGE TREATMENT PLANTS

Noise levels in the range 65 – 70 dB (A) may be expected near equipment such as pumps, ventilators and air compressors. However, as mentioned above, the distance of the site from residential areas is itself a mitigation measure against impacts on the resident population. Other measures include:

- ⇨ Use of low noise equipment
- ⇨ The application of noise control equipment at various stages of the treatment process
- ⇨ Enclosing the sources of noise
- ⇨ Use of noise screens, including tree plantings.

A monitoring programme for the control of noise is addressed in the Environmental Management Programme.

- NOISE AT PUMPING STATIONS

The careful design of pumping stations will ensure the minimization of any noise produced during operation. As pumping stations work intermittently, operation will be more frequent during peak hours which are not usually during the night time, therefore any impacts are inherently minimized. The use of low noise equipment and the design of buildings to incorporate specific acoustic features, together with their sitting at appropriate locations as far away from residential areas as possible and again the use of natural barriers will ensure the mitigation of any such impacts.

- ODOUR IMPACTS DURING THE OPERATION OF THE SEWAGE TREATMENT PLANTS AND THE PUMPING STATIONS

During the operation of the sewage treatment plants and the conveyance systems, odours can potentially arise from a number of sources, including screenings and grit removal facilities, primary settling tanks, sludge thickening tanks, sludge conditioning and dewatering facilities, or sludge digesting and composting operations. However, the risk of odour impacts can be effectively mitigated through:

- ⇨ The application and adherence to proper process procedures
- ⇨ The covering of process areas and the provision for adequate air filtration
- ⇨ The regular monitoring of processes and the conducting of all appropriate chemical and biochemical analyses
- ⇨ The regular maintenance of the plant and pumping stations.

The introduction of odour control systems in the STP design and the distance of the site from residential areas, as mentioned above, in conjunction with these measures will effectively mitigate odour impacts.

Regarding the formation of sulphides in the case of the forcemains along the conveyance system, with appropriate design no impacts are expected for lengths of forcemain below 10m, which corresponds to a transfer time of approximately 3 hours. It is being proposed that during the design the flow (maximum hourly flow) should be at 100% of the pipe capacity, so that the air that could transfer odour will not be allowed to enter the pipes.

6.2.4.3. IMPACTS ON UNDERGROUND WATER RESOURCES

The project is expected to have positive impacts on the groundwater resources. The treated effluent quantities that will be produced from the sewage treatment plants in 2005, 2015 and 2030 are as follows:

	TREATED EFFLUENT QUANTITIES
Episkopi Sewage Treatment Plant	
2005	801 271 m^3/year
2015	957 120 m^3/year
2030	1 257 027 m^3/year
Polis Chrysochous Sewage Treatment Plant	
2005	220 313 m^3/year
2015	314 875 m^3/year
2030	476 157 m^3/year

The treated effluents from the Astromeritis sewage treatment plant can be reused for irrigation purposes in the region, thus providing a permanent water resource for the communities. This will result in a decrease in the amount of groundwater that is pumped, therefore reducing the risk of groundwater depletion, and the reduction of the sea water inflow to the aquifers of Akrotiri and Pomou.

An additional advantage is that the project will result to the reduction of nitrates which are currently released into the soil from the existing sanitary system (septic tanks) in the communities.

More information can be found in Appendix 16, after the questions asked during the meetings that took place at the Environmental Department of the Ministry of Agriculture, Natural Resources and Environment on November 22, 2004 and February 16, 2005.

6.2.4.4. RISK OF SYSTEM OVERLOAD

The risk of system overload is minimal. The STP design parameters will be based on the population projections for the year 2030, while by accounting for the summer tourism requirements for each of the communities the risk of seasonal overload is not anticipated. Additionally, connections with valves of the various treatment units will be included during the designing of the station, so that the possibility of by-passing any malfunctioning unit is given, as well as the continuance of the smooth operation of the station. Any accidental overload from equipment failure will be mitigated though the construction of the emergency storage reservoir. In case it will be impossible to by-pass a malfunctioning unit, the untreated effluent will be temporarily placed in the emergency storage reservoir, until their appropriate treatment is possible.

6.2.4.5. RISK OF INSUFFICIENT TREATMENT OF EFFLUENTS

The strictest limits will be applied for the designing if the stations, combining the European Standards of the Regulation 91/271/EEC and the Cyprus Standards for the usage of treated effluent in agriculture. Therefore, the nitrogen and phosphorus removal will be based on the European Standards, while the BOD limits for the suspended substances and the microorganisms will be based on the Cyprus Standards. Thus the satisfactory effluent treatment will be ensured. The quality of the treated effluent should be regularly monitored though, to ensure that the treatment process runs according to the set parameters and to timely detect any emergency situations.

The proper maintenance of the station equipment and the timely replacement or repair of the various units included in the stations will also help the efficient and sufficient effluent treatment.

6.2.5. IMPACTS FROM THE PRODUCTION AND REUSE OF SEWAGE SLUDGE

The sludge quantities that are expected to be produced are outlined in the following table.

	EXPECTED SLUDGE QUANTITY, 30% DS CONTENT (m/year)		
	2005	2015	2030
Episkopi Sewage Treatment Plan	1 383 m^3/year	1 618 m^3/ year	2 051 m^3/ year
Polis Chrysochous Sewage Treatment Plan	216 m^3/ year	302 m^3/ year	450 m^3/ year

Table 6.6 gives the average sludge composition in Cyprus. Detailed information regarding sludge quality and constituents is outlined in Appendix 8.

TABLE 6.6: AVERAGE COMPOSITION OF SLUDGE IN CYPRUS

	MEAN VALUE
Date	1995 – 1999
Dry Matter (DM) (%)	22 – 73
Organic Matter (% DM)	67 – 72
N % DM	3.75 – 4.53
P % DM	1.97 – 2.27
K % DM	0.25 – 0.26
mg/kg DM	
Cd	1.85 – 3.5
Cr	22 – 133
Cu	129 – 202
Hg	0.4
Ni	30 – 32
Pb	44 – 70
Zn	659 – 1173
nb/g wm	
Enteric virus	4.3 x 10^4/100g
Viable Helminth eggs	0

6.2.5.1. SLUDGE DISPOSAL AND REUSE

Particularly during the first years of operation of the sewage treatment plants, the main disposal route for the sewage sludge will be landfill, which will accommodate a significant percentage of the quantities produced annually. Regarding landfill disposal, two options are available:

- Either the sludge will be transported for disposal to the nearest official controlled landfill site that is appropriately designed to receive such waste, or,
- for the creation of a new controlled landfill, designed to accommodate such waste as sewage sludge, in addition to the solid waste from the communities.

For this purpose, a feasibility study must be conducted to:

- Assess the costs of the two options, i.e. the costs for the transport of sludge to the existing landfill site as compared to the costs for the creation of a new site(s) near the STPs,
- Identify possible locations for a new landfill site/sites,
- Evaluate the costs and benefits of each option in economic, technical and environmental terms.

However, the volume of sludge that is disposed in landfill must be reduced, primarily through the reuse of sludge for agricultural purposes. Based on this objective, the quality of the treated sludge must be according to the set standards, while provisions must be made for the storage and drying of the sludge at the STP sites. A minimum storage period of two months is recommended, in addition to the treatment process, to further reduce the pathogens present in sludge to appropriate levels. Such reuse will recycle the constituents of sludge which are important nutrients in crop production, while at the same time reducing the need for fertilizers, and the quantities of sludge that are disposed in landfills.

For the efficient use of sludge in agriculture, a regional management plan must be drafted which will increase the percentage of sludge that is recycled and ensure safe reuse practices.

6.2.5.2. SLUDGE REUSE: MANAGEMENT PLAN

The drafting of a regional management plan is proposed to ensure the availability and efficiency of long term disposal and, more importantly, recycling possibilities for sludge.

Although landfills are currently the main disposal route for sludge, and will continue to be the base option for a significant percentage of the total sludge quantities that will be produced, EU policy is in favor of developing the use of sludge in agriculture, as it is considered to be the best option from both the economic and environmental perspectives.

To increase the percentage of sludge used in agriculture and ensure the sustainability and acceptance of this route, together with the adoption and adherence to appropriate management practices, the development of a regional reuse plan is recommended. This plan will seek to increase the extent and possibility for sludge recycling and secure that the reuse of sludge shall be carried out in such a way as to minimize any risk of negative effects to:

- Human, animal and plant health
- The quality of groundwater and surface water
- The long term quality of the soil

The reuse plan must be based on the following criteria:

- Sludge quality: sludge quality must be according to the set standards regarding heavy metal concentrations, as well as N and P concentrations.

- Application rates: they must be determined based on the N and P requirements of the specific crops, the N and P levels in the sludge, the metal concentrations in the sludge and the application rates specified in the set standards, and the quality of the soil.

- Crop selection: based on crop nutrient requirements and crop tolerance to certain sludge constituents.

- Application methods: depending of the physical characteristics of the sludge and soil, and the types of crops.

- Scheduling of application: the timing of land applications must be scheduled around the tillage, planting and harvesting operations for the crops grown, also taking into account climate and soil properties.

- Site identification: possible sites where sludge can be used (also securing acceptance by farmers).

- Measures to encourage use of sludge and reduce constraints: including,
  - Technical options:
    - Implement regular monitoring of sludge quality
    - Guarantee quality of sludge recycling practices
  - Economic and regulatory options:
    - Establish clear provisions on producer responsibility ensuring that sludge producers are responsible for the quality of the sludge supplied and shall guarantee its suitability for use.

- ⇨ Measures to ensure that sludge suppliers accept liability for any economic or damage associated with the use of sludge.
- ⇨ Establishment of guarantee funds or insurance systems in case of accidents.
- ⇨ Arrange voluntary agreements between farmers and food suppliers to ensure no discriminative measures are taken against products grown with the use of sludge.

6.2.5.3. MITIGATION MEASURES FOR THE APPROPRIATE USE OF SLUDGE IN AGRICULTURE

Misuse of the agricultural value of sludge Leaching of nitrates to groundwater
⇩ Better knowledge of sludge content in terms of compounds of agricultural value
❑ Adequate sampling procedures (frequency, number of samples, etc.)
❑ Adequate analysis protocols
⇩ Improve use of sludge agricultural value
❑ Determination of the sludge agricultural value (N, P, K, content)
❑ Planning and application adapted according to: ⇨ Plant needs ⇨ Other fertiliser sources ⇨ N remaining in the soil ⇨ Nutrient bioavailability ⇨ Adequate spreading periods according to agricultural and environmental constraints
❑ Regular soil analyses to establish increase in nutrient content
❑ Information from farmers about quantities spread
Soil contamination by heavy metals and organic pollutants
⇩ Determination of background levels in soil
⇩ Determination of pollutant content in sludge
⇩ Safe storage of sludge
❑ Safe storage to reduce leaching
❑ Sufficient storage capacity
❑ Reduction of storage duration in the field
Water contamination by heavy metals and organic contaminants
⇩ Forbid sludge spreading in sensitive areas, especially:
❑ On sloping land ❑ Near surface water ❑ On wet areas ❑ Within water resource protection areas ❑ On sandy soils ❑ On frozen grounds ❑ In areas where the water table is near the surface
⇩ Encourage fast ploughing down in order to reduce the risk of runoff and the use of close-to-ground techniques in order to reduce the formation of aerosols
⇩ Safe storage of sludge
Crop contamination by heavy metals and organic pollutants
❑ Reduce transfer in the food chain
⇨ Encourage sludge spreading before non-food crops

⇩ Limit plant uptake
⇨ Adapt sludge spreading to soil types (mainly according to pH and CEC)
⇨ Take into consideration heavy metal bioavailability in soil
⇨ Define a crop/sludge type matrix with specific recommendations
⇨ Prohibit sludge spreading on plant/crops which are known to accumulate heavy metals
⇩ Limit deposition on plant
❑ Limit use of sludge on vegetable and certain fruit productions
⇩ Analyses of the metal level in crops and foodstuff
Animal contamination by heavy metals and organic pollutants
⇩ Limit pollutant transfer to animals
❑ Tighten limits concerning quantity and quality of sludge which may be applied
❑ Grazing land: ⇨ Introduce a time period before harvesting ⇨ Favor sludge ploughing down
❑ Grassland: ⇨ Allow spreading before sowing and after each cut
⇩ Control of the metal levels in foodstuffs
❑ Analysis of the pollutant levels in animal products
Human contamination risks
⇩ Limit pollutant transfer in the food chain
⇩ Protection of operating equipment
❑ Ensure safe manipulation of sludge
❑ Material cleaning and maintenance
❑ Protective clothes
Contamination by pathogens
⇩ Animal contamination
❑ Grazing land: introduce a time period before grazing
❑ Grassland: allow spreading before sowing and after each cut
❑ Encourage fast ploughing down of sludge
⇩ Human contamination
❑ Prohibition of sludge spreading on products which are to be consumed raw
❑ Safe transportation of sludge
❑ Prohibition of sludge spreading in the vicinity of houses and near bathing water and drinking water supply areas

Sludge must be used according to the following table:

TABLE 6.7: SAFE-SLUDGE MATRIX

	ADVANCED TREATMENTS	CONVENTIONAL TREATMENTS
Pastureland	Yes	Yes, deep injection and 6-week no-grazing
Forage crops	Yes	Yes, 6-week no-harvest
Arable land	Yes	Yes, deep injection or immediate ploughing down
Fruit and vegetable crops in contact with the ground	Yes	No. no harvest for 12 moths following application
Fruit and vegetable crops in contact with the ground – eaten raw	Yes	No. no harvest for 30 moths following application
Fruit trees, vineyards, tree plantations and reforestation	Yes	Yes, deep injection and 10-month no-access to the public

Source : EE, 2000 (“ Working document on sludge, 3rd Draft”)

6.2.5.4. SUGGESTED LIMIT STANDARDS FOR SLUDGE QUALITY

A set of limit values are suggested for the concentrations of heavy metals in the sludge, the soils on which sludge will be applied and for the heavy metal application rates. These are lower than the standards set by the Regulations on the Use of Sludge in Agriculture (517/2002) and the respective Code of Practice.

TABLE 6.8: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SOIL

PARAMETER	LIMIT VALUES(mg/kg DS)			
	Regulation 517/2002 6<pH<7	Proposed Limit Values		
		5 ≤ pH < 6	6 ≤ pH < 7	pH ≥ 7
Cadmium (Cd)	1 – 3	0.5	1	1.5
Copper (Cu)	50 – 140	20	50	100
Nickel (Ni)	30 – 75	15	50	70
Lead (Pb)	50 – 300	70	70	100
Zinc (Zn)	150 – 300	60	150	200
Mercury (Hg)	1 – 1.5	0.1	0.5	1
Chromium (Cr III)	–	30	60	100

TABLE 6.9: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SLUDGE USED IN AGRICULTURE

PARAMETER	LIMIT VALUE (mg/kg DS)		LIMIT VALUE (mg/kg P)
	Regulation 517/2002	Proposed Limit Values	Proposed Limit Values
Cadmium (Cd)	20 – 40	10	250
Copper (Cu)	1 000 – 1 750	1 000	25 000
Nickel (Ni)	300 – 400	300	7 500
Lead (Pb)	750 – 1 200	750	18 750
Zinc (Zn)	2 500 – 4 000	2 500	62 500
Mercury (Hg)	16 – 25	10	250
Chromium (Cr III)	–	1 000	25 000

TABLE 6.10: PROPOSED LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO SOIL

PARAMETER	LIMIT VALUE (kg/ha/year)	
	Regulation 517/2002	Proposed Limit Values
Cadmium (Cd)	0.15	0.03
Copper (Cu)	12	3
Nickel (Ni)	3	0.9
Lead (Pb)	15	2.25
Zinc (Zn)	30	7.5
Mercury (Hg)	0.1	0.03
Chromium (Cr III)	–	3

6.2.5.5. MONITORING PROGRAM

In addition to the mitigation measures and the sludge management plan, a monitoring programme is required regarding sludge and soil quality, and application rates and practices, to ensure that implementation of the mitigation measures and good practice guidelines, as well as the adherence to the set standards. This is outlined in the Environmental Management Programme.

6.2.6. TREATED EFFLUENT DISPOSAL

6.2.6.1. TREATED EFFLUENT QUANTITIES

The maximum expected quantities of treated effluent for the years 2005, 2015 and 2030 have been estimated as follows:

	TREATED EFFLUENT QUANTITY
Episkopi Sewage Treatment Plant	
2005	801 271 m^3/year
2015	957 120 m^3/year
2030	1 257 027 m^3/year
Polis Chrysochous Sewage Treatment Plant	
2005	220 313 m^3/year
2015	314 875 m^3/year
2030	476 157 m^3/year

6.2.6.2. REUSE OF TREATED EFFLUENT IN AGRICULTURE

The low rainfall patterns in Cyprus have often resulted in long periods of drought and, as a result, water shortages with their associated impacts on the agricultural sector. During the years between 1997 and 2000, for instance, the supplies for irrigation water were severely limited due to the low rainfall, with the available water in dams having reached critical levels. Irrigation water was rationalized and the amount allocated to farmers ranged between 30 – 70 % of the normal demand. Priority was given only to permanent crops, at the expense of annual cultivations. To overcome shortages groundwater supplies were excessively pumped to meet demand, while, at the same time, the agricultural sector had suffered severe losses. Taking the situation in Cyprus with regard to such shortages, the reuse of the treated effluents for irrigation purposes is recommended, since it will provide an additional permanent water resource. Additionally, as the regulations regarding the disposal of treated effluents in water bodies in essence prohibits discharges in dry rivers, as the quantity of the effluent must not exceed 10 % of the river flow, and while government policy discourages disposal in the sea, then agricultural reuse is the only viable option.

In consideration of the above, it is recommended that the treated effluents be used for irrigation purposes, either directly or indirectly through aquifer recharge.

6.2.6.3. QUALITY OF THE TREATED EFFLUENTS

The suggested limit standards regarding the quality of the treated effluent are a combination of EU and Cyprus Standards. As a result the discharge limits will be those imposed by the Code of Practice for the use of Treated Sewage Effluents in Irrigation, for the irrigation of all crops; while also addressing the removal of nitrogen and phosphorus as indicated by the EU Standards. This will ensure that no adverse impacts arise from the reuse of the treated effluent.

TABLE 6.11: SUGGESTED LIMIT STANDARDS FOR TREATED EFFLUENT QUALITY

PARAMETER	LIMIT
BOD_5	10 mg/l
COD	< 125 mg/l
Suspended Solids	10 mg/l
Total N	15 mg/l
Faecal Coliforms	5 units/100 ml (in 80% of the samples) 15 units/100 ml (maximum)
Intestinal Worms	Nil
Total P	2 mg/l

6.2.6.4. LAND REQUIREMENTS FOR THE REUSE OF THE TREATED EFFLUENT

Taking an average water demand of 800 m^3/donum/year, the total land requirements for the reuse of the treated effluent for crop irrigation are as follows:

YEAR	QUANTITY OF TREATED EFFLUENT (m^3)	LAND REQUIREMENTS (DONUMS)
Episkopi Sewage Treatment Plant		
2005	801 271m^3/year	1 002
2015	957 120 m^3/year	1 196
2030	1 257 027 m^3/year	1 571
Polis Chrysochous Treatment Plant		
2005	220 313 m^3/year	275
2015	314 875 m^3/year	394
2030	476 157 m^3/year	595

Although the actual area which will be required for reuse of the treated effluent will depend on the crops to be irrigated, taking the average water demand to be 800 m^3/donum/year, the treated effluent from the two sewage plants can be reused for the irrigation of agricultural land within the project villages, which are not included in an existing irrigating network.

6.2.6.5. TREATED EFFLUENT REUSE FOR IRRIGATION: REGIONAL MANAGEMENT PLANT

To ensure the efficiency and sustainable reuse of the treated effluent for irrigation the drafting of a Regional Management Plan is recommended, aimed at optimizing crop yields and quality, maintaining soil productivity and safeguarding the environment.

❑ COMPOSITION OF THE TREATED EFFLUENT

One of the key considerations in drafting an agricultural reuse management plan is the composition of the treated effluent in nutrients and other constituents.

One of the main reasons of concern regarding the reuse of the treated effluent for agricultural irrigation is their contenting some elements like salinity, sodium, trace elements, chlorine and nutrients. Treated water tends to have higher concentrations of these constituents than groundwater or surface water and a reuse scheme must take into account the sensitivity of the crops to be irrigated in relation to these constituents.

⇩ Salinity

Salinity is one of the most important agricultural water parameters affecting plant growth, and crop yield and quality, while the tolerance of plants to salinity varies widely. Generally, crops must be chosen carefully to ensure that they can tolerate the salinity of the treated effluent that will be used for irrigation, while the soil must be properly drained and adequately leached to prevent salt build-up.

Salinity has an influence on the soil's osmotic potential and specific ion toxicity, and may result in degradation of the soil physical conditions. These could result in reduced plant growth rates or reduced yields. Table 6.14 taken from a document of the international organisation FAO (Food and Agriculture Organisation) named “Wastewater treatment and use in Agriculture – FAO – irrigation paper 47”, which was written by M.B. Pescod in 1992, shows the relevant salt tolerance of certain crops. To avoid any adverse effects, the salinity of the treated effluents must be monitored regularly and the crops to be irrigated must be carefully selected in accordance with their sensitivity.

TABLE 6.12: RELATIVE SALT TOLERANCE OF AGRICULTURAL CROPS

TOLERANT	
Fiber, Seed and Sugar Crops	
Barley	*Hordeum vulgare*
Cotton	*Gossypium hirsutum*
Jojoba	*Simmondsia chinensis*
Sugar beet	*Beta vulgaris*
Grasses and Forage Crops	
Alkali grass	*Puccinellia airoides*
Alkali sacaton	*Sporobolus airoides*
Bermuda grass	*Cynodon dactylon*
Kallar grass	*Diplachne fusca*
Saltgrass, desert	*Distichlis stricta*
Wheatgrass, fairway crested	*Agropyron cristatum*
Wheatgrass, tall	*Agropyron elongatum*
Wildrye, Altai	*Elymus angustus*
Wildrye, Russian	*Elymus junceus*
Vegetable Crops	
Asparagus	*Asparagus officinalis*
Fruit and Nut Crops	
Date palm	*Phoenix dactylifera*
Moderately Tolerant	
Fiber, Seed and Sugar Crops	
Cowpea	*Vigna unguiculata*
Oats	*Avena sativa*
Rye	*Secale cereale*
Safflower	*Carthamus tinctorius*
Sorghum	*Sorghum bicolour*
Soybean	*Glycine max*

Triticale	*X Triticosecale*
Wheat	*Triticum aestivum*
Wheat, Durum	*Triticum turgidum*
Grasses and Forage Crops	
Barley, forage	*Hordeum vulgare*
Brome, mountain	*Bromus marginatus*
Canary grass, reed	*Phalaris, arundinacea*
Clover, Hubam	*Melilotus alba*
Clover, sweet	*Melilotus*
Fescue, meadow	*Festuca pratensis*
Fescue, tall	*Festuca elatior*
Harding grass	*Phalaris tuberose*
Panic grass, blue	*Panicum antidotale*
Rape	*Brassica napus*
Rescue grass	*Bromus unioloides*
Rhodes grass	*Chloris gayana*
Ryegrass, Italian	*Lolium italicum multiflorum*
Ryegrass, perennial	*Lolium perenne*
Sudan grass	*Sorghum sudanense*
Trefoil, narrowleaf birdsfoot	*Lotus corniculatus tenuifolium*
Trefoil, broadleaf	*L. corniculatus arvenis*
Wheat, forage	*Triticum aestivum*
Wheatgrass, standard crested	*Agropyron sibiricum*
Wheatgrass, intermediate	*Agropyron intermedium*
Wheatgrass, slender	*Agropyron trachycaulum*
Wheatgrass, western	*Agropyron smithii*
Wildrye, beardless	*Elymus triticoides*
Wildrye, Canadian	*Elymus canadensis*
Vegetable Crops	
Artichoke	*Helianthus tuberosus*
Beet, red	*Beta vulgaris*
Squash, zucchini	*Cucurbita pepo melopepo*
Fruit and Nut Crops	
Fig	*Ficus carica*
Jujube	*Ziziphys jujuba*
Olive	*Olea europaea*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*
Pomegranate	*Punica granatum*
Moderately Sensitive	
Fiber, Seed and Sugar Crops	
Broadbean	*Vicia faba*
Castorbean	*Ricinus communis*

Maize	*Zea mays*
Flax	*Linum usitatissimum*
Millet, foxtail	*Setaria italica*
Groundnut/peanut	*Arachis hypogaea*
Rice, paddy	*Oryza sativa*
Sugarcane	*Saccarum officinarum*
Sunflower	*Helianthus annuus palustris*
Grasses and Forage Crops	
Alfalfa	*Medicago sativa*
Bentgrass	*Agrostisstoloniferapalustris*
Bluestem, Angleton	*Dichanthium aristatum*
Brome, smooth	*Bromus inermis*
Buffelgrass	*Cenchrus ciliaris*
Burnet	*Poterium sanguisorba*
Clover, alsike	*Trifolium hydridum*
Grasses and Forage Crops	
Clover, Berseem	*Trifolium alexandrinum*
Clover, ladino	*Trifolium repens*
Clover, red	*Trifolium pratense*
Clover, strawberry	*Trifolium fragiferum*
Clover, white Dutch	*Trifolium repens*
Corn, forage (maize)	*Zea mays*
Cowpea (forage)	*Vigna unguiculata*
Dallis grass	*Paspalum dilatatum*
Foxtail, meadow	*Alopecurus pratensis*
Grama, vlue	*Bouteloua gracilis*
Lovegrass	*Eragrostis sp.*
Milkvetch, Cicer	*Astragalus deer*
Oatgrass, tall	*Arrhenatherum, Danthonia*
Oats, forage	*Avena saliva*
Orchard grass	*Dactylis glomerata*
Rye, forage	*Secale cereale*
Sesbania	*Sesbania exaltata*
Siratro	*Macroptilium atropurpureum*
Sphaerophysa	*Spaerophysa salsula*
Timothy	*Phleum pratense*
Vetch, common	*Vicia angustifolia*
Vegetable Crops	
Broccoli	*Brassica oleracea botrytis*
Brussel sprouts	*B. oleracea gemmifera*
Cabbage	*B. oleracea capitata*
Cauliflower	*B. oleracea botrytis*
Celery	*Apium graveolens*

Corn, sweet	*Zea mays*
Cucumber	*Cucumis sativus*
Eggplant	*Solanum melongena esculentum*
Kale	*Brassica oleracea acephala*
Kohlrabi	*B. oleracea gongylode*
Lettuce	*Latuca sativa*
Muskmelon	*Cucumis melon*
Pepper	*Capsicum annum*
Potato	*Solanum tuberosum*
Pumpkin	*Cucurbita peop pepo*
Radish	*Raphanus sativus*
Spinach	*Spinacia oleracea*
Squash, scallop	*C. pepo melopepo*
Sweet potato	*Ipomoea batatas*
Tomato	*Lycopersicon lycopersicum*
Turnip	*Brassica rapa*
Watermelon	*Citrullus lanatus*
Fruit and Nut Crops	
Grape	*Vitis sp.*
Sensitive	
Fibre, Seed and Sugar Crops	
Bean	*Phaseolus vulgaris*
Guayule	*Parthenium argentatum*
Sesame	*Sesamum indicum*
Vegetable Crops	
Bean	*Phaseolus vulgaris*
Carrot	*Daucus carota*
Okra	*Abelmoschus esculentus*
Onion	*Allium cepa*
Parsnip	*Pastinaca sativa*
Fruit and Nut Crops	
Almond	*Prunus dulcis*
Apple	*Malus sylvestris*
Apricot	*Prunus armeniaca*
Avocado	*Persea americana*
Blackberry	*Rubus sp.*
Boysenberry	*Rubus ursinus*
Cherimoya	*Annona cherimola*
Cherry, sweet	*Prunus avium*
Cherry, sand	*Prunus besseyi*
Currant	*Ribes sp.*
Gooseberry	*Ribes sp.*
Grapefruit	*Citrus paradisi*

Lemon	*Citrus limon*
Lime	*Citrus aurantifolia*
Loquat	*Eriobotrya japonica*
Mango	*Mangifera indica*
Orange	*Citrus sinensis*
Passion fruit	*Passiflora edulis*
Peach	*Prunus persica*
Pear	*Pyrus communis*
Persimmon	*Diospyros virginiana*
Plum: Prune	*Prunus domestica*
Pummelo	*Citrus maxima*
Raspberry	*Rubus idaeus*
Rose apple	*Syzgium jambos*
Sapote, white	*Casimiroa edulis*
Strawberry	*Fragaria sp.*
Tangerine	*Citrus reticulata*

The concentration of specific ions in the treated water may cause trace elements to accumulate in the soil and plants, while long term build-up may potentially result in animal and human health impacts or phytotoxicity in plants. Of particular concern are sodium, chloride and boron ions, as they may be present in treated wastewaters in concentrations such as to cause toxicity. Toxicity normally results in impaired growth, reduced yields and changes the morphology of the plant.

- Sodium

Then present in exchangeable form, sodium salts may cause adverse physico-chemical changes in the soil, particularly soil structure, lowering the permeability and affecting the tilth of the soil. Although sodium does not impair the uptake of water by the plants, it impairs the infiltration of water into the soil, thus affecting the growth of plants through the unavailability of soil water.

Cadmium and magnesium act as stabilizing ions in contrast to the destabilizing effect of sodium, regarding soil structure. However, treated water may be high in sodium relative to calcium and may cause soil permeability problems if not properly managed. Regular monitoring is required to ensure that adverse effects are avoided.
The table below is also taken from the FAO document (Pescod M.B, 1992) and it presents the relative tolerance of crops selected by the writer to exchangeable sodium.

TABLE 6.13: RELATIVE TOLERANCE OF SELECTED CROPS TO EXCHANGEABLE SODIUM

SENSITIVE	SEMI-TOLERANT	TOLERANT
Avocado	Carrot	Alfalfa
(Persea americana)	*(Daucus carota)*	*(Medicago sativa)*
Deciduous Fruits	Clover, Ladino	Barley
Nuts	*(Trifolium repens)*	*(Hordeum vulgare)*
Bean, green	Dallisgrass	Beet, garden
(Phaseolus vulgaris)	*(Paspalum dilatatum)*	*(Beta vulgaris)*
Cotton, at germination	Fescue, tall	Beet, sugar
(Gossypium hirsutum)	*(Festuca arundinacea)*	*(Beta vulgaris)*
Maize	Lettuce	Bermuda grass
(Zea mays)	*(Lactuca sativa)*	*(Cynodon dactylon)*

SENSITIVE	SEMI-TOLERANT	TOLERANT
Peas	Bajara	Cotton
(Pisum sativum)	*(Pennisetum typhoides)*	*(Gossypium hirsutum)*
Grapefruit	Sugarcane	Paragrass
(Citrus paradisi)	*(Saccharum officinarum)*	*(Brachiaria mutica)*
Orange	Berseem	Rhodes grass
(Citrus sinensis)	*(Trifolium alexandrinum)*	*(Chloris gayana)*
Peach	Benji	Wheatgrass, crested
(Prunus persica)	*(Mililotus parviflora)*	*(Agropyron cristatum)*
Tangerine	Raya	Wheatgrass, fairway
(Citrus reticulata)	*(Brassica juncea)*	*(agropyron cristatum)*
Mung	Oat	Wheatgrass, tall
(Phaseolus aurus)	*(Avena sativa)*	*(Agropyron elongatum)*
Mash	Onion	Karnal grass
(Phaseolus mungo)	*(Allium cepa)*	*(Diplachna fusca)*
Lentil	Radish	
(Lens culinaris)	*(Raphanus sativus)*	
Groundnut	Rice	
(Arachis hypogaea)	*(Oryza sativus)*	
Gram	Rye	
(Cicer arietinum)	*(Secale cereale)*	
Cowpeas	Ryegrass, Italian	
(Vigna sinensis)	*(Lolium multiflorum)*	
	Sorghum	
	(Sorghum vulgare)	
	Spinach	
	(Spinacia oleracea)	
	Tomato	
	(Lycopersicon esculentum)	
	Vetch	
	(Vicia sativa)	
	Wheat	
	(Triticum vulgare)	

⇩ Trace Elements and Heavy Metals

Trace elements are present in treated effluents normally in concentrations less than a few mg/L. Although some are essential for plants and animals, at elevated concentrations they become toxic. Trace elements include aluminium (Al), beryllium (Be), cobalt (Co), fluoride (F), iron (Fe), lithium (Li), manganese (Mn), molybdenum (Mo), selenium (Se), tin (Su), titanium (Ti), Tungsten (W) and Vanadium (V).

Heavy metals are a group of trace elements that have been shown to create health impacts when taken up by plants. These include arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and zinc (Zn).

- Chlorine

Free chlorine residual at concentrations less than 1 mg/L usually poses no problems to plants. However, some sensitive crops may be damaged at levels as low as 0.05 mg/L, while some woody crops may accumulate chlorine in the tissue to toxic levels. Chlorine at concentrations greater than 5 mg/L causes severe damage to most plants.

TABLE 6.14: CHLORINE TOLERANCE OF SOME FRUIT CROP CULTIVARS AND ROOTSTOCKS

CROP		MAXIMUM PERMISSIBLE Cl^- WITHOUT LEAF INJURY	
		ROOT ZONE (Cl_e) (me/l)	IRRIGATION WATER (Cl_w)[2 3] (me/l)
	ROOTSTOCKS		
Avocado *(Persea americana)*	West Indian	7.5	5.0
	Guatemalan	6.0	4.0
	Mexican	5.0	3.3
Citrus *(Citrus spp.)*	Sunki Mandarin	25.0	16.6
	Grapefruit		
	Cleopatra mandarin		
	Rangpur lime		
	Sampson tangelo	15.0	10.0
	Rough lemon		
	Sour orange		
	Ponkan mandarin		
	Citrumelo 4475	10.0	6.7
	Trifoliate orange		
	Cuban shaddock		
	Calamondin		
	Sweet orange		
	Savage citrange		
	Rusk citrange		
	Troyer citrange		
Grape*(Vitis spp.)*	Salt Creek, 1613-3	40.0	27.0
	Dog Ridge	30.0	20.0
Stone Fruits *(Prunus spp.)*	Marianna	25.0	17.0
	Lovell, Shalil	10.0	6.7
	Yunnan	7.5	5.0
	CULTIVARS		
Berries *(Rubus spp.)*	Boysenberry	10.0	6.7
	Olallie clackberry	10.0	6.7
	Indian Summer	5.0	3.3
	Raspberry		
Grape*(Vitis spp.)*	Thompson seedless	20.0	13.3
	Perlette	20.0	13.3
	Cardinal	10.0	6.7
	Black Rose	10.0	6.7

Strawberry *(Fragaria spp.)*	Lassen	7.5	5.0
	Shasta	5.0	3.3

[1] For some crops, the concentration given may exceed the overall salinity tolerance of that crop and cause some reduction in yield in addition to that caused by chloride ion toxicities.
[2] Values given are for the maximum concentration in the irrigation water. The values were derived from saturation extract data (EC_e) assuming a 15-20 percent leaching fraction and $EC_d = 1.5\ EC_w$.
[3] The maximum permissible values apply only to surface irrigated crops. Sprinkler irrigation may cause excessive leaf bum at values far below these.

- Boron

TABLE 6.15: RELATIVE BORON TOLERANCE OF AGRICULTURAL CROPS[1]

VERY SENSITIVE (< 0.5 mg/l)	
Lemon	*Citrus limon*
Blackberry	*Rubus spp.*
SENSITIVE (0.5 – 0.75 mg/l)	
Avocado	*Persea americana*
Grapefruit	*Citrus X paradisi*
Orange	*Citrus sinensis*
Apricot	*Prunus armeniaca*
Peach	*Prunus persica*
Cherry	*Prunus avium*
Plum	*Prunus domestica*
Persimmon	*Diospyros kaki*
Fig, kadota	*Ficus carica*
Grape	*Vitis vinifera*
Walnut	*Juglans regia*
Pecan	*Carya illinoiensis*
Cowpea	*Vigna unguiculata*
Onion	*Allium cepa*
SENSITIVE (0.75 – 1.0 mg/l)	
Garlic	*Allium sativum*
Sweet potato	*Ipomoea batatas*
Wheat	*Triticum eastivum*
Barley	*Hordeum vulgare*
Sunflower	*Helianthus annuus*
Bean, mung	*Vigna radiata*
Sesame	*Sesamum indicum*
Lupine	*Lupinus hartwegii*
Strawberry	*Fragaria spp.*
Artichoke, Jerusalem	*Helianthus tuberosus*
Bean, kidney	*Phaseolus vulgaris*
Bean, lima	*Phaseolus lunatus*
Groundnut/Peanut	*Arachis hypogaea*

MODERATELY SENSITIVE (1.0 – 2.0 mg/l)	
Pepper, red	*Capsicum annuum*
Pea	*Pisum sativa*
Carrot	*Daucus carota*
Radish	*Raphanus sativus*
Potato	*Solanum tuberosum*
Cucumber	*Cucumis sativus*
MODERATELY TOLERANT (2.0 – 4.0 mg/l)	
Lettuce	*Lactuca sativa*
Cabbage	*B. oleracea capitata*
Celery	*Apium graveolens*
Turnip	*Brassica rapa*
Bluegrass, Kentucky	*Poa pratensis*
Oats	*Avena sativa*
Maize	*Zea mays*
Artichoke	*Cynara scolymus*
Tobacco	*Nicotiana tabacum*
Mustard	*Brassica juncea*
Clover, sweet	*Melilotus indica*
Squash	*Cucurbita pepo*
Muskmelon	*Cucumis melo*
TOLERANT(4.0 – 6.0 mg/l)	
Sorghum	*Sorghum bicolor*
Tomato	*L. lycopersicum*
Alfalfa	*Medicago sativa*
Vetch, purple	*Vicia benghalensis*
Parsley	*Petroselinum crispum*
Beet, red	*Beta vulgaris*
Sugarbeet	*Beta vulgaris*
VERY TOLERANT (6.0 – 15.0 mg/l)	
Cotton	*Gossypium hirsutum*
Asparagus	*Asparagus officinalis*

[1] Maximum concentrations tolerated in soil water without yield or vegetative growth reductions. Boron tolerances vary depending upon climate, soil conditions and crop varieties. Maximum concentrations in the irrigation water are approximately equal to these values or slightly less.

⇩ Nutrients

Treated sewage effluents contain nutrients important for crop growth. The most beneficial nutrient is nitrogen, however, the concentrations in treated water are not sufficient enough to produce satisfactory crop yields and supplementary fertiliser is necessary. Similarly, the concentrations of phosphorus are usually too low to meet plant requirements, yet over time it can build-up in the soil and reduce the need for phosphorus supplementation.

REUSE MANAGEMENT PLAN OF TREATED EFFLUENT FOR IRRIGATION

In consideration of the above, the reuse management plan must be based on a combination of criteria.

- Site Selection

  The objective is the identification of suitable sites for reuse, in case reuse will be in areas outside the Irrigation Scheme, where the long term application of the treated effluent will be feasible without adverse environmental or health impacts.

- Water requirements

  Assessment of the specific crop water demands to estimate the required amounts of water to be applied and the resulting total land requirements for reuse. Information on crop water demand and indicative land requirements for the irrigation of specific crops are given in Appendix 9.

- Crop Selection

  An evaluation must be made of viable combinations of the cropping options possible on the land available, taking into consideration crop sensitivity to specific effluent constituents, as outlined above, in conjunction with a selection of types of crops to be irrigated to eliminate the risk of adverse health impacts. Based on the suggested treated effluent quality standards, the irrigation of all crops is possible, with the exception of leaved vegetables, bulbs and corms eaten uncooked (Code of Practice).

- Irrigation Methods

  Appropriate irrigation methods must be identified, based on the types of crops to be irrigated and the site specific characteristics, such as soil type and structure.

TABLE 6.16: IRRIGATION METHODS

CROP TYPE	IRRIGATION METHODS
Vines	⇩ Drip irrigation ⇩ Mini sprinklers and sprinklers ⇩ *Movable irrigation systems are not allowed*
Fruit trees	⇩ Drip irrigation ⇩ Hose basin irrigation ⇩ Bubblers irrigation ⇩ Mini sprinklers
Vegetables	⇩ Subsurface irrigation ⇩ Drip irrigation
Vegetables eaten cooked	⇩ Sprinklers ⇩ Subsurface irrigation ⇩ Drip irrigation
Industrial and fodder crops	⇩ Subsurface irrigation ⇩ Bubblers ⇩ Drip irrigation ⇩ Pop-up sprinklers ⇩ Surface irrigation methods ⇩ Low capacity sprinklers ⇩ Spray or sprinkler irrigation with a buffer zone of about 300 m

⇨ Irrigation Scheduling

This encompasses timing and quantity determination on two levels:

⇨ Timing of application prior to harvesting

⇩ Ensuring that the loading rates of water, nutrients and salts are balanced with a site's ability to safely convert, absorb, use or store the nutrients and salts over the long term.

⇨ Nutrient Loading Rates

The nutrient balance must be determined to ensure that nutrients are applied at an optimal rate and load for each specific crop.

⇨ Nitrogen: The nitrogen loading rate must be balanced annually with the crop requirements to prevent excessive nitrogen leaching to groundwater.

⇩ Phosphorus: The loading rates must be determined to prevent phosphorus leaching to groundwater or accumulation in the surface layers of soils.

⇨ Salt Loading Rates

A salt balance must be undertaken so as to limit its potential to contaminate groundwater and affect soil productivity.

Overall, the performance objectives of the Reuse Management Plan will include:

⇨ The optimization of water and nutrient uptake by plants

⇨ The prevention of adverse changes to soil structure, chemistry and therefore productivity

⇩ The prevention of adverse environmental and health impacts.

6.2.6.6. MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENTS IN AGRICULTURE

MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENTS FOR IRRIGATION
❑ Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality
⇨ Drafting of Reuse Management Plan, incorporating:
⇩ Appropriate site identification ⇩ Crop water requirements ⇩ Crop selection ⇩ Irrigation methods and scheduling ⇩ Evaluation of nutrient and salt loading rates
❑ Nitrogen leaching to groundwater, accumulation in soil
⇨ Balance nitrogen loading rates with crop requirements
❑ Phosphorus leaching to groundwater, accumulation in soil
⇨ Balance phosphorus loading rates with crop requirements
❑ Adverse impacts on soil productivity and risk of groundwater contamination
⇨ Determine salt loading rates
⇨ Ensure irrigation practices do not result in off-site run-off, appropriate leaching and drainage provisions
❑ Adverse impacts on crop yields and quality
⇨ Crop selection based on crop sensitivity to treated effluent constituents
❑ Adverse impacts on health
⇨ Timing of irrigation prior to harvesting
⇨ Correct irrigation practices
⇨ Minimize site access during irrigation periods

	⇨ Use of signs specifying that treated effluent is used
	⇨ Establishment of buffer zones around irrigated areas where necessary
❑ Quality considerations	
	⇨ Implementation of treated effluent quality monitoring programme to ensure compliance with the set standards
	⇨ Implementation of soil quality monitoring programme
	⇨ Implementation of monitoring programme for the application rates of heavy metals, nutrients and salts
	⇨ Monitoring of irrigation methods and practices

6.2.6.7. URBAN REUSE OF THE TREATED EFFLUENT

The treated sewage effluents can be reused for the irrigation of public parks and recreation centres, hotel gardens, athletic fields, highway medians and shoulders, landscaped areas surrounding public buildings and facilities, or commercial office and industrial developments, golf courses, decorative. fountains, sanitary facilities in commercial buildings, dust control and concrete production in construction activities, as well as along the highways etc.

In the case of urban reuse of the treated effluent system reliability must be ensured regarding the quality of the treated effluent, so as to avoid any adverse public health impacts. Additionally, a number of safeguards must be adopted, including:

- Assurance that the treated water delivered meets the quality requirements for the intended uses
- Prevention of improper operation of the system through regular monitoring and maintenance
- Prevention of improper use of the water through a clear labeling of any pipes conveying treated effluent and of areas irrigated with such water
- Prevention of cross connections with drinking water supply lines.

6.2.6.8. GROUNDWATER RECHARGE

The treated sewage effluents can alternatively be used indirectly for agricultural purposes through the recharge of groundwater aquifers. Apart from providing an additional supply of water in aquifers that are currently over-pumped and in danger of depletion, recharge can offer a number of additional advantages:

- The barrier creation for the infiltration of seawater in the coastal aquifers: As in the case of Kiti aquifer, the excessive pumping of groundwater often results to the infiltration of seawater into the aquifers. A range of injection and pumping manholes using treated effluent can be installed, which will create a hydraulic barrier maintaining the injection control.
- Provision of further treatment of effluents: Infiltration and percolation of the treated water takes advantage of the sub-soil's natural ability for biodegradation and filtration, thus providing additional in situ treatment of the wastewater and additional treatment reliability to the overall system.
- Provision of storage for the treated effluent: Groundwater aquifers provide a natural mechanism for storage and subsurface transmission of the treated wastewater. Groundwater recharge eliminates the need for additional storage facilities. Aquifers also serve as a natural distribution system and may reduce the need for surface conveyance systems.
- Groundwater recharge helps provide a loss of identity between the treated effluents and groundwater. This has a positive psychological impact where reuse is considered, particularly for irrigation purposes, and is an important factor in making reclaimed water acceptable for a variety of uses.

- INFILTRATION BASINS

Surface spreading is a direct method of recharge, whereby the water moves from the land surface to the aquifer by infiltration and percolation through the soil matrix.

Infiltration basins are the most widely used method of groundwater recharge, affording high loading rates, and relatively low maintenance and land requirements. Rapid infiltration basins require highly permeable soil to achieve high hydraulic loading rates. For additional treatment, the soil must be fine enough to provide sufficient soil surfaces for biochemical and microbiological reactions.

- DIRECT INJECTION

This involves the pumping of the treated effluent directly into the groundwater zone. This is used where groundwater is deep or where the hydrogeological conditions are not conducive to surface spreading, including unsuitable soils of low permeability, unfavourable topography for construction of basins, or scarcity of land.

Direct injection requires water of higher quality that surface spreading because of the absence of the soil matrix treatment.

Groundwater recharge may increase the risk of aquifer contamination, particularly in the case of direct injection, therefore a monitoring programme is required regarding the quality of the treated effluents to be recharged, as well as the quality of the groundwater, to ensure that any impacts are avoided.

Even though groundwater recharge is not a widely used practice in Cyprus, in the case of Limassol treatment plant, it is expected that the recycled water not being used for direct irrigation will be used for recharging the Akrotiri aquifer and then for irrigation. In this case, additional quality standards were set for the recycled water used for recharging, especially as far as the nitrogen deduction is concerned.

According to the public consultation presented in Chapter 9 of this assessment, the Episkopi community is against the aquifer recharging. Therefore, the WDD excluded this possibility.

7. PROJECT ALTERNATIVES

7.1. ALTERNATIVE SEWAGE TREATMENT METHODS

In order to achieve the suggested discharge standards, the requirements for the treatment process are high. The discharge standards are stringent and therefore the treatment process needs to be highly performing on a wide range of parameters. In addition to these requirements purely related to process performances, further requirements related to the protection of the area, the architectural insertion and the limited space available should be met depending on the location of the site. A number of processes have been examined including:

- Activated sludge
- Trickling filters
- Bio aerated filters
- Membrane bio reactors
- Stabilization ponds
- Anaerobic reactors

7.1.1. ACTIVATED SLUDGE: RECOMMENDED METHOD

The activated-sludge process is one of the most common treatment processes and is currently in operation in three of the main treatment plants in Cyprus (Paralimni, Limassol and Larnaca). The process can be designed in many modified forms, including: selection of the reactor type, oxygen requirements and transfer, and types of settling tanks, but fundamentally the theoretical aspects of the process are similar:

- Wastewater is introduced into a reactor (aeration basin) where an aerobic bacterial culture is maintained in suspension. The reactor contents are referred to as the “mixed liquor”. In the reactor, the bacterial culture carries out the conversion of the organic matter into biological solids.
- The aerobic environment in the reactor is achieved by the use of diffused or mechanical aeration, which also serves to maintain the mixed liquor in a completely mixed regime .
- After a specific period of time, the mixture of biological solids is passed into a settling tank, where some of the settled sludge is recycled to maintain the desired concentration of organisms in the reactor and the remainder is removed from the system.
- The level at which the biological mass in the reactor should be kept (mean cell - residence time) depends on the desired treatment efficiency and other considerations, including the nature of the wastewater, and the local environmental conditions.

Different parameters can be used for the design of the activated-sludge process:

- The food to micro-organism ratio or mass loading defined as the mass of BOD applied per day to the treatment system divided by the mass of mixed liquor suspended solids (MLSS) in the aeration tank.
- The mean cell-residence time or sludge age that is the ratio of the mass of MSS in the aeration tank to the mass of sludge removed per day from the system.

⇨ The volume loading defined as the mass of BOD applied per day to the treatment system divided by the aeration tank volume.

The activated sludge process was initially designed for removal of dissolved organic pollution (expressed as BOD, COD and SS), where removal rates up to 90%-95% can be expected depending on the design parameters. In the later years, the removal of nitrogen by biological nitrification and denitrification has been largely developed, requiring an increase of the sludge age in the tank and specific mixing, aeration and recycling arrangements. It has also been shown that biological phosphorus reduction can be achieved if an anaerobic tank is added at the inlet of the biological reactor and this development is now gaining more and more interest.

Aeration equipment for injecting oxygen into the MLSS can consist of mechanical aerators or diffused air systems that blow air into the MLSS.

Final settling tanks are used to separate the biological solids produced in activated sludge from the treated wastewater. Settling tanks are mainly designed on the basis of an overflow rate. Overflow rates may range from 0.5 to 0.7 m/h at peak flows.

It should be pointed out that an activated-sludge process does not provide any significant reduction in coliform counts (only a factor 10 to 100). Where coliform reduction is required, as the case is here, a tertiary treatment should be added to the treatment train, most often consisting in sand filtration and disinfection by chlorine or UV radiation.

Provided with tertiary treatment, the activated sludge process would meet the set performance requirements. However, due to the space requirements, the process could be difficult to locate where little land is available and leads to high costs if the plant should be covered and odour treated.

7.1.2. TRICKLING FILTERS

The tricking filter consists of a bed of a highly permeable medium to which micro-organisms are attached and through which wastewater is percolated or trickled. The filter medium consisted in the past of carefully graded rock. Rock has been replaced by synthetic medium (plastic essentially) in the recent trickling filters. Plastic medium offers better specific surface area (surface area per unit of volume of the medium) and air circulation than the rock medium. Another advantage of the plastic medium is the best resistance to plugging due to its important void space and the lower mass to unit volume enabling lower surface area than for the rock medium. In terms of efficiency, operation and maintenance, the plastic medium has the best advantages and has to be recommended, although rock medium has the advantage of low cost.

In comparison with activated-sludge process, trickling filters have the following disadvantages:

- important transportation costs of the specific medium filter, that has to be imported
- necessity of a primary sedimentation, in order to avoid nozzle plugging of the rotary distributor that causes reduced performance.
- problems of odours and flies especially during the summer
- the flow of air in a trickling filter is governed by the temperature difference and wind forces. During the summer, when the temperature is hot and wind is weak, airflow could be decreased and problems of odours and flies increased.

The trickling filters are particularly adapted where the incoming wastewater is concentrated and where the discharge requirements are not too strict. But for our case, several additional steps of treatment would be required to treat nitrogen, to further reduce BOD and SS and to reduce the coliform count. The trickling filter process is therefore not recommended for the treatment plants in this project.

7.1.3. BIO AERATED FILTERS

The bio aerated filter technology is an attached growth process, i.e. the purifying biomass is attached on a substrate (the contrary is the suspended growth process, e.g. activated sludge, where the biomass is kept in suspension in the biological reactor). In a biofilter, the substrate consists in grains with size in the range 1 to 4 mm with a high specific favourable to bacterial development. This material combines the functions of biological reactor and solid-liquid separation and therefore, no additional sedimentation tank is required.

The result of progress made during the last decade is that today, bio filtration has become a particularly advantageous treatment process. In municipal wastewater treatment, it makes it possible to carry out secondary biological treatment (removal of BOD and nitrogen) and retention of the SS at the same time.

The biofiltration process uses biomass of greater concentration and, above all, of greater activity than activated sludge and have the following advantages:
- savings in land space, particularly due to elimination of the secondary clarifier stage. This compactness makes it easier to cover units, control harmful effects (odours and sound) and produce aesthetic units.
- no risk of leaching since the biomass is attached to a support such that flow variations can be readily handled,
- quick restarting, even after stopping for several months, and therefore suitable to seasonal variations in load,
- modular construction and easy automation.
- The filtration could be either upflow or downflow depending on the supplier.

The biofiltration is normally used after primary settling or flotation (these steps can be preceded by flocculation).
The process provides a high degree of treatment of BOD and SS and can also perform nitrification-denitrification to desired level. However, as most intense biological processes, the faecal coliform reduction is low and the process needs to be completed by tertiary disinfection to provide a quality required for reuse.

7.1.4. MEMBRANE BIO REACTORS

The development of submerged membrane bioreactor technology started in the 1980s and there are today several thousands of facilities implemented around the world. The membrane bioreactor technology combines a biological treatment of pollutants (BOD, N, P) with a membrane separation of the biomass and the treated water. The biological treatment used is an activated sludge process with high sludge concentration. The solid-liquid separation is carried out by microfiltration (MF) membranes, which most often are submerged directly in the aeration tank. Depending on suppliers, either flat sheet membranes, hollow fiber membranes or tubular membranes are used.

The most visible advantage with a membrane bioreactor, compared with an activated sludge plant, is the reduced footprint. This is due to, on one hand, that there is no more need for sedimentation tanks. The biological reactor is also operated at much higher MLVSS concentrations (in the range of 12 to 15 g/l) and the reactor can therefore be smaller.

The process is therefore very well adapted where the site is small and the plant needs to be covered in order to reduce odour and noise problems.

Due to the high sludge age, the production of sludge is reduced. Some sources indicate a reduction of up to 40% compared with an activated sludge process. The high sludge age also favours biological nitrification.

The microfiltration membranes have a pore size in the range of 0.1 to 0.4 microns, which retains suspended solids and some bacteria but not macro-molecules and virus. However, experience show that the membranes are rapidly covered by a layer of cellular material which enhances the filtration performances.

The replacement of membranes is an important item in the operating cost budget. Nevertheless, membranes are today guaranteed by the suppliers for at least 5 years operation and could in many cases operate for more than 10 years.

The capital cost for a membrane bioreactor plant is higher than a conventional activated sludge plant, when only BOD and SS reduction to "normal' level (25-30 mg/l) is imposed. But when reuse of the treated effluent is planned and treatment requirements are tougher, including coliform reduction, then the membrane bioreactor becomes competitive.

7.1.5. STABILIZATION PONDS

Aerobic stabilization lagoons are large, shallow earthen basins of wastewater where the treatment is provided by natural processes involving the use of both algae and bacteria. Natural aeration processes are used to supply some or all of the oxygen needed by the bacteria to metabolize organic matter and reduce the BOD.

Stabilization lagoons have become very popular in small communities, because they are simple and economical to operate, requiring minimal operation and maintenance, namely one sludge removal of the primary lagoon once every two to three years and one sludge removal of the secondary lagoon once every five years.

Aerobic lagoons are designed with a maximum depth of 1.5 m. A large surface area is then required to maximize the natural aeration capacity of the system. The rate of surface area may range from 6 to 10 m^2/inhabitant, depending on the variation of water temperature. This area requirement includes only the lagoons themselves, with no allowance for access roads or other facilities. With a maximum depth of 1.5 m, the retention time is about 60 days, which is the minimum required to achieve a significant reduction in coliform counts (reduction of about 10^4).

The process would be expected to meet the discharge requirements regarding coliforms and, with addition of tertiary sand filters, the requirements for SS and possibly BOD. The standards for nitrogen would probably not be met. However, the most significant disadvantage is the large size of the plants, and stabilization ponds are therefore not retained in this case.

7.1.6. ANAEROBIC REACTORS

Anaerobic reactors, of UASB type, represent a simple and reliable solution with low operating costs. This technology, which has been much developed during the latest decade, is much used for industrial pre-treatment, for initial reduction of the organic pollution of strong wastewater. However, its use for treatment of urban wastewater is not very widespread, in particular not for large size plants. The current discharge standards for BOD (10 mg/l) are largely below the expected performance limits of the process (50 mg/l at the best). This process is therefore not further considered.

7.1.7. COMPARISON OF ALTERNATIVE TREATMENT METHODS

A number of these processes have been eliminated at an early stage as they cannot meet the requirements and the remaining processes have been compared in more detail. Table 7.1 summarises the advantages and disadvantages of these processes

TABLE 7.1: COMPARISON OF TREATMENT PROCESSES

METHOD	ADVANTAGES	DISADVANTAGES
Activated sludge	❑ Proven and reliable process. ❑ Stable performances at variations in hydraulic load. ❑ Moderate cost for the base	❑ Additional tertiary treatment required to meet treatment requirements. ❑ High sludge production. ❑ Relatively high land

METHOD	ADVANTAGES	DISADVANTAGES
	process.	requirements. ❑ Large basins, difficult to cover. ❑ Long start-up of the biological process, can not treat peak loads
Bio aerated filters	❑ Compact process, easy to cover. ❑ Modular design makes easy to adapt the process to incoming loads and flows. ❑ Quick restarting, therefore suitable to seasonal variations in load. ❑ Modular construction and easy automation.	❑ Additional tertiary treatment required to meet treatment requirements. ❑ High sludge production. ❑ Higher investment costs than for activated sludge (~30%)
Membrane bioreactors	❑ Very high treatment performances, also on faecal coliforms. ❑ No chlorination or UV disinfection required. ❑ Low sludge production. ❑ Compact process, easy to cover. ❑ Modular construction and easy automation.	❑ Some uncertainty regarding the membrane life length and related replacement cost. ❑ Higher investment costs.

The three processes can provide treatment to the level required for discharge and reuse according to current regulations. However, for the purpose of the study, the activated sludge process with tertiary treatment will be retained as base solution for sewage treatment.

7.2. SCREENING OF ALTERNATIVE OPTIONS

7.2.1. ALTERNATIVE SCHEMES

7.2.1.1. PRELIMINARY SELECTION OF ALTERNATIVE SCHEMES

Six alternative schemes were examined initially for the Limassol district communities, based on a different number of STPs, locations and conveyance routes. These are outlined in Table 7.2. Additional information requested by the Environment Service regarding the alternative schemes are also outlined in Appendix 16.

TABLE 7.2: ALTERNATIVE SCHEMES FOR THE LIMASSOL DISTRICT COMMUNITIES

SCHEME	STP LOCATION	CONVEYANCE SYSTEM NETWORK
D1a	One STP near Episkopi	Wastewaters from Ypsonas will be conveyed to Kolossi. South of Kolossi the pipeline will connect to the pipeline conveying the wastewater from Trachoni. From there the wastewater will be conveyed to the connection with the Episkopi and Erimi pipelines and they will be then conveyed to the STP.

SCHEME	STP LOCATION	CONVEYANCE SYSTEM NETWORK
D1b	One STP near Trachoni	The wastewater from Ypsonas will be conveyed towards Kolossi. South of Kolossi the pipeline will connect to the pipeline conveying the wastewater from Erimi and Episkopi. From this connection the wastewater will be conveyed through Trachoni towards the STP which will be located south of the community.
D1c	One STP: the existing Limassol STP	The wastewater from Ypsonas will be conveyed towards Limassol. The wastewater from Episkopi will be conveyed towards Trachoni, while there will be a connection to this pipeline with the pipelines from Erimi and Kolossi. The wastewater will be conveyed from Trachoni to the Limassol STP.
D2a	Two STPs: ⇩ One near Episkopi and ⇩ The existing Limassol STP	⇨ The wastewater from Ypsonas will be conveyed to Limassol STP. ⇨ The wastewater from Episkopi will be conveyed to the Episkopi STP. The connection with the wastewater conveyance pipelines from Trachoni, Kolossi and Erimi will be near the STP.
D2b	Two STPs: ⇩ One near Trachoni and ⇩ The existing Limassol STP	⇨ The wastewater from Ypsonas will be conveyed to Limassol STP. ⇨ The wastewater from Episkopi will be conveyed to Trachoni, while there will be a connection with the Erimi and Kolossi pipelines. The wastewaters from Trachoni will be conveyed to the STP near the community.
D5	Five STPs – one for each community	Each community has its own STP.

As far as the Polis Chrysochous STP is concerned, two schemes have been examined and are outlined in the next Table.

TABLE 7.3. ALTERNATIVE SCHEMES FOR POLIS CHRYSOCHOUS

SCHEME	STP LOCATION	CONVEYANCE SYSTEM NETWORK
1	One STP near Limni, within Pelathousa.	When the wastewater is collected by the collection system from Polis Chrysochous, it will be lead with a northeast direction towards the Pelathousa location, partly through gravity pipelines and partly through pumping pipelines.
2	One STP within Steni	In this case the wastewater will be collected by the collection system, will be lead through pumping pipelines northeast of Polis Chrysochous to the location.

Schematic presentations of the schemes for the Limassol district communities are included in Appendix 10.

After the initial valuation and screening of the alternative schemes for the Limassol district, the location near Trachoni has been excluded due to its nature, since the construction of the treatment station in the area would lead to serious environmental impacts. Therefore, schemes D1b and D2b have been excluded during the stage of the initial screening. The following table outlines the results of the screening of the alternative schemes for Limassol district as well as the two schemes for Polis Chrysochous.

TABLE 7.4: RESULTS OF THE INITIAL SCREENING OF THE ALTERNATIVE SCHEMES FOR LIMASSOL DISTRICT AND POLIS CHRYSOCHOUS

SCHEME	LOCATION	NOTES
D1a	One treatment plant near Episkopi.	A financial analysis of the scheme was conducted.
D1b	One treatment plant near Trachoni	The scheme was cancelled.
D1c	One treatment plant: the existing Limassol plant	A financial analysis of the scheme was conducted
D2a	Two treatment plants: ⇩ One near Episkopi and ⇩ The existing Limassol plant.	A financial analysis of the scheme was conducted
D2b	Two treatment plants: ⇩ One near Trachoni and ⇩ The existing Limassol plant.	The scheme was cancelled
D5	Five treatment plants – one for each community	A financial analysis of the scheme was conducted
Scheme 1 Polis Chrysochous	One treatment plant near Limni, within Pelathousa.	A financial analysis of the scheme was conducted
Scheme 2 Polis Chrysochous	One treatment plant within Steni	A financial analysis of the scheme was conducted

7.2.1.2. BRIEF DESCRIPTION OF THE ALTERNATIVE SCHEMES

❑ SCHEME D1A

Scheme D1A includes one sewage treatment plant for all communities of Limassol district, which will be constructed near Episkopi.

All communities are connected to the STP Episkopi. Wastewater from Episkopi is partly conveyed by gravity and partly by pumping towards the connection with the pipeline from Erimi. The connection from Erimi will also be partly with gravity and partly with pumping. In the area of the treatment plant there will be the connection with the pipeline conveying the wastewater from the other project communities. The wastewater from Ypsonas will be conveyed be gravity towards Kolossi and them towards the connection with the pumping pipeline from Trachoni. From this connection the wastewater will be pumped towards the connection with the pipeline from Erimi and Episkopi. From this point on, the wastewater will be conveyed by gravity to the Episkopi treatment plant.

The main components of the system are:

⇨ Gravity pipes	Total length of gravity pipes is 10.7 km with the diameter between 200 mm and 500 mm.
⇨ Forcemains	Total length of forcemains is 5.6 km and with diameter between 100 mm and 300 mm.
⇨ Pumping stations	Four pumping stations are estimated with the discharge capacity varying from 6.0 l/s to 58.0 l/s and installed power from 1 kW to 14 kW.
⇨ Sewage treatment plant	Location of STP is southeast of Episkopi, with the nominal capacity of 5 395 m^3/day. An estimation of the area required for the STP and the emergency storage is 145 730 m^2.

❑ SCHEME D1C

Scheme D1C includes one treatment plant for all communities of Limassol district and specifically the existing Limassol plant.
All communities are connected to the existing Limassol sewage treatment plant. Wastewater from Episkopi will be conveyed partly by gravity and pumping towards the connection with the pipeline from Erimi. The connection from Erimi will also be partly with gravity and pumping. The wastewater will be conveyed by gravity towards the connection with the gravity pipeline from Erimi. The flow towards Trachoni will be partly with gravity and pumping. From Trachoni the wastewater will be conveyed to Limassol and the pipeline will be partly a gravity pipeline and partly a pumping pipeline. Due to the limited capacity of the existing pipeline in Limassol, a new conveyance system towards the treatment plant is being planned. The wastewater from Ypsonas will also be conveyed to Limassol partly with gravity and pumping.

The main components of the system are:

⇨ Gravity pipes	Total length of gravity pipes is 26.2 km and with a diameter between 200 mm and 500 mm.
⇨ Forcemains	Total length of forcemains is 11.5 km and with a diameter between 125 mm and 350 mm
⇨ Pumping stations	Five pumping stations are estimated (Episkopi, Erimi, 2 in Trahoni and 1 in Limassol) with the discharge capacity varying from 5.8 l/s to 74.0 l/s and installed power from 1 kW to 93.0 kW
⇨ Sewage treatment plants	The existing Limassol sewage plant with the extra capacity of 5 395 m^3/day. The required area for the plant and for the emergency storage reservoir will be about 145 730 m^2, although this cannot be said with certainty, since the Limassol STP already has plans for expansion and land acquired.

❑ SCHEME D2A

Scheme D2a includes two treatment plants which will serve the Limassol district communities, one near Episkopi and the existing Limassol plant.

The wastewater from Ypsonas will be conveyed by gravity and pumping towards the Limassol STP. According to intelligence from the Sewage Board of Limassol – Amathounta, the existing Limassol sewage conveyance system can accept only this additional flow.

Wastewater from Episkopi will be conveyed by gravity and pumping towards the connection with the pipeline from Erimi. The connection from Erimi will also be partly with gravity and partly with pumping. In the STP area there will be the connection with the pipeline conveying the wastewater from Trachoni and Kolossi. The wastewater from Kolossi will be conveyed by gravity towards the connection with the forcemain from Trachoni. From this connection the wastewater will be pumped until the connection with the pipeline from Erimi and Episkopi. From this point on the wastewater will be conveyed by gravity to the treatment plant.

The main components of the system are:

⇨ Gravity pipes	Total length of gravity pipes is 12.0 km and with a diameter between 200 mm and 400 mm
⇨ Forcemains	Total length of forcemains is 5.6 km and with diameter between 100 mm and 200 mm
⇨ Pumping stations	Four pumping stations are estimated with the discharge capacity varying from 5.8 l/s to 27.0 l/s and installed power from 1 kW to 8.2 kW
⇨ Sewage treatment plant	⇨ One STP in Episkopi with the nominal capacity of 2 950 m^3/day. The required area for the STP and the emergency storage reservoir will be about 79 550 m^2 ⇨ The Limassol STP will be expanded will extra capacity of 2 450 m^3/day. The required area for the expansion of the STP and the emergency storage reservoir will be 66 110 m^2 , although, as mentioned afore, this cannot be said with certainty, since the Limassol STP already has plans for expansion and acquired land.

❑ SCHEME D5

Scheme D5 includes one treatment plant for each community of Limassol district. The connection of each community will be a part of the collection system.

The main components of the system are:

⇨ Forcemains	Total length of forcemains is 7.5 km and with a diameter of 200 mm.
⇨ Pumping stations	Five pumping stations are estimated with the discharge capacity varying from 5.8 l/s to 31.0 l/s and installed power from 2 kW to 31.0 kW

The location of STPs is predicted to be at the lowest area of the community. The nominal capacities of the treatment plants are as follows:

	Treatment Plant Capacity
Episkopi	772 m^3/day
Erimi	397 m^3/day
Kolossi	1 040 m^3/day
Ypsonas	2 448 m^3/day
Trachoni	737 m^3/day

❑ POLIS CHRYSOCHOUS: SCHEME 1

Scheme 1 includes one plant near the area Limni (Location 5a).

The main components of the system are:

⇨ Gravity pipes	Total length of gravity pipe is 600 m and with a diameter of 500 mm.
⇨ Forcemains	Total length of forcemains is 2.7 km and with a diameter of 300 mm
⇨ Pumping stations	One pumping station is estimated with the discharge capacity of 64.0 l/s and installed power of 62.0 kW
⇨ Sewage treatment plant	The STP will be in the area Limni and will be of a capacity of 5 499 m^3/day. The required land for the expansion of the plant and for the emergency storage reservoir will be 131 970 m^2.

❑ POLIS CHRYSOCHOUS: SCHEME 2

Scheme 2 includes one treatment plant near Steni community (Location 5b).

The main components of the system are:

⇨ Forcemains	Total length of forcemains is 3.4 km and with a diameter of 300 mm
⇨ Pumping stations	One pumping station is estimated with the discharge capacity of 64.0 l/s and installed power of 115 kW
⇨ Sewage treatment plant	The STP will be located in the village Steni and it will be of capacity of 5 499 m^3/day. The required area for the STP expansion and the emergency storage reservoir will be 131 970 m^2.

7.2.2. ALTERNATIVE SITES FOR THE SEWAGE TREATMENT PLANTS

A number of alternative sites have been examined for the construction of the sewage treatment plants that will service the communities of the project, including 2 sites near Episkopi, 1 near Kolossi, 1 near Trachoni and the case of the existing Limassol plant. Two sites for the Polis Chrysochous STP have also been examined. The proposed alternative sites for the STPs were selected at a preliminary stage based on the following criteria:

- ⇨ Location at a low point so as to reduce the needs for pumping installations for the conveyance of the wastewaters.
- ⇨ Position at the barycentre of the group of communities in order to reduce the length of the wastewater conveyance pipes.
- ⇨ Environmental criteria, including distance from residential areas, land uses, etc.
- ⇨ Existing storage options in the area for the treated effluents, like dams or suitable geological formations for the easy construction of a reservoir.

The result of the preliminary environmental evaluation of these alternative sites are included in Appendix 11.

7.2.2.1. ALTERNATIVE SITE 1: NEAR EPISKOPI

Schemes D1a and D2a include the construction of a STP near the Episkopi community to service the communities of Limassol and more specifically Episkopi, Erimi, Ypsonas, Kolossi and Trachoni in the case of the scheme D1a, or all of the communities except Ypsonas in the case of the scheme D2a. Three alternative sites have been selected for the construction of the plant, near river Kourris and the road connecting Trachoni with Episkopi.

❑ ALTERNATIVE SITE 1(A): NORTH OF THE KOURRIS RIVER BRIDGE

The first alternative site is north of the bridge of Kourris river, near the road of Trachoni-Episkopi and at a distance of approximately 1 km from the boundary of the residential zone of Episkopi. The main disadvantage of this location is that is within the river and the construction of the plant is expected to lead to serious impacts upon the surface water hydrology of the area. At the same time the location will be prone to floods in case of an overflow of the Kourris dam and therefore protective measures during the designing of the plant would be necessary.

The main advantages of this location are:

- ⇨ The distance of the location from the residential zone will ensure that there will be no serious odour or noise impacts on the residents of the communities during the operational stage of the plant.
- ⇨ The location consists of barren land and there are no crops, so the construction of the treatment plant will not lead to the acquisition of any agricultural land and the destruction of crops and trees.
- ⇨ Since there are no other constructions in the location or the surrounding area, there will be no destruction or any negative impacts on other properties due to the project construction.

- Even though the construction of a reservoir for the long-term storage of the treated effluent will be necessary, the impacts are eliminated due to the geomorphology of the area, which is suitable for the reservoir construction.
- The plant construction will lead to some impacts on the landscape and on visual impacts, since the area is not developed, but these will be eliminated due to the geomorphology of the location, which will prevent the surrounding areas from viewing the plant.
- The existing access to the location will efface the need to build access roads, which would lead to additional impacts.
- The closeness of the location to an electricity line will eliminate the impacts arising from the power collection system of the plant.

Some of the disadvantages of the location are:
- The main disadvantage of the location is that the construction of the treatment plant will take place upon the Kourris river bed, something that requires further examination regarding the river flow, especially during the winter months and in case of an overflow of the Kourris dam, and the need for the river direction change.
- The location is near drinking water drillings, therefore measures for their protection are necessary to take.

- ALTERNATIVE SITE 1(B): SOUTH OF THE KOURRIS RIVER BRIDGE.

The second alternative site is south of the bridge, next to Kourris river and at a distance of approximately 1.4 km from the boundary of the residential zone of Episkopi. In this case the location is prone to floods in case of an overflow of the Kourris dam as well, therefore protective measures during the designing of the plant will be necessary.

The main advantages of this location are:
- The distance of the location from the residential zone will ensure that there will be no serious odour or noise impacts on the residents of the communities during the operational stage of the plant.
- The location consists of barren land and there are no crops, so the construction of the treatment plant will not lead to the acquisition of any agricultural land and the destruction of crops and trees.
- Since there are no other constructions in the location or the surrounding area, there will be no destruction or any negative impacts on other properties, due to the project construction.
- Even though the construction of a reservoir for the long-term storage of the treated effluent will be necessary, there already are on location recharge reservoirs, which can be expanded and used for storage purposes, eliminating the impacts from the reservoir construction.
- The existing access to the location will efface the need to build access roads, which would lead to additional impacts.
- The location is near the river and therefore the expected impacts on the surface water hydrology of the area will be comparatively more limited. Additionally, the closeness of the location to a river is considered to be an advantage, since this provides the possibility of emergency dismissal of treated effluent in case this is necessary.

Some of the disadvantages of the location are:
- The plant construction will lead to some impacts on the landscape and to visual impacts, since the location is flat and without any other developments.
- The location is near drinking water drillings, therefore measures for their protection are necessary to take.
- The distance of the location from the electricity line is longer compared to location 1(a), therefore the impacts arising from the power collection system of the plant will be greater.

7.2.2.2. ALTERNATIVE SITE 2: NEAR TRACHONI

Schemes D1b and D2b include the construction of a sewage treatment plant near Trachoni, south of the village, for the connection either of all Limassol communities in the case of scheme D1b, or those of Episkopi, Erimi, Kolossi and Trachoni in the case of scheme D2b. Situating the treatment plant in this area though, will result to serious negative impacts:

- ⇨ The area south of Trachoni is within protection zone Z1 and it consists of irrigated agricultural land, which is mainly used for intensive farming. The area includes permanent crops and more specifically fruit-bearing trees and olive trees. As a result, the treatment plant construction will lead to serious negative impacts on land usage, including the destruction of good quality agricultural land and land of permanent crops.
- ⇨ Due to the non-developed character of the area, which mainly consists of tree cultivations, the plant construction will inevitably lead to serious impacts on the landscape and visual impacts. Additionally, the plant will be visible to the surrounding areas, since the location is flat.
- ⇨ The area is relatively close to the boundary of the residential zone of the village.
- ⇨ The geomorphology of the region is not suitable for the easy construction of the long-term storage reservoir for the treated effluent, while at the same time land availability problems are expected due to the restrictions referring to town planning.

As a result of the negative impacts expected to arise from the sewage treatment plant construction in this area, this alternative site has been excluded.

7.2.2.3. ALTERNATIVE SITE 3: EXISTING LIMASSOL SEWAGE TREATMENT PLANT

Schemes D1c, D2a and D2b include the connection of either all of Limassol communities, or only that of Ypsonas respectively, to the existing Limassol sewage treatment plant. In the case of Ypsonas the plant can respond to additional treatment needs without any further expansion, except the one being planned for Phase B of the Limassol sewage disposal system. Since the area near Trachoni has been excluded, scheme D2b is no more a feasible alternative solution. For the connection of all communities to the existing Limassol plant according to scheme D1c, the further expansion of the plant is required, in order to be able to serve the additional effluent flow.

The alternative of the community connection to the existing Limassol treatment plant offers enough advantages, since it includes only the expansion of the existing plant, as opposed to the construction of an additional unit on another site. Still, the impacts resulting from the sewage conveyance system from the communities to the treatment plant will be serious, since the pipeline will cover large distances and will pass from central points of the town of Limassol.

7.2.2.4. ALTERNATIVE SITE 4: NEAR KOLOSSI

For the plant required for the schemes D1a and D2a another site near Kolossi has also been examined. This location is north of the A1 road, behind the administrative buildings of the British Bases and at a distance of approximately 700m from the boundary of the residential zone of the community.

The main advantages of this location are:

- ⇨ The distance of the location from the residential zone will ensure that there will be no serious odour or noise impacts on the residents of the communities during the operational stage of the plant.
- ⇨ Since there are no other constructions in the location or the surrounding area, there will be no destruction or any negative impacts on other properties, due to the project construction.
- ⇨ The existing access to the location will efface the need to build access roads, which would lead to additional impacts.
- ⇨ The closeness of the location to an electricity line will eliminate the impacts arising from the power collection system of the plant.

Some of the disadvantages of this location include the following:

- ⇨ The plant construction will lead to some impacts on the landscape and on visual impacts, since the location is flat and without any other developments.
- ⇨ The land of the location is mainly agricultural and is being used for annual cultivations as well as for olive and fruit bearing trees, so the plant construction will lead to the destruction of these cultivations and trees.

- The construction of a long-term storage reservoir for the treated effluent will be necessary and, since the geomorphology of the location is not suitable for its easy construction, the impacts resulting will be increased.
- The location is next to a protected archaeological site and the project construction may result to negative impacts on the excavation site.

As a result of the serious negative impacts expected to arise from the plant construction on this site, this alternative site has been excluded.

7.2.2.5. POLIS CHRYSOCHOUS SEWAGE TREATMENT PLANT

- ALTERNATIVE SITE 5(A): NEAR LIMNI

The first alternative location chosen for the sewage treatment plant serving Polis Chrysochous is east of the village, at a distance of approximately 1.4 km from the boundary of the residential zone. The location is within the administrative boundaries of Pelathousa village, at a distance of approximately 2 km from the residential area in the northeast.

The main advantages of this site are:

- The distance of the location from the residential zone will ensure that there will be no serious odour or noise impacts on the residents of the communities during the operational stage of the plant.
- Since there are no other constructions in the location or the surrounding area, there will be no destruction or any negative impacts on other properties, due to the project construction.
- Even though the construction of a reservoir for the long-term storage of the treated effluent will be necessary, the geomorphology of the area is suitable for its construction.
- Even though the plant construction will result to some impacts on the landscape since the area is not developed, these will be minimized due to the geomorphology of the site, which will significantly prevent the plant being visible from the surrounding areas. Additionally the site is distant and isolated and so it will not be visible from the main roads or the residential areas.
- The existing access to the location will efface the need to build access roads, which would lead to additional impacts.
- The closeness of the location to an electricity line will eliminate the impacts arising from the power collection system of the plant.

The disadvantage of this site is that it mainly consists of agricultural land, with some uncultivated parts and the treatment plant construction will result to the destruction of annual crops and some olive trees.

- ALTERNATIVE SITE 5(B): WITHIN STENI VILLAGE

The second alternative location for the Polis Chrysochous sewage treatment plant construction is within the administrative boundaries of the village Steni. It is at a distance of approximately 1.7 km from the boundary of the Polis residential zone, in the southeast of the village.

The main advantages of this site are:

- The distance of the location from the residential zone will ensure that there will be no serious odour or noise impacts on the residents of the communities during the operational stage of the plant.
- Even though the construction of a reservoir for the long-term storage of the treated effluent will be necessary, the geomorphology in the area is suitable for its construction.
- Even though the plant construction will result to some impacts on the landscape since the area is not developed, these will be minimized due to the geomorphology of the site, which will significantly prevent the plant being visible from the surrounding areas.
- The existing access to the location will efface the need to build access roads, which would lead to additional impacts.

Some of the disadvantages of the site include:

- One of the main disadvantages of this location is that is within the administrative boundaries of another community from which it would be difficult to ensure an approval for the project.
- This area consists mainly of agricultural land, with some uncultivated parts and the treatment plant construction will result to the destruction of annual crops and some olive trees.
- The distance of this site from the electricity line is larger comparatively to site 1(a), and so the impacts resulting from the power collection of the plant will be greater.

7.2.2.6. PRELIMINARY SELECTION OF THE ALTERNATIVE SITES

During the preliminary environmental selection the alternative sites have been assessed according to some indicative parameters. Specifically:

- Long-term storage reservoir: The need for construction of a long-term storage reservoir for treated effluent is expected to lead to negative impacts, such as the permanent acquisition of private land, impacts on land use, destruction of agricultural land and influence the soil geology. Wherever the reservoir construction is needed the presence of suitable geological forms is considered to be an advantage, since it will minimize the impacts resulting from the excavations and the construction.
- Land Cover: The impacts on mulching as a result of the crop and trees or vegetation destruction are considered to be significant, compared to the impacts resulting from the plant constructed upon waste land, which would minimize the vegetation destruction.
- Land ownership: The use of governmental land for the project's construction is preferable than the acquisition of private land, since this would decrease the compensation claims and any income loss may result from i.e. agricultural land requisition.
- Urban zones: Locating the treatment plant in an industrial or breeding area, the negative impacts will be decreased, since these are often blighted areas regarding the landscape, the noise and the odours. Additionally the impacts on land use will be decreased, since there will be no destruction of agricultural land, while at the same time these areas often comprise of waste land; therefore the vegetation destruction is limited. The treatment plant construction in protected areas should be avoided due to the nature of these areas regarding the mulching and their ecological or other value as well as due to the serious negative impacts that would probably arise.
- Other constructions: The presence of other constructions in or near the site is a disadvantage, since the project's construction and operation might lead to property destruction or to negative impacts and inconveniences.
- Proximity to protected areas: The site closeness to protected areas or archaeological sites is a disadvantage.
- Distance to the residential zone limit: Closeness of the plant site to residential areas might result to negative impacts upon the residents arising from odours or noises. In order to avoid any impacts the site should be at a sufficient distance from residential areas.
- Access: The access availability to the site will eliminate the need to built roads, as well as the negative impacts resulting from their construction.
- Distance from electricity line: The closeness to an electric flux will minimize the distance from where additional power cables should be installed for the power collection of the plant.
- Proximity to boreholes: It is preferable if the plant location is at some distance from water supply drillings, in order to ensure that there will be no negative impacts on the underground water sources.
- Impacts on landscape and visual impacts: The impact size will depend on the geomorphology of the site, the nature of the area regarding the natural and structured environment, the distance from main roads, residential and other areas etc.
- Communities' opinion: The community approval for the final selection of the plant alternative sites is required.

The impacts expected for each parameter has been multiplied by the respective weight of the parameter, for the weighted result of each alternative choice to be determined. The results of the preliminary environmental evaluation are included in Appendix 11.

7.3. EVALUATION OF ALTERNATIVES

Based on the probable impacts that might result from the proposed development, as identified in the impact scoping stage, the alternative sites and schemes, including the 'no action' alternative, have been evaluated in terms of their expected impact on the environment.

The extent of each impact that is expected as a result of the project was assessed, for each alternative option, based on the following criteria:

- The expected severity of the impact,
- Its duration,
- The expected probability of occurrence for the impact.

The added score based on these parameters was then calculated by the extent of mitigation following the implementation of measures, to obtain the final impact score. For each of the environmental impacts assessed a weight was assigned according to their significance in relation to the environment, the extent to which the impact would immediately affect the concerned population, the sensitivity of the environmental receptor, and the cumulative impact potential of the impact. The final impact scores were then multiplied with the respective weights for each environmental aspect to provide the weighted impact scores for each alternative. The evaluation was carried out for each of the final alternative sites examined, and then for each of the alternative schemes.

The following tables summarize the evaluation criteria, and the weight of each environmental parameter which were used for the evaluation of the total weighted score of the impacts for each alternative location and scheme studied.

In more detail, the criteria weight selection took place as following:

An evaluation of the various impacts on the environment expected to result from the project took place and it has been ascertained that the project (the construction and the operation of the STPs, and of the effluent collection and/ or conveyance systems), due to its design, could have impacts on the environment during its construction and during its operation. Additionally the reuse of treated effluent is expected to result to some impacts on the environment. The list of the various impacts or the sites and/or the situations on which the project is expected to have impacts are outlined in Table 7.6 below.

It is obvious that this list includes impacts relating to (or are expected from) the project's site, the design of the STPs and the collection and conveyance system, the project's operation and the reuse of treated water. What is included in Table 7.6 have been taken into consideration as the environmental criteria. Based on their relative significance, a weight factor from 1 to 5 was given to each, as shown in the Table, where 5 was given to the criterion judged as the most important. As shown in the Table, the impacts concerning the operation of the project (of the STPs and the collection and conveyance systems) were given the highest weight, as the criterion regarding the reuse of treated water. This weight was given to emphasize the fact that possible impacts expected to arise during the operation will be long-term. The lowest weight regarding the criteria concerning the plant operation was given to "risk of system overload" because this possibility is very small, since the STP is usually designed for peak flows. Following the same rationale, the impacts of a accidental overload are not expected to be long-term.

The criteria "Noise and odours", "impacts on soils", "impacts on underground resources" and "risk of insufficient treatment of effluent" were given the highest weight factor. This was in order for the importance of the criteria to be stressed, since "noise and odours" is one of the primary worries of the communities' residents and the rest of the criteria are important for the preservation of the good quality of the water and soil, as well as of the public health. The criterion named "impacts of sludge production" was given the second highest weight factor, in order to emphasize the importance of a good treatment, the quantity of sludge produced and with the appropriate ingredients, if it is to be used in agriculture.

Weight was also given to land availability since non-availability could result to many problems. One of them, even improbable, is that the non-availability of suitable land would make this project implausible and the continuance of the existing situation necessary (meaning reduction of the possible alternatives). Another reason why a high weight was given to this criterion, is that the STP site also concerns the community residents, especially regarding its present use; if this land is of socio-economic, archaeological or environmental significance, it should be taken into serious consideration. Additionally if the land chosen is governmental and already acquired (either partly or in whole), this is considered to be an advantage. The STP and collection and/or conveyance pipelines site will be long-term and it therefore reflects upon the high weight factor.

Possible impacts regarding the STP construction are mainly temporary and this lead to the selection of the respective weight factors. Not all impacts are expected to be temporary though, something that shows from the weight factor given to them. For example the impacts on soil could be permanent due to the excavations, the compression and the removal and transfer of soil to another location. Additionally, the soil and water pollution that might result during the project's construction could have long-term impacts. On the contrary, the temporary land acquisition which will take place during the construction for machinery storage needs and for correct, profitable and secure working conditions were given a small weight factor, since it will be temporary and controlled, as the temporary waste management, a criterion to which was also given a small weight factor. The criteria "vegetation clearing" and "ecological impacts" were given even lower weight factors.

The same weight factor was given to the short-term impacts expected on traffic and on public safety, as well as to the criterion referring to the on-site safety. The correct application of the suitable constructive procedures reduces the risk of security threats on and off sites and this possible risk is temporary. Traffic is expected to be temporary influenced, therefore the weight factor given to it is not high but neither is it the lowest.

TABLE 7.5. EVALUATION PROCEDURE

IMPACT EXTENT

Severity		Duration		Possibility		Impact Extent
Negative Impacts						Severity + Duration + Possibility
Major	-15	*Negative Impacts*		*Negative Impacts*		
Moderate	-10	Long term	-10	High probability	-10	
Minor	-5	Short term	-5	Low probability	-5	
No Impact	0	No Impact	0	No Impact	0	
Positive Impacts						
Minor	5	*Positive Impacts*		*Positive Impacts*		
Moderate	10	Long term	10	High probability	10	
Major	15	Short term	5	Low probability	5	

IMPACT SCORE

Impact Extent		Impact Mitigation		Score
Negative Impacts		*Negative Impacts*		Impact Extent x Impact Mitigation
	-35	Not possible to mitigate impacts	2	
	-30	Impacts reduced	1	
	-25	Impacts prevented	0	
	-20	Negative impacts prevented and positive impacts derived	-(2)	
	-15			
No Impact	0	No Impact	0	
Positive Impacts		*Positive Impacts*	2	
	15			
	20			
	25			
	30			
	35			

TABLE 7.6. WEIGHT OF ENVIRONMENTAL PARAMETERS

WEIGHT OF ENVIRONMENTAL PARAMETERS	
	WEIGHT
Impacts related to project location	
Land Availability	5
Permanent Land acquisition	3
Impacts on surface water hydrology	2
Impacts on geology and soils	2
Impacts on ecological values	3
Impacts on land use and land cover	2
Impacts related to project design	4
Impacts During Project Construction	
Temporary land acquisition	1
Vegetation clearing	2
Ecological impacts	2
Soil impacts	4
Air pollution (dust, fumes)	3
Noise impacts	3
On-site safety	2
Waste management	1
Pollution	4
Off-site public safety	2
Traffic	2
Impacts During Project Operation	
Landscape impacts	3
Noise and odours	5
Impacts on soils	5
Impacts on underground resources	5
Impacts of sludge production and reuse	4
Risk of system overload	2
Risk of insufficient treatment of effluents	5
Impacts from the Reuse of the Treated Effluents	
Use for agricultural irrigation	4
Urban reuse	4
Groundwater recharge	5
TOTAL	**84**

8. ENVIRONMENTAL MANAGEMENT PLAN

8.1. PURPOSE AND OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN

A key objective of the Impact Assessment process is to identify the potential impacts on the environment of the activities anticipated and to develop a set of mitigation measures technically appropriate, financially acceptable and practically feasible. These mitigation measures are usually identified during the Environmental Impact Assessment (EIA) stage and then set out in a practical and coordinated way in the EMP.

The role of the EMP is to outline the mitigation, monitoring and institutional measures to be taken during project implementation and operation to avoid or control adverse environmental impacts, and the actions needed to implement these measures. The EMP provides the crucial link between alternative mitigation measures evaluated and described in the EIA and ensuring that such measures are effectively implemented.

For each proposed measure, the EMP defines the technical content, the estimated cost, the schedule of implementation, the role and responsibilities of Government Agencies, the source of funding and the way to monitor the results.

8.2. SUMMARY OF IMPACTS AND MITIGATION MEASURES

TABLE 8.1: EXPECTED IMPACTS AND PROPOSED MITIGATION MEASURES

EXPECTED IMPACTS	PROPOSED MITIGATION MEASURES
IMPACTS RELATED TO PROJECT LOCATION	
Episkopi Sewage Treatment Plant	
Permanent Land Acquisition Permanent acquisition of private land for construction of the STP, the storage reservoirs and the pumping stations	- Compensation for loss of land, agricultural trees and possible loss of income.
Impacts on Ecological Values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat and park in the area.	No mitigation measures required.
Polis Chrysochous Treatment Plant	
Permanent Land Acquisition Permanent acquisition of private land for construction of the STP, the storage reservoirs and the pumping stations	- Compensation for loss of land, agricultural trees and possible loss of income.

Impacts on Ecological Values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat and park in the area.	No mitigation measures required.
IMPACTS RELATED TO PROJECT DESIGN	
No significant impacts are expected	- Treatment process is reliable and proven and effluent will meet the set performance standards. - Emergency storage will safeguard against problems in treatment process. - Sludge treatment to be chosen will be effective in achieving required standards.
IMPACTS DURING THE CONSTRUCTION STAGE	
Temporary Land Acquisition Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.	- Compensation for the temporary use of land, loss of production, or inconvenience created. - Design to minimize construction land requirements. - Special obligation on contractor to minimize impacts on temporarily acquired agricultural land so that it can be put back to production quickly. Measures include the preservation of soil through profiling of the top and sub soil to the original level. Building material must be fenced and the land should be cleared after construction. - Full rehabilitation of sites to be required form contractor.
Vegetation Clearing Clearing of vegetation for construction of the sewage treatment plants, the storage reservoirs, the pumping stations and the conveyance system.	- Compensation for the destruction of agriculture, particularly trees (permanent crops). - Prior to construction a rapid survey of affected trees and vegetation should be carried out to clearly indicate the number of trees to be cleared. - An equivalent number of trees and vegetation to be planted by contractor.
Soil Impacts - Soil erosion: resulting from uncovered and unconsolidated materials during construction	- Strict clauses regarding earthworks management during construction to be imposed to the contractor. - Careful design of construction operations, including the selection of haulage routes into the site and the location of stockpiles. - Pipe construction should be divided into sub-sections, after excavating one section, backfilling it and clearing the area. - Timely carry away discarded soil. The

	temporary deposits should be kept within barriers to prevent erosion. - Avoid large scale excavations during rainfall or strong winds. - Remove as little vegetation as possible during construction and revegetate bare areas as soon as possible after construction. - Avoid creating large expanses of bare soil. If such expanses are created, then windbreaks may be required.
- Soil disaggregation	- Take the soil out in horizons and keep each horizon in a separate pile.
- Soil compaction	- Use wide tires to spread the weight of vehicles. - Use a single or as few tracks as possible to bring vehicles to construction sites. - Till the area after compaction has taken place.
Dust, Fumes and Noise	
- Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds.	- Frequent spraying of stockpiles and haulage roads with water. - Regular sweeping of access roads. - Covering of vehicles carrying materials. - Early planting of peripheral tree screens where they will be part of the development. - A system of monitoring site accesses and stockpiles should be implemented.
- Noise: from construction operations, machinery and vehicle movements.	- Use equipment with low noise outputs. - Where it is necessary for construction sites to operate at night, causing an impact on residents, it is required that noise reduction measures are taken so that reasonable noise levels are maintained. - Blasting and other operations with significant noise outputs should be restricted to certain hours of the day, while being prohibited at night. - A plan for the management of construction activities, so as to minimize noise impacts and ensure compliance with noise control measures to be imposed on contractor. - Construction operations must be carefully planned to minimize construction time.
- Air pollution: From vehicle transport and from mechanical equipment..	- Plan routes to minimize vehicle movements as far as possible.

On-Site Safety	- Strict clauses imposed on contractor for the implementation of on-site health and safety measures and standards. - Regular maintenance of construction equipment, machinery and vehicles must be ensured. - Measures to ensure traffic security to be adopted. - Preparedness procedures in case of accidents and emergency situations to be established.
Waste Management Construction waste, domestic solid waste.	- Contractors must make arrangements for the collection and transportation of domestic waste to official landfill sites. - The contractor must prepare a plan for the collection and appropriate disposal of construction waste and transportation plans must be made. - Transportation at peak hours must be avoided. - Spoil and wastes should be transported along specified routes and disposed of at designated sites. - Inspection should be carried out to ensure that the plans are properly implemented.
Pollution Air water and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.	- Strict clauses regarding the operation and maintenance of construction equipment to be imposed on contractor. - Regular monitoring of water and air quality near construction sites must be carried out. - Procedures must be taken for the containment of pollutants at storage sites. - Measures must be taken to avoid impacts from any accidental spills, including the containment of storage tanks on concrete floors will walls to prevent the release of effluents on the soil. - Preparation and implementation of a management plan for the collection, storage and disposal of used oils and other pollutants.
Traffic As a result of increased vehicle movement and road excavations.	- The construction of the conveyance system should be phased and excavation, pipe laying and trench refilling should be completed as quickly as possible. - For busy roads, construction at peak hours should be avoided. - Spoil soils on roads under construction should be kept to a minimum so as not to affect local traffic. - Specific routing must be prepared for vehicles.

IMPACTS DURING OPERATION	
Landscape impacts Limited Impacts	Planting within and around the site and maintenance of the existing vegetation where possible.
Noise At STP sites and pumping stations. Impact at STP sites limited as they are at as sufficient distance from residential areas, however pumping stations are within urban areas.	- Enclose sources to insulate noise and incorporate specific acoustic features in the design of buildings. - Use low noise equipment. - Application of noise control equipment where necessary. - Use of noise screens, including tree plantings - The noisiest sources should be monitored four times a year and noise measurements should be carried out near the plant and pumping stations two times a year during the day and night.
Odours	- Implementation and observance of the appropriate treatment processes. - Cover of the treatment areas and provision for air filtration. - Regular monitoring of the processes and appropriate chemical and biochemical testing. - Regular maintenance of the pumping station units. - Use of odour control systems in the design of the treatment plants. - Appropriate design of the conveyance system in order to avoid the creation of sulphur compounds (H_2S).
Impacts on Groundwater Resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment	No measures required.
Impacts from Sludge Production and Reuse	- Choice of treatment process to meet standards for reuse in agriculture. - Correct soil application methods according to the Code for the Use of Sewage Sludge in Agriculture. - Monitoring of sludge and soil quality in accordance with the Code.
Risk of System Overload Minimum risk: emergency storage available, design includes seasonal variations	No measures required.
Risk of Insufficient Treatment of Effluents	- Regular monitoring of effluent quality.
Reuse of Treated Effluent for Irrigation	- Regular monitoring of effluent quality according to the Code of Practice for the Use of Treated Effluent for Irrigation. - Choice of irrigation methods according to

	the Code. ↳ Crop selection to avoid adverse impacts on crop yields.
Urban Reuse of Treated Effluent	↳ Regular monitoring of effluent quality. ↳ Labeling of pipes and use of signs in areas irrigated with treated effluent. ↳ Choice of irrigation methods according to the Code of Practice.
Groundwater Recharge	↳ Monitoring of effluent and groundwater quality to avoid risk of aquifer pollution.
MITIGATION MEASURES FOR THE REUSE OF SLUDGE	
Misuse of the agricultural value of sludge Leaching of nitrates to groundwater	
⇩ Better knowledge of sludge content in terms of compounds of agricultural value	
❑ Adequate sampling procedures (frequency, number of samples, etc.)	
❑ Adequate analysis protocols	
⇩ Improve use of sludge agricultural value	
❑ Determination of the sludge agricultural value (N, P, K, content)	
❑ Planning and application adapted according to: ⇨ Plant needs ⇨ Other fertiliser sources ⇨ N remaining in the soil ⇨ Nutrient bioavailability ⇨ Adequate spreading periods according to agricultural and environmental constraints	
❑ Regular soil analyses to establish increase in nutrient content	
❑ Information from farmers about quantities spread	
Soil contamination by heavy metals and organic pollutants	
⇩ Determination of background levels in soil	
⇩ Determination of pollutant content in sludge	
⇩ Safe storage of sludge	
❑ Safe storage to reduce leaching	
❑ Sufficient storage capacity	
❑ Reduction of storage duration in the field	
Water contamination by heavy metals and organic contaminants	
⇩ Forbid sludge spreading in sensitive areas, especially:	
❑ On sloping land ❑ Near surface water ❑ On wet areas ❑ Within water resource protection areas	

❑ On sandy soils ❑ On frozen grounds ❑ In areas where the water table is near the surface
⇩ Encourage fast ploughing down in order to reduce the risk of runoff and the use of close-to-ground techniques in order to reduce the formation of aerosols
⇩ Safe storage of sludge
Crop contamination by heavy metals and organic pollutants
⇩ Reduce transfer in the food chain
❑ Encourage sludge spreading before non-food crops
⇩ Limit plant uptake
❑ Adapt sludge spreading to soil types (mainly according to pH and CEC)
❑ Take into consideration heavy metal bioavailability in soil
❑ Define a crop/sludge type matrix with specific recommendations
❑ Prohibit sludge spreading on plant/crops which are known to accumulate heavy metals
⇩ Limit deposition on plant
❑ Limit use of sludge on vegetable and certain fruit productions
⇩ Analyses of the metal level in crops and foodstuff
Animal contamination by heavy metals and organic pollutants
⇩ Limit pollutant transfer to animals
❑ Tighten limits concerning quantity and quality of sludge which may be applied
❑ Grazing land: ⇨ Introduce a time period for the application of sludge before harvesting ⇨ Favor sludge ploughing down
❑ Grassland: ⇨ Allow spreading before sowing and after each cut
⇩ Control of the metal levels in foodstuffs
❑ Analysis of the pollutant levels in animal products
Human contamination
⇩ Limit pollutant transfer in the food chain
⇩ Protection of operating equipment
❑ Ensure safe manipulation of sludge
❑ Material cleaning and maintenance
❑ Protective clothes
Contamination by pathogens
⇩ Animal contamination

❑ Grazing land: introduce a time period before grazing
❑ Grassland: allow spreading before sowing and after each cut
❑ Encourage fast ploughing down of sludge
⇩ Human contamination
❑ Prohibition of sludge spreading on products which are to be consumed raw
❑ Safe transportation of sludge
❑ Prohibition of sludge spreading in the vicinity of houses and near bathing water and drinking water supply areas
MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENTS FOR IRRIGATION PURPOSES
Impacts on soil productivity, groundwater contamination, health impacts, impacts on crop growth and quality
⇨ Drafting of Reuse Management Plan, incorporating:
⇩ Appropriate site identification ⇩ Crop water requirements ⇩ Crop selection ⇩ Irrigation method selection and scheduling. ⇩ Evaluation of nutrient and salt loading rates
❑ Nitrogen leaching to groundwater and accumulation in soil.
⇨ Balance nitrogen loading rates with crop requirements.
❑ Phosphorus leaching to groundwater and accumulation in soil.
⇨ Balance phosphorus loading rates with crop requirements.
❑ Adverse impacts on soild productivity and risk of groundwater contamination
⇨ Determine salt loading rates
⇨ Ensure irrigation practices do not result in off-site run-off, appropriate leaching and drainage provisions.
❑ Adverse impacts on crop yields and quality
⇨ Crop selection based on crop sensitivity to treated effluent constituents.
❑ Adverse impacts on health
⇨ Timing of irrigation prior to harvesting
⇨ Correct irrigation practices
⇨ Minimize site access during irrigation periods.
⇨ Use of signs specifying that treated effluent in used.
⇨ Establishment of buffer zones around irrigated areas where necessary.
❑ Quality of treated effluent
⇨ Implements treated effluent quality monitoring programme to ensure compliance with the set standards
⇨ Implement soil quality monitoring programme
⇨ Monitoring of application rates of heavy metals, nutrients and salts
⇨ Monitoring of irrigation methods and practices

8.3. MITIGATION MEASURES

8.3.1. CONTRACTS FOR ENVIRONMENTAL MANAGEMENT

8.3.1.1. CONTRACTUAL DISPOSITIONS

From experience, it has been observed that obtaining any specific task from a contractor requires first that the task is specified in the contract documents and then, that a specific payment is allocated to that task. This is the basis for any construction contract which relies on detailed technical specifications and their related payment quantities.

To be effective, the environmental and social obligations of a contractor must be comprehensively specified and individually payable through the contract documents. Both actions work together because the payment system will influence the way specifications are prepared and displayed.

In case of a project, the Environmental Impact Assessment report is generally mentioned in the Assurances in a way that all mitigation measures recommended have to be implemented.

Thus, the preparation of detailed environmental and social specifications for the Contractor is proposed prior to the bidding process, with the objective to have eventually a legal document which establishes clearly the obligations of the contractor, the quantities of work involved and the related cost of measures.

8.3.1.2. PREPARATION OF TECHNICAL ENVIRONMENTAL SPECIFICATIONS

The environmental and social specifications for the Contractor will be organized into 4 sections:

- ❑ Section A: Environmental Protection Management
- ❑ Section B: Labor Camps and Worker Health Management
- ❑ Section C: Safety Management
- ❑ Section D: Social Management

Each section will address the 2 following aspects:

- ⇨ description of the Contractor's obligations with regards to those aspects covered by the section
- ⇨ description of the parameters that will be monitored for payment

❑ DESCRIPTION OF CONTRACTOR OBLIGATIONS

⇩ SECTION **A**: Environment Protection Management

The Section A will specify the Contractor obligations with regards to the preparation of a Construction Site Environmental Management Program (CSEMP) aiming at protecting the work sites and their surroundings against potentially adverse impacts. The Contractor's CSEMP will include the facilities and procedures for the management of solid wastes, the soil conservation measures and proposed rehabilitation works once the construction ends, the measures aiming at protecting the local fauna and flora, the preventive measures against water pollution and the monitoring program (air, water). For each aspect, the environmental specifications will provide the contractor with standards or quality objectives to be achieved.

⇩ SECTION **B**: Labor Camps and Worker Health Management

The Section B will address the minimum standards to be implemented in the labor camps and facilities regarding issues as accommodation, food supply and canteen, water supply, waste management, treatment of sewage and sanitary conditions on site. The following topics will be addressed:

- Maximization of employment of locally based labor who will be transported to the sites by bus;
- Mechanisms to ensure contractors provide their work force and camps with adequate quantities and standards of the following :
  - Water supply
  - Sanitation and solid waste disposal
  - Health checks
  - Security and lighting
  - Disease pathogen and vector control
  - Fire extinguishers and fire drills
  - Training for specific tasks, particularly safety training
  - Catering and canteen services
  - Personal Protective Equipment (PPE)
  - Transport to public transport facilities
- Actual volumes, quantities and standards for the above mentioned items.

SECTION Γ: Safety Management

For safety issues, Environmental Specifications will have to address two distinct aspects:

- The On-site Safety, PPE, and Medical issues, and
- The Off site Safety, Medical and Road traffic issues

The *On-site Safety, PPE, and Medical Aspects* will address all the measures the Contractor needs to implement to ensure a safety standard close to international standards, and appropriate medical evacuation of the workforce.

For most *Off-site Safety accident and Medical issues*, the Environmental Specifications will fix the objectives. In its offer, the Contractor will detail which measures he intends to apply for achieving these objectives. Major issues to be covered under this headline include:

- Road signs
- Road accidents
- Speed limits through populated areas and speed control bumps (near schools, at the entrance of villages))
- Project traffic regulations including: night-stop regulations, truck cleaning, washing and cargo transfers, use of headlights, carriage of unofficial persons and goods, educating project drivers in safety matters, regular inspections of vehicle condition, compulsory first aid kits, fire extinguishers, use of vehicle log books, seat belts, etc.
- First aid and emergency medical facilities,
- Third party, livestock and property accident insurance cover
- Hazardous cargo movement and accident procedures,
- Exceptional load movement procedures,
- Accident reporting procedures,
- Off-site damage / injury claim procedures,
- Village liaison and discussion arrangements,
- Repairs of local roads and bridges damaged by project traffic,
- Load shedding and spillage accidents

SECTION Δ: Social Management

The Section D will fix the minimum conditions to be applied by the Contractor while managing all social aspects related to construction activities. Most of them will focus on how to reduce nuisance to villagers.

Meetings must be arranged between the contractors and the village authority of all villages likely to experience nuisance events.

As a result of the meetings, the contractors will prepare a nuisance control program which will be posted in public places in affected villages. This program includes measures to deal with at least the following issues.

- Traffic density: Possible by-pass route, Speed bumps near villages, Crossing places, Prohibition of night traffic
- Noise: Regulations about traffic and working hours in residential areas.
- Fumes, dust: Regulations on refueling, fly ash or cement transfer in or near residential areas, road watering, effective covering of truck loads such as sand or gravel.
- Traffic obstruction: Temporary parking, regulations for keeping open roads even during upgrading works or during movements of exceptional loads.
- Social relation: Monthly meeting between contractor and representative of potentially affected village to be organized for solving conflict issues.

Public information can be carried out among concerned villages to use the monthly meeting with contractor to ensure the nuisance reduction program continues to serve their interests.

MONITORING INDICATORS

For the four specification sections, the indicators that will be monitored during the site inspections must be specified.

Measurable Items

Most of the contractor environmental and social obligations are actually measurable. For these ones, indicators to be monitored will be quantities and the Contractor will be paid only if these quantities are observed on the sites.

For example in Section B "Labor Camps and Worker Health Management", the following obligations and indicators could be considered with regards to Restrooms:

- Description of the Contractor's obligations:

  "The Contractor shall provide washrooms and other facilities, as necessary, to satisfy the needs and customs of its workforce. Washrooms shall be located and sized based upon the size of the workforce and shall include adequate lighting and appropriate number of facilities. Separate facilities shall be provided for men and women. Washrooms shall be constructed in well-ventilate areas, and supplied with an adequate amount of hot and cold water (potable) and other ancillaries".

- Description of indicators

"As a minimum, the following shall be provided:
- toilets: 1 unit per 15 persons. Each unit being supplied with toilet paper and holders, waste receptacle, and deodorant ;
- urinals: 1 unit per 25 men ;
- shower stalls: 1 per 10 persons ;
- washbasins and mirrors: 1 per 5 persons".

Non-measurable Items

Some environmental and social obligations remain difficult to quantify. A typical example is the protection of areas adjacent to construction areas: It is not realistic to specify a penalty for a number of trees cut at a wrong place, or for any cubic meter of material cast aside the road.

But for these non-measurable items, it is important to specify the methods anticipated to reduce adverse impacts and also to specify clearly which condition would constitute a non-payment situation.

❑ PAYMENT PROCEDURES FOR ENVIRONMENTAL AND SOCIAL OBLIGATIONS

An adapted payment procedure is the most efficient tool to oblige a Contractor to fulfill its obligations. The payment procedures should provide the executive agency with the maximum guarantee that money is to be paid only when the work is totally and satisfactorily completed. Also, the payment procedure should act as an incentive for the Contractor, exacerbating its willingness to fulfill its environmental and social obligations with the best results. In such case, the budget considered for the services should be significantly higher than what should be the expenses to implement the measures.

These issues will be discussed when preparing the environmental specifications for the contractor, and they will consider the most appropriate and acceptable solutions for the remuneration of Contractor Environmental and Social Obligations.

8.3.2. COMPENSATION FOR LAND ACQUISITION

Compensation must be paid for all permanent land acquisitions as well as temporary acquisitions during the construction stage.

8.3.3. COMPENSATION FOR THE LOSS OF TREES

The executing authority will carefully confirm the number of trees affected by the Project and discuss with the Contractor to identify any possibility to minimize the loss during the construction.

The Contractor will make provisions for the planting of an equivalent number of trees lost because of construction activities. These trees will be planted in an area to be determined with the relevant authority and resident representatives.

The cost for purchase of plants, their transport to the project site, their planting and 2 years of follow up will be included in the environmental budget of the contractor.

8.3.4. PROJECT COMPLETION: RECLAMATION OF TEMPORARY USED SITES

Decommissioning refers to the dismantling, decontamination and removal of process equipment and facility structures, at the end of the construction stage, and to recontouring the land and planting vegetation to prevent soil erosion as appropriate. Assuming there is no other use for field facilities, all structures and related infrastructure facilities are to be dismantled by the contractor.

All the sites used temporary by the contractor installations will be fully rehabilitated at the end of the construction stage and shall be returned to their initial use. This concerns areas for borrowing earth, for temporary access roads, for workers camps and facilities, for material storage and for machinery parking and maintenance.

- Site Reclamation: Construction related sites to be decommissioned and reclaimed will be re-contoured and restored so that the pre-disturbance vegetation can re-establish itself in a short period of time. Reclamation will be limited to disturbed areas of the site. To facilitate re-vegetation, mitigation measures that may apply include fertilizing and seeding. Close attention will be paid to areas where erosion potential is high. Large plots of land such as storage yards, borrow areas, and main camp sites will be re-vegetated and maintained until plant growth is established.

- Grading and Surface Reclamation: Disturbed areas where temporary construction facilities existed will be returned to natural contours where possible. Areas of high erosion will be identified in the field and treated with special design measures that may include anti erosion mats or mulching. Compaction of the sub-soil will be relieved by scarification in areas of disturbance. The topsoil stored during the initial phase of construction will be returned to the site, evenly spread and lightly packed to prevent depressions and water pockets. In areas where topsoil was not stripped, the surface will be ripped or scarified to relieve compaction. Grading and surface reclamation activities will not take place when the topsoil is muddy or the subsoil wet.

- Revegetation: If seeding and planting are needed, native seed mixtures or plant seedlings used will be compatible with local soil conditions and climatic zones. Seed will be applied uniformly in a manner appropriate for the type of seed used and will be placed in a firm, moist seedbed at a suitable depth. Seedlings will be planted at a density and in a manner conducive to successful growth. In disturbed temporary construction site areas with little topsoil or naturally sparse vegetation, fertilization and mulching may be included in the site reclamation works. Seeded or planted sites failing to show successful growth after one growing season will be assessed to determine cause for failure, and corrections will be made as appropriate.

- Temporary Storage of Removed Topsoil: Will be done at appropriate sites in a manner that maintains its fertility (i.e. storage of removed topsoil for less than 6 months, protection of topsoil stockpiles from surface drainage).

8.4. MONITORING PROGRAMMES

Environmental monitoring programs are designed to provide the necessary feedback about the actual impacts of the projects during its construction and operation stage. Monitoring helps judge the success of mitigation measures in protecting the environment. Monitoring is also used to ensure compliance of activities with existing standards, as for example, effluent quality discharged in a water body.

If efficiently backed up by powers to ensure corrective action when the results of monitoring show it necessary, a monitoring program is a proven way to ensure effective implementation of mitigation measures.

8.4.1. WATER QUALITY MONITORING DURING CONSTRUCTION

8.4.1.1. OBJECTIVES OF MONITORING

The objectives of water quality monitoring are:

- To ensure a strict control of pollution from construction activities and to check the efficiency of water quality protection measures set up by the civil work contractor;
- To ensure that construction activities do not alter significantly the river or reservoir or aquifer water quality.

To satisfy these objectives, two monitoring systems must be organized: one, focusing on construction sites and on the release of pollutants, the other on the condition of the receiving water bodies.

The first monitoring system is called a Compliance Monitoring, which will compare discharges from the site activities with existing standards. Implicit in this system is the assumption that if a characteristic being monitored is within acceptable limits, then the effects will also be within acceptable limits.

The second system is called an Effect Monitoring, as it tries to link specific human activities to any changes in the environmental characteristics of the receiving water body. This monitoring is the most widely used in EIA, but unfortunately, too frequently with very limited results.

8.4.1.2. LOCATION OF SAMPLING SITES

For the construction sites monitoring (compliance monitoring), sampling sites will be distributed in points where the control of effluents from construction activities can be easily implemented: surface drainage channels from construction sites, from concrete preparation plant, from worker camps sewage facilities, from disposal areas for earth-fill or for solid waste, from machinery reparation yards and from petrol products storage areas.

For the follow up of water body quality, the selection of sampling stations located upstream and downstream the anticipated influence zone will be considered. All the sites for monitoring will have to be determined at the early stage of project implementation, when the Contractor has already submitted the location for camps, storage and major earthworks.

8.4.1.3. SAMPLING AND ANALYSIS

- PARAMETERS TO BE MEASURED

The selection of parameters to be measured depends on the potential pollution expected, the type of water body and water use concerned, and the sensitivity of the biological environment, as well as the relevant legislation (if any).

Two types of indicators should be considered:

- ⇨ Those related to the follow up of potential pollution sources resulting from construction activities, and
- ⇨ Those related to larger characterization of the receiving (or threatened) water body in relation to its quality and sensitivity for the biodiversity.

The most frequently observed pollution types from construction works are mainly suspended solids due to earthworks, acidification due to concrete related activities, and hydrocarbons from engine leakage and maintenance. Potential pollution from workers camps is mainly of bacteriological nature and related to sanitation systems. The parameters to be followed must be the best indicators of activities anticipated in the sites, which may clearly establish the presence or not of a nuisance directly induced by the activities.

The other group of parameters concerns those providing more general information on the condition of the receiving water body, either a river or a reservoir. Sampling stations have to be located at a greater distance from the construction sites, to ensure that they reflect the wider influence (if any) of the construction activities on the receiving water body and on the biodiversity it supports. In this case, sampling is performed simultaneously upstream the activity area and downstream.

The recommended parameters to be monitored are:

- Group 1: Indicators of Pollution
  - At any discharge point from the construction sites: Temperature, pH, electrical conductivity, Dissolved Oxygen (DO).
  - At the treated effluent discharge point from the labor camps: faecal coliforms, total coliforms, Ammonia, Biochemical Oxygen Demand in 5 days (BOD_5).
  - At the outlet of concrete production effluent (if any): Total Suspended Solids (TSS) pH.
  - At the outlet/drains draining construction activities and mechanical maintenance areas: pH, Turbidity or (TSS), Lead, Hydrocarbons (HPA), oils.

- Group 2: Indicators of Water Body Quality

  Temperature, pH, electrical conductivity, TSS, TDS, Chemical Oxygen Demand (COD), Ammonia, Total Nitrogen, Total Phosphorus.

- TYPE OF SAMPLING AND FREQUENCY OF COLLECTION

- Sampling for Group 1 indicators should be performed on a weekly basis[1]. The Contractor will be requested to carry out the sampling and the analysis, the implementing Agency being mainly in charge of random control sampling.
- Sampling for Group 2 indicators should be performed on a monthly basis.

Samples should be kept in the dark and maintained as cool as possible within a chilled insulated container and returned to the laboratory promptly after collection. Samples should be analysed as soon as possible and preferably within 8h of collection. Samples storage is recommended not to exceed 24h at 5°C.

Temperature, turbidity, TSS, pH and Dissolved Oxygen could be measured directly on site in using a multi-parameter probe, with regular laboratory calibration. BOD_5 , Lead, Hydrocarbons (HPA) and bacteriology must be measured in a Water Quality Laboratory.

[1] *Weekly basis the first few months of construction, then twice a month if results appear satisfactory.*

- ❑ REPORTING AND DATA INTERPRETATION

All results (site and laboratory) will be recorded in a logbook and computerized so as to ensure proper data record and an easy data interpretation with graphs.

8.4.1.4. ORGANISATION

The Contractor will be requested to follow up on a weekly *basis* the pollution load from its installations, in accordance with sampling procedures determined. Samples have to be delivered to an agreed laboratory for analysis. It is advisable to carry out on a random basis control sampling to ensure the results provided by the Contractor are true and correct. A minimum control sampling of once per month is recommended.

8.4.1.5. REPORTING

Weekly results from compliance monitoring compiled by the Contractor will be immediately submitted to the relevant authority. Monthly report with results and interpretative analysis will be submitted monthly together with other monitoring material by. The monthly report will also include results from random control analysis and of water bodies monitoring.

8.4.1.6. SCHEDULE OF ACTIVITIES

TABLE 8.2: SCHEDULE OF ACTIVITIES FOR WATER QUALITY MONITORING

PERIOD	ACTIVITIES	COMMENTS
Prior to Construction	Prepare Contractor specifications for water quality compliance monitoring	Defines number of sites, location, parameters to analyze, frequency of sampling, procedures for sampling, laboratory designated for analysis, reporting of results.
	Identify suitable sites on receiving water body and carry out preliminary sampling & analysis	Sites must be selected for easy access and on how good they represent the conditions prevailing in the area. If possible should rely on existing stations used for long term monitoring of the whole river system.
Construction Stage	Sampling on weekly basis, deliver samples to laboratory and provide weekly report on results	Weekly report submitted to relevant authority.
	Carry out monthly sampling to control accuracy of contractor's monitoring.	Results to be submitted to relevant authority for further action if required.
	Prepare formal notice to Contractor if results do not comply with standards	Follow up for effective implementation of corrective action by Contractor, if required.
	Carry out monthly sampling of receiving water body	Results to be submitted to the relevant authority for further action if required.
	Monthly report of water quality results to be prepared	Report with conclusions to be submitted to relevant authority.
	Quarterly report on water quality monitoring	Report with conclusions to be submitted to relevant authority.
Operational Stage	Carry out monthly sampling of receiving water body	Regular monitoring of the receiving water quality in case of groundwater recharge

8.4.2. WATER QUALITY MONITORING DURING OPERATION

During the operation of the STP, if the treated effluent is stored in an existing dam, or if it is used for groundwater recharge purposes, regular monitoring of the quality of the receiving waters is required.

The following parameters must be examined:

- ⇨ Temperature, pH, electrical conductivity, suspended solids
- ⇨ BOD_5, COD
- ⇨ Coliforms, intestinal worms
- ⇨ Total N, total P

Monitoring must be carried out on a weekly basis.

8.4.3. AIR AND NOISE MONITORING

8.4.3.1. OBJECTIVES OF MONITORING

Air quality is anticipated to be locally and temporally altered by the construction activities, due to the Generation of exhaust fumes from trucks and heavy machinery, the production of noise and emission of dust because of earthworks.

❑ FUMES AND GASES

Direct monitoring of possible sources of pollution is strongly recommended. Direct control of exhaust systems on trucks may limit the production of exhaust gas resulting from the use of old or badly maintained trucks. The strict enforcement of speed limitation in urbanized areas will also reduce the production of exhaust gas. General control of air quality will not provide usable information, as few dozens of trucks or bulldozers will not alter significantly the air quality of widely opened and windy areas.

❑ PRODUCTION OF NOISE

Noise must be monitored at workers camps level, on the construction sites (within the worker safety component) and in the nearby villages or residential areas. Monitoring of noise does not just concern measuring a point, but also collecting any claims of nearby population or of workers suffering from noise. Request or suggestion boxes have to be opened in various places where people may express their inconvenience regarding noise, and from where the breaking of the rules by the Contractor can be proved and discussed. Strict rules have to be established regarding the use of noisy equipment near residences, including the traffic of trucks.

During the operation of the STP noise levels must be regularly monitored near plant equipment, such as pumps, ventilators and air conditioners, near pumping stations, and in the nearby villages or residential areas, or recreation areas.

.

❑ PRODUCTION OF DUST

Dust will be produced in several places where construction and pipe laying will commence, particularly during the summer when the dry climate will increase the risk of soil erosion from winds. Dust will also be produced by the trucks along the earth roads and with a particular adverse influence when crossing residential areas. For the well being of the workforce and of the surrounding population, dust emission has to be minimized in the most critical areas. For that purpose, regular watering of such areas is necessary. Strict clauses will be established regarding the obligation of the Contractor to water soil regularly along the roads crossing villages, inside camps and construction sites and on the disposal areas for earth fill.

8.4.3.2. LOCATION OF MEASURE SITES

Specific sites for regular measurement of air quality are not anticipated. If disputes arise between the Contractor and workers or resident population on a specific air quality issue, appropriate analysis in appropriate locations will be conducted in order to assess the magnitude of the inconvenience and its level compared to existing standards. This will probably mainly concern noise and dust emissions. Selective measurements of exhaust gas may also be carried out in case doubtful equipment is used.

However, before construction starts, it is advisable to carry out a campaign of measures in the project area, in villages crossed by the access road in order to establish a broad baseline of local conditions which may eventually referred to in case of dispute or claim. Parameters to be checked are Total Suspended Particulate (TSP), No_x, SO_2 and noise level at various times of the day.

8.4.3.3. ORGANIZATION

The concerned authorities will carry out on a random basis control measures of noise, dust or exhaust gases to ensure that the Contractor is operating within the Standards or to oblige it to appropriate measures in case standards are not respected.

8.4.3.4. SCHEDULE OF ACTIVITIES

TABLE 8.3: SCHEDULE OF ACTIVITIES FOR AIR QUALITY AND NOISE MONITORING

PERIOD	ACTIVITIES	MONITORING
Prior to Construction	Prepare Contractor specifications for air quality compliance to existing standards	Includes also specifications for maintenance of engines, watering of roads and stock piles, noise limitation, and traffic in urbanized areas
	Identify suitable sites in project area and carry out preliminary sampling & analysis	Sites must be selected for easy access and on how good they represent the conditions prevailing in the area.
Construction Stage	Carry out public information about obligations of contractor regarding fumes, dust & noise Inform villagers on grievance procedure	Compare grievance of the villages concerned to the specifications and standards the Contractor should meet.
	Review monthly grievance, and if justified meet with concerned villagers/head of village to identify corrective measure	Impose measures on contractor if required. Request analysis to be carried out if justified
	Carry out sampling to control respect by Contractor of standards and specifications	Results to be submitted to relevant authority for further action if required
	Prepare formal notice to Contractor if results do not comply with standards or obligations	Follow up for effective implementation of corrective action by Contractor, if required
	Monthly report of air related activities to be prepared	Report with conclusions to be submitted to relevant authority
	Quarterly report on air quality activities	Report with conclusions to be submitted to relevant authority

PERIOD	ACTIVITIES	MONITORING
Operational Stage	No activity anticipated	

8.4.4. SLUDGE MONITORING AND CONTROL

A sludge control monitoring programme must be implemented incorporating:

- Monitoring of sludge quality
- Monitoring of soil quality
- Monitoring of sludge application rates
- Monitoring of application methods and practices.

The Code of Practice for the Use of Sludge for Agricultural Purposes (Appendix B) and the Regulations on the Use of Sludge for Agriculture (517/2002) set out the minimum monitoring requirements and limit values. A more detailed monitoring programme, incorporating these requirements, is recommended to ensure the safe reuse of sewage sludge in agriculture.

8.4.4.1. MONITORING OF SLUDGE QUALITY

The following parameters must be analysed in order to characterize and monitor the composition of sludge in terms of heavy metal and nutrient content:

- Dry matter and organic matter
- pH
- Primary nutrients: Nitrogen (as Total N and NH_4^-N), Phosphorus (P) and Potassium (K)
- Secondary nutrients: Calcium (Ca), Magnesium (Mg), Sulphur (S)
- Micro-nutrients: Boron (B), Cobalt (Co), Iron (Fe), Manganese (Mn), Molybdenum (Mo)
- Heavy metals: Cadmium (Cd), Nickel (Ni), Lead (Pb), Zinc (Zn), Mercury (Hg) and Chromium (Cr III).

Values for the maximum permissible heavy metal content in the sludge according to the Regulations and the proposed limit values are outlined in Table 7.5.

According to the Regulations and the Code of Practice, the sludge must be analysed every 6 months. In cases where change is observed in the quality of the sewage, the frequency of the analyses will need to be adjusted accordingly. If the analyses results do not differ significantly during the period of one year the sludge can be analysed every 12 months. However, to ensure the safe use of sludge in agriculture, the following analysis frequency is recommended as a minimum, depending on the sludge quantity produced:

TABLE 8.4: PROPOSED ANALYSIS FREQUENCY FOR SLUDGE

QUANTITY OF SLUDGE PRODUCED PER YEAR AND PER PLANT (TONNES OF DS)	MINIMUM NUMBER OF ANALYSES PER YEAR		
	Agronomic Parameters	Heavy Metals	Micro-organisms
< 250	2	2	2
250 – 1 000	4	4	4
1 000 – 2 500	8	4	8
2 500 – 4 000	12	8	12
> 4 000	12	12	12

The analyses must be carried out at regular intervals during the year.

Sludge quality will be assumed to conform to the recommended limit values for heavy metals, or to a maximum to the set regulation standards, if for each concentration limit considered, the 90% of the samples within a twelve-month period are at or below the threshold value and if the 10% of the samples exceed only one threshold value and by less than 50%.

TABLE 8.5: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SLUDGE USED IN AGRICULTURE

PARAMETER	LIMIT VALUES (mg/kg DS)		LIMIT VALUES (mg/kg P)
	Regulation 517/2002	Proposed Limit Values	Proposed Limit Values
Cadmium (Cd)	20 – 40	10	250
Copper (Cu)	1 000 – 1 750	1 000	25 000
Nickel (Ni)	300 – 400	300	7 500
Lead (Pb)	750 – 1 200	750	18 750
Zinc (Zn)	2 500 – 4 000	2 500	62 500
Mercury (Hg)	16 – 25	10	250
Chromium (Cr III)	–	1 000	25 000

- SAMPLING

The samples must be representative of the final sludge to be applied on land, and sampling must be carried out after the treatment of sludge and before its delivery to the user. To achieve this, samples must be representative of the entire amount of sludge being sampled, collected after the last treatment process, and taken from the same location each time monitoring is performed.
Ideally, sampling locations must be as close as possible to the stage before final application. It is therefore recommended that samples are taken at the storage site prior to track loading for transport to the application sites.

Sample collection and sampling procedures must be clearly defined and followed consistently to minimize process errors. For this a sampling procedure must be drafted, which will include:

- Specification of the personnel responsible for the sampling
- Identification of the appropriate sampling equipment
- Description of sample mixing procedures
- Specification of the size and type of sample containers
- Specification of sample preservation procedures and holding times
- Specification of equipment cleaning procedures to ensure that cross contamination of samples does not occur
- Description of procedures to ensure that the integrity of samples is maintained during transport and analyses.

8.4.4.2. SOIL QUALITY MONITORING

The frequency of the analyses will depend on the initial condition of the soil and its heavy metal content, which must be verified before the application of sludge begins, together with the heavy metal content of the sludge and the frequency of the sludge deposition.

Analyses must be carried out for the following parameters (according to Regulations):

- pH
- Cadmium, copper, nickel, lead, zinc, mercury and chromium.

In addition, further analyses are recommended to determine the soil characteristics and chemical parameters in order to assess the sludge application rates depending on crop requirements in nutrients. Monitoring of the following parameters is suggested:

❑ MONITORING PRIOR TO SLUDGE APPLICATION

- Surface layer:
  - Particle size distribution
  - Electrical conductivity
  - Cation exchange capacity (CEC)
  - Lime requirement (acid soils)
  - Plant available P and K
  - Soil N parameters:
    - NO_3^-N
    - NH_4^-N
    - Organic matter
    - Organic N
    - O:N ratio
    - Soil microbial biomass C and N
    - N mineralization potential
- Subsurface layers:
  - Particle size distribution
  - Electrical conductivity
  - Cation exchange capacity (CEC)
- Surface layer:
  - Electrical conductivity
  - Lime requirements (acid soils)
  - Plant available P and K
  - Soil N parameters
    - Organic matter
    - Organic N
  - Subsurface layers:
    - Electrical conductivity

The concentrations of heavy metals in the soil must be according to the proposed standards, or to a maximum according to the set regulation standards.

TABLE 8.6: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SOIL

PARAMETER	LIMIT VALUES (mg/kg DS)			
	Regulation 517/2002 6<pH<7	Proposed Limit Values		
		5 ≤ pH < 6	6 ≤ pH < 7	pH ≥ 7
Cadmium (Cd)	1 – 3	0.5	1	1.5
Copper (Cu)	50 – 140	20	50	100
Nickel (Ni)	30 – 75	15	50	70
Lead (Pb)	50 – 300	70	70	100
Zinc (Zn)	150 – 300	60	150	200
Mercury (Hg)	1 – 1.5	0.1	0.5	1
Chromium (Cr III)	–	30	60	100

Sampling must be carried out up to a depth of 0.25 m below the soil surface, unless the depth of the topsoil is less than this limit, in which case the sampling should not be carried out to a depth less than 10cm. A representative sample is that which is prepared by the mixture of 5 samples from different points per hectare. For smaller areas, mixtures must contain samples that have been taken proportionally at 1 sample per hectare.

8.4.4.3. MONITORING OF SLUDGE APPLICATION RATES

The sludge application rates must be in accordance with the recommended limit values for the heavy metal concentrations that can be added annually to soils. The table below outlines the limit values of the concentration of the heavy metals which may be annually added to soil, based on a ten year average.

TABLE 8.7: PROPOSED LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO SOIL, BASED ON A TEN YEAR AVERAGE

PARAMETER	LIMIT VALUES (kg/ha/year)	
	Regulation 517/2002	Proposed Limit Values
Cadmium (Cd)	0.15	0.03
Copper (Cu)	12	3
Nickel (Ni)	3	0.9
Lead (Pb)	15	2.25
Zinc (Zn)	30	7.5
Mercury (Hg)	0.1	0.03
Chromium (Cr III)	–	3

8.4.4.4. MONITORING OF SLUDGE APPLICATION METHODS AND PRACTICES

Regular monitoring is required to ensure that the sludge application practices followed are in accordance to the specifications of the Sludge Management Plan and the Regulations for the Use of Sludge in Agriculture, regarding:

- Crop selection
- Application methods
- Scheduling of application and harvesting.

Harvesting following sludge application must follow the following guidelines (this Table was taken from an EU document named "Working Document on Sludge, 3rd Draft" which was published in 2000). More information regarding the definition of the advanced and conventional treatment is given in Appendix 16:

TABLE 8.8: SLUDGE APPLICATION AND HARVESTING GUIDELINES

	ADVANCED TREATMENTS	CONVENTIONAL TREATMENTS
Pastureland	Yes	Yes, deep injection and 6-week no-grazing
Forage crops	Yes	Yes, 6-week no-harvest
Arable land	Yes	Yes, deep injection or immediate ploughing down
Fruit and vegetable crops in contact with the ground	Yes	No. no harvest for 12 moths following application
Fruit and vegetable crops in contact	Yes	No. no harvest for 30 moths

	ADVANCED TREATMENTS	CONVENTIONAL TREATMENTS
with the ground – eaten raw		following application
Fruit trees, vineyards, tree plantations and reforestation	Yes	Yes, deep injection and 10-month no-access to the public

8.4.4.5. INFORMATION REQUIREMENTS AND RECORD KEEPING

Records must be kept on the following information requirements:

- The quantity of sludge produced and the quantities supplied for use in agriculture
- The composition and properties of the sludge in relation to the agronomic parameters suggested above
- Results of the analyses of the sludge in relation to the heavy metal content
- Names and addresses of the receivers of sludge
- Location of the plots of land on which the sludge will be applied, their area and the quantities of sludge received for use
- Type of land use, i.e. crops grown
- Results of the analyses of the soil
- Monitoring results in relation to the application rates and practices.

8.4.5. MONITORING PROGRAMME FOR THE REUSE OF THE TREATED EFFLUENT

8.4.5.1. MONITORING OF THE QUALITY OF THE TREATED EFFLUENT

The quality of the treated effluent must be regularly monitored to ensure compliance with the set standards. Monitoring must be carried out for the following parameters:

PARAMETER	SUGGESTED FREQUENCY
pH	Weekly
BOD_5	Weekly
COD	Weekly
SS	Daily
Coliform, intestinal worms	Daily
Turbidity	Continuous
Cl_2 residual	Periodic monitoring
Nitrogen, phosphorus	Periodic monitoring
Total Dissolved Solids (TDS)	Periodic monitoring
Heavy Metals	Periodic monitoring

Concentration limits must be according to the suggested design standards for the quality of the treated effluent.

TABLE 8.9: SUGGESTED TREATED EFFLUENT QUALITY STANDARDS

PARAMETER	LIMIT VALUE
BOD_5	10 mg/l
COD	< 125 mg/l
SS	10 mg/l
Total N	15 mg/l

PARAMETER	LIMIT VALUE
Faecal coliforms	5 units/100 ml (in 80% of the samples) 15 units/100 ml (maximum)
Intestinal worms	Nil
Total P	2 mg/l
Free Chlorine	> 0.5 mg/l and < 2 mg/l

These values must not be exceeded in 80 % of the samples per month (minimum number of samples: 5).

TABLE 8.10: HEAVY METAL CONCENTRATION LIMITS

HEAVY METAL	MAXIMUM CONCENTRATION LIMIT(mg/l)
Aluminium	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.75
Cadmium	0.01
Chromium	0.1
Cobalt	0.05
Copper	0.2
Iron	5.0
Lead	5.0
Lithium	2.5
Manganese	0.2
Molybdenum	0.01
Nickel	0.2
Selenium	0.02
Vanadium	0.1
Zinc	2.0
Mercury	0.005

These values must not be exceeded for 75 % of the samples yearly. For the total concentration of metals the following relationship must be valid:

$C_{M1}/L_{M1} + C_{M2}/L_{M2} + \text{--------} + C_{Mi}/L_{Mi} \leq 1$,
where, C_{Mi} is the metal concentration and L_{Mi} the permissible metal concentration limit.

SAMPLING LOCATION

The most representative sample of the treated effluent is from a point where the effluent is thoroughly mixed and close to the outlet from the treatment plant.

8.4.5.2. MONITORING OF SOIL QUALITY

The soil should be analysed at least every 2 to 3 years, including the initial baseline monitoring for the following parameters:

- pH
- Electrical conductivity
- Exchangeable cations
- Total N, P and K
- Total cation concentration
- Sodium absorption ratio
- Heavy metal concentrations

SAMPLING LOCATIONS

The number and location of sampling sites will depend on the distribution of soil types in the area to be irrigated. If there is little variation, 3 to 5 sites may be sufficient for 5 to 10 hectares. More sites will be required for more complex land systems.

8.4.5.3. MONITORING OF IRRIGATION PRACTICES

Monitoring of the irrigation practices followed is recommended to ensure that the appropriate methods are implemented in accordance with the Reuse Management Plan and the Code of Practice.
The irrigation methods applied must be as follows:

TABLE 8.11: MONITORING OF IRRIGATION METHODS

CROP TYPE	IRRIGATION METHOD
Vines	⇩ Drip irrigation ⇩ Mini sprinklers and sprinklers ⇩ *Movable irrigation systems are not allowed*
Fruit trees	⇩ Drip irrigation ⇩ Hose basin irrigation ⇩ Bubblers irrigation ⇩ Mini sprinklers
Vegetables	⇩ Subsurface irrigation ⇩ Drip irrigation
Vegetables eaten cooked	⇩ Sprinklers ⇩ Subsurface irrigation ⇩ Drip irrigation
Industrial and fodder crops	⇩ Subsurface irrigation ⇩ Bubblers ⇩ Drip irrigation ⇩ Pop-up sprinklers ⇩ Surface irrigation methods ⇩ Low capacity sprinklers ⇩ Spray or sprinkler irrigation with a buffer zone of about 300 m

The timing of irrigation prior to harvesting must also be monitored. As a minimum, the following conditions are suggested for application and harvesting:

- Fodder crops: Irrigation is recommended to stop at least one week before harvesting
- Vines: No crops must be collected from the ground
- Fruit trees: In case where crops are wetted, irrigation must stop one week before harvesting

8.4.5.4. INFORMATION REQUIREMENTS AND RECORD KEEPING

Records must be kept on the following information requirements:

- The quantity of the treated effluent supplied for irrigation
- The plots of land irrigated with the treated effluent
- Type of crops irrigated
- Results of the analyses of the treated effluent
- Monitoring results for soil quality and irrigation management.

8.4.6. MONITORING OF CONSTRUCTION ACTIVITIES

8.4.6.1. OBJECTIVE OF MONITORING CONSTRUCTION ACTIVITIES

Past experience has shown that many construction contractors do not fully understand their obligations with respect to environmental mitigation measures. Most of the time, they do not make adequate provision for the work to be done during bid preparation and they find themselves without sufficient funds to fully implement the mitigation measures. This is unfortunately frequent for the works which come at the end of a project construction and which often concern the rehabilitation of construction or disposal sites.

It is thus of utmost importance that the construction contract includes provisions to ensure:

- The contractor understands clearly environmental mitigation measures and its obligations,
- The mitigation measures are specified in sufficient detail that the contractor can make reasonable estimates of actual costs in its tender document,
- The project management has the legal and financial power to enforce the application of mitigation measures through the contractor,
- The project management has the capability to monitor the contractor's performance in this regard.

Practically this means that to be effective, the EMP must rely on 1) clear contractual dispositions, 2) clear technical environmental specifications and 3) a capable body empowered with legal and technical authority to monitor contractor environmental activities.

Contractual dispositions and technical environmental specifications are major mitigation measures proposed and discussed in the following section.

8.4.6.2. CONTENT AND IMPLEMENTATION OF THE MONITORING PROGRAM

The environmental monitoring of construction activities is at the heart of the effective implementation of the EMP. The objective is to carry a regular and comprehensive review of the actual status of the environmental obligations of the Contractor. This monitoring aims at ensuring compliance of Contractor activities with its contractual commitments and the environmental regulations and standards. It is carried out all along the project construction on a monthly basis.

In accordance with the Environmental specifications, monitoring will be carried out for all aspects relevant to the 4 sections of the specifications: Environmental Protection Measures Section, Labor camps and Worker Health Management Section, Safety Management Section and Social Management Section. For each section, a *Standard Review Sheet (SRS)* will be prepared at the early beginning of the project. The SRS system should allow 1) a rapid review of the status of all components, 2) an easy way for ranking the level of satisfaction for each group of components, and 3) a formal way to check if requirements expressed to the Contractor the previous month have been given due attention and satisfaction. The results on the review shall be the approval or not of payments for the concerned issues.

Prior to the start of construction, responsibilities must be assigned by the relevant authorities for the preparation of the environmental specifications for the contractor and organisation of programmes and reviews.

8.4.6.3. SCHEDULE OF ACTIVITIES

TABLE 8.12: SCHEDULE OF ACTIVITIES FOR CONSTRUCTION ACTIVITIES MONITORING

PERIOD	ACTIVITIES	COMMENTS
Prior to Construction	Recruit personnel	
	Organize training of personnel	Training on EIA standards and formats, training on monitoring construction activities
	Prepare Technical Environmental Specifications for construction activities	To be included in the bidding documentation
	Prepare Standard Review Sheets and working Program	
	Participate to Tender evaluation and contract negotiation with contractor	Review all aspects related to social and environmental matters
Construction	Review with contractor location of borrow areas, disposal sites, camps, temporary access roads	Determine clearly land allocated and ensure compensation is fair and received by affected people.
	Review weekly standard of camps and facilities, of request made to contractor, of implementation of mitigation measures	Impose measures on contractor if required.
	Carry out control analysis if justified	
	Co-ordination of responsible bodies	Co-ordination of all monitoring programs at sub-project level
	Prepare formal notice to Contractor if results do not comply with standards or obligations	All orders or advises to Contractor to be forwarded through the responsible authority. Follow up for effective implementation of corrective action by Contractor, if required.
	Monthly Review	
	Monthly report on monitoring of construction activities	
	Quarterly report on monitoring of construction activities	Report with conclusions to be submitted to authority
Operation	Follow up of sites rehabilitation 1-2 years after completion of construction	Reporting of problems to relevant authority

8.5. ENVIRONMENTAL MANAGEMENT ORGANISATION

The Water Development Department (WDD) will be responsible for the implementation of the mitigation measures required during the construction stage. Responsibility for the operation of the STP and monitoring programmes will be with the Sewage Board that will direct the STP with the assistance of the WDD.

8.6. COST ESTIMATE FOR THE EMP

ITEM	ANNUAL BUDGET (CY£)	5-YEAR BUDGET (CY£)	RESPONSIBILITY FOR EXECUTION
INVESTMENTS	(During first year only)		
Creation of Internet Site	15 000	15 000	WDD/Consultant
Technical Assistance to WDD	20 000	20 000	WDD/Consultant
Communication campaign	15 000	15 000	WDD/Consultant
Land Acquisition & Compensation	1 820 000	1 820 000	WDD
Total	*1 870 000*	*1 870 000*	
OPERATIONAL COSTS			
Environmental Manager (WDD)	20 000	100 000	WDD
Environmental Supervisor (CSE)	18 000	90 000	
Budget for Ad Hoc expertise	10 000	50 000	WDD/Consultant
Budget for Construction EMP	120 000	600 000	Contractor
Construction Monitoring			
Water quality	2 400	12 000	WDD/Consultant
Air quality and noise	2 000	10 000	WDD/ Consultant
Monitoring during operation			
Water quality	1 000	-	
Air quality and noise	1 000	-	
Sludge quality	1 000		WDD/Sewerage Board
Treated water quality	1 000		WDD/ Sewerage Board
Sub-total	*17 6400*	*862 000*	
TOTAL COST	2 046 400	2 732 000	

9. PUBLIC CONSULTATION

There has been consultation with the appropriate authority including:

- ⇨ The Water Development Department
- ⇨ The Environmental Service
- ⇨ The Town and Country Planning Department

The consultations took place during the techno economical study during which the selection of the scheme and location took place. The recommendations made from the above authorities were taken into consideration on the final choice of the location. These suggestions can be found in Appendix 13.

Consultation also took place with the local authorities. Their suggestions were taken into consideration in the preliminary stage of the selection of a location from the sewage treatment plants. After the completion of the preliminary evaluation of the locations and the submittal of the feasibility study, a presentation of the technical, economical and environmental aspects of the project was given to the representatives of the community councils of Episkopi, Erimi, Kolossi, Trachoni and Ypsonas and another one to the council of Polis Chrysochous.

Some of the information taken from Episkopi community during its meeting that took place on February 16, 2005 is also presented in Appendix 13. The statement of the community against the reuse of treated effluent for the recharging of Akrotiri aquifer is mentioned here, as well as the expression of WDD's acquiescence regarding the community's decision

APPENDIX 1

QUALITY STANDARDS IN CYPRUS AND THE EU

CODE OF PRACTICE FOR THE USE OF TREATED WASTEWATER IN IRRIGATION

A Sewage Effluent Technical Committee Cyprus has developed draft regulation concerning the reuse of wastewater effluents in the irrigation of crops for human consumption, of fodder crops, industrial crops and amenity areas. These regulations are presented in Table A1.1.

TABLE A1.1: CYPRUS STANDARDS FOR URBAN TREATED EFFLUENT USED FOR IRRIGATION

IRRIGATION OF	BOD_5 (mg/l)	SS (mg/l)	FAECAL COLIFORMS / 100 ml	INTESTINAL WORMS/L	TREATMENT REQUIRED
All crops	(A) 10*	10*	5* 15**	Nil	Tertiary and disinfection
Amenity areas of unlimited access and vegetables eaten cooked	(A) 10* 15**	10* 15**	50* 100**	Nil	Tertiary and disinfection
Crops for human consumption Amenity areas of limited access	(A) 20* 30**	30* 45**	200* 1000**	Ni	Secondary and storage > 7 days and disinfection or Tertiary and disinfection
	(B) –	–	200* 1000**	Ni	Stabilisation – maturation ponds total retention time > 30 days or Secondary and storage > 30 days
Fodder crops	(A) 20* 30**	– 30* 45**	1000* 5000*	Nil	Secondary and storage > 7 days and disinfection or Tertiary and disinfection
	(B) –	–	1000* 5000*	Nil	
Industrial crops	50* 70**	–	3000* 10000**	-	Secondary and disinfection
	(B) –	–	300** 10000*	-	Stabilisation – maturation ponds total retention time > 30 days or Secondary and storage > 30 days

A: Mechanised methods of treatment (activated sludge, etc.)
B: Stabilisation ponds
*: These values must not be exceeded in 80 % of samples per month
**: Maximum value allowed
COD < 125 mg/l

For the purpose of this project, the category corresponding to unrestricted irrigation (all crops) has been assumed. The WDD would thus have the flexibility to reuse the wastewater for any purpose.

Furthermore, it is understood that most of the treated wastewater reuse currently practiced in Cyprus is for irrigation of hotel lawns and gardens and golf courses, for which a high quality effluent is required.

TABLE A1.2: CONTROL OF METALS
METAL CONCENTRATION LIMITS FOR THE TREATED WATER FOR PURPOSES OF CONTINUOUS IRRIGATION

METAL	CONCENTRATION, mg/l
Aluminium	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.75
Cadmium	0.01
Chromium	0.1
Cobalt	0.05
Copper	0.2
Iron	5.0
Lead	5.0
Lithium	2.5
Manganese	0.2
Molybdenum	0.01
Nickel	0.2
Selenium	0.02
Vanadium	0.1
Zinc	2.0
Mercury	0.005

For the total concentration of metals, the following relationship must be valid:

$$\frac{C_{M1}}{L_{M1}} + \frac{C_{M2}}{L_{M2}} + - - - - + \frac{C_{Mi}}{L_{Mi}} \leq 1$$

Where, C_{Mi} = the metal concentration and
L_{Mi} = the permissible metal concentration limit

The values must not be exceeded for 75% of the samples yearly.

TABLE A1.3: MONITORING OF TOXICITY OF TREATED EFFLUENT FOR IRRIGATION

TESTS	IRRIGATION[1]
ACUTE TOXICITY 1. Microtox: organism *Photobacterium phosphorium* (*Vibrio fischeri*) 2. Algaltox 72 hours: organism *Selenastrum capricornutum* 3. Daphtox: organism	Applied in uses 1, 2, 3

TESTS	IRRIGATION[1]
Daphnia magna Straus GENE TOXICITY Mutatox with or without activation of hepatic enzymes S9: Organism *Photobacterium phosphorium* (*Vibrio fischeri*) ACCEPTABLE LIMITS The results from the limits are expressed in Toxicity Units TU*	Applied only in uses 1, 2, 3 75% pf samples must be consistent with the above limits of acute toxicity: Microtox, Daphnia & Algae: TU50 ≤ 1 Mutatox: The treated waste must not be positive to the direct or upon activation with S9 test Mutatox

1. The testing for acute toxicity must be done twice a year and the testing for gene toxicity at least once a year. If it is ascertained that the waste due to its quality and in combination with the quantity or even dilution does not logically have the capacity to a) be toxic and b) its specific use contribute directly or indirectly to the deterioration of the recipient and the environment, then the toxicity testing is possible to be limited accordingly
2. TU50, TU20 mean toxicity units for 50% and 20% effect under the organism test or the corresponding biological activity

- The sewage treatment and disinfection must be kept and maintained continuously in satisfactory and effective operation so long as treated sewage effluent are intended for irrigation, and according to the license that will be issued under the existing legislation.

- Skilled operators should be employed to attend the treatment plant, following formal approval by the appropriate authority that the persons are competent to perform the required duties, necessary to ensure that the above conditions are satisfied.

- The treatment and disinfection plant must be attended every day according to the programme issued by the Authority and records to be kept of all operations performed according to the instructions of the appropriate Authority. A copy must be kept for easy access within the treatment facilities.

- All outlets, taps and valves in the irrigation system must be secured to prevent their use by unauthorised persons. All such outlets must be coloured red and clearly labelled so as to warn the public that the water is unsafe for drinking.

- No cross connections with any pipeline or works conveying potable water, is allowed. All pipelines conveying sewage effluent must be satisfactorily marked with red tape so as to distinguish them from domestic water supply. In unavoidable cases where sewage/effluent and domestic water pipes must be laid close to each other the sewage pipes should be buried at least 0.5 m below the domestic water pipes.

- Irrigation methods allowed and conditions of application differ between plantations as follows:

  ⇩ *Park lawns and ornamental in amenity areas of unlimited access*

- ⇨ Subsurface irrigation methods
- ⇨ Drip irrigation
- ⇨ Pop-up, low pressure and high precipitation rate, low angle sprinklers (less than 11 degrees). Sprinkling preferably to be practiced at night and when people are not around.

⇩ *Park lawns and ornamental in areas of limited access, industrial and fodder crops*
- ⇨ Subsurface irrigation
- ⇨ Bubblers
- ⇨ Drip irrigation
- ⇨ Pop-up sprinklers
- ⇨ Surface irrigation methods
- ⇨ Low capacity sprinklers
- ⇨ Spray or sprinkler irrigation is allowed with a buffer zone of about 300 m

For fodder crops, irrigation is recommended to stop at least one week before harvesting and no milking animals should be allowed to graze on pastures irrigated with sewage. Veterinary Services should be informed.

⇩ *Vines*
- ⇨ Drip irrigation
- ⇨ Minisprinklers and sprinklers (in case where crops get wetted, irrigation should stop two weeks before harvesting)
- ⇨ Movable irrigation systems are not allowed
- ⇨ No crops should be selected from the ground

⇩ *Fruit trees*
- ⇨ Drip irrigation
- ⇨ Hose basin irrigation
- ⇨ Bubblers irrigation
- ⇨ Mini sprinklers

No fruits to be collected from the ground except for nut trees. In case where crops are wetted, irrigation should stop one week before harvesting.

⇩ *Vegetables*
- ⇨ Subsurface irrigation
- ⇨ Drip irrigation

Crops must not come in contact with the ground or the effluents (only vegetables which are supported).

Other irrigation methods could also be considered.

⇩ *Vegetable eaten cooked*
- ⇨ Sprinklers
- ⇨ Subsurface irrigation
- ⇨ Drip irrigation

Other irrigation methods may be allowed after the approval of the appropriate Authority. Restrictions may be posed to any method of irrigation by the appropriate authority in order to protect public health or environment.

The following tertiary treatment methods are acceptable:
- ⇩ Coagulation plus flocculation followed by Rapid Sand Filtration
- ⇩ Slow Sand Filters
- ⇩ Any other method, which may secure the total removal of Helminth ova and reduce faecal coliforms to acceptable levels. Must be approved by the appropriate authority.

Appropriate disinfection methods must be applied when sewage effluent are to be used for irrigation. In the case of chlorination the total level of free chlorine in the effluent at the outlet of the chlorination tank, after an hour of contact time should be at least 0.5 mg/l and not greater than 2 mg/l.

Suitable facilities for monitoring the essential quality parameters, and according to what the appropriate authority specifies, should be kept on the site of treatment.

CODE OF PRACTICE FOR THE DISPOSAL OF TREATED SEWAGE WATER IN SURFACE WATERS

- The disposal of treated water in the water bodies mentioned below only if any other method of disposal is practically impossible or excessively costly and provided it does not create any dangers to public health and following an environmental study.

- The recycled water must have the quality specified in the specifications for the purposes of irrigation of all cultivations. (BOD_5 < 10mg/l, SS < 10mg/l, Faecal Coliform < 5/100ml, eggs of intestinal parasites = none.).

- Also there will be toxicity tests and control according to Appendix E1 and control for the concentration of heavy metals according to Appendix A1.

- In case of disposal of recycled water in sensitive water bodies it is imposed that (total) nitrogen concentrations in the recycled water must not exceed 10mg/l.

- For the disposal of recycled water from treatment plants with equivalent population above 100 000 the phosphorus concentration in the recycled water must not exceed 1mg/l, while from plants with equivalent population between 10 000 – 100 000 the concentration must not exceed 2mg/l. Alternatively a minimum reduction (phosphorus) of 80% must be achieved during treatment.

- The disposals must stop in cases where eutrophication appears.

- IN RIVERS/STREAMS ACCORDING TO THE FOLLOWING CONDITIONS:
  - Disposal is not allowed in rivers/streams that are directly related to water supply sources.
  - In cases of disposal in rivers/streams that are indirectly related to sources of water supply there must be no possibility of contamination/pollution.
  - In no case must the disposal rate for the recycled water exceed 10% of the river/stream flow at the moment of disposal. The percentage will be smaller if other disposals are being carried out, depending on distances and the natural purification capacity of the water.

- DAMS/BARRAGES ACCORDING TO THE FOLLOWING CONDITIONS:
  - Under no circumstances will the direct disposal of recycled water of any degree of treatment be allowed in dams/barrages where the water is used for water supply purposes. However, such a disposal can be examined in the case of rivers/streams which end up in sources of water supply if the disposal is carried out at a distance of at least 10km from them.
  - In dams/barrages that are used only for irrigation purposes. The total daily volume of disposals of recycled water must not exceed 5% of the stored volume during the time of disposal. Also, denitrification must be carried out (total nitrogen < 15mg/l) and the phosphorus must be observed.

⇩ In rivers/streams, dams/barrages where there are fish or where there is aquaculture the disposals must be such so as to ensure the water quality as it is defined by the EU directive 78/659/EEC.

❑ IN NATURAL LAKES/WETLANDS ACCORDING TO THE FOLLOWING CONDITIONS:

The disposal in rivers and wetlands is not permitted.
Relaxations of these terms may be granted if with the relaxations public health is not endangered and under the condition that the environmental impact assessment will indicate that any negative environmental impacts will be marginal.

TABLE A1.4: TOXICITY CONTROL, TESTS AND TOXICITY LIMITS FOR THE DISPOSAL OF TREATED SEWAGE WATER IN WATER BODIES

TESTS	DISPOSAL IN STREAMS[1]	DISPOSAL IN DAMS AND LAKES[1]
ACCUTE TOXICITY 4. Microtox: organism *Photobacterium phosphorium* (*Vibrio fischeri*) 5. Algaltox 72 hours: organism *Selenastrum capricornutum* 6. Daphtox: organism *Daphnia magna Straus*	Applicable	Applicable
GENE TOXICITY Mutatox with or without activation with hepatic enzymes S9: Organism *Photobacterium phosphorium* (*Vibrio fischeri*)	Not required	Applicable
ACCEPTABLE LIMITS The results and the limits are expressed in toxicity units TU*	In accordance with the term that the maximum daily disposal < or equal to 10% of the running water and provided that the streams are not directly related to irrigation the 75% of the samples will have to be consistent with the following limits fro acute toxicity: Microtox: TU50 ≤ 1 or/and TU20 ≤ 1.5 Daphnia: TU50 ≤ 1 Algae: TU50 ≤ 1	In accordance with the term that the maximum daily disposal < or equal to 3% of the stored water and provided that the water will not be used for irrigation the 75% pf samples will have to be consistent with the following limits for acute toxicity: Microtox: TU50 ≤ 1 or/and TU20 ≤ 1.5 Daphnia: TU50 ≤ 1 Algae: TU50 ≤ 1 Mutatox: The treated waste must not be positive in the direct or following the activation with S9 Mutatox test

1. The acute toxicity control is carried out 4 times a year and the control at least once a year. If it is confirmed that the waste because of its quality and in conjunction with the quality or dilution does not have a reasonable potential a) to be toxic and b) its specific use to contribute directly or indirectly to the degradation of the receivers and the environment, then the control for toxicity could be restricted appropriately.
2. TU50, TU20: toxicity units for 50% and 20% influence of the organism under trial or the equivalent biological action.

CODE OF PRACTICE FOR THE USE OF SLUDGE FROM THE TREATMENT OF SEWAGE FOR AGRICULTURAL PURPOSES

- The installations for the treatment of sludge that is expected to be used or made available according to the license or licenses issued from the Competent Authority must continuously operate to a satisfactory level

- The storage area for the treated sludge must be such so as not to create any danger to public health or environmental problems including the danger of underground or surface water resources.

- The quality of the sludge must be monitored according to the programme approved by the Competent Authority.

- The sludge treatment installations must be supervised and kept at a satisfactory level of operation by suitably qualified staff approved by the Competent Authority.

- he following sludge treatment methods are acceptable:
  - Anaerobic Digestion
    - Mesophilic
    - Regular
  - Aerobic Digestion
  - Thermal Treatment
  - Deposition in shallow reservoirs for a period of two years
  - Sludge stabilization and use of lime (CaO)
  - Sludge stabilization after a complete biological cleaning or extended aeration
  - Drying in specially designed areas
  - Storage of sludge balls for a year
  - Any other method which will be approved by the Competent Authority and through which the quality standards for the use of sludge can be ensured.

- The rate and quantity of sludge deposition on the soil for agricultural purposes will depend on the quality of the sludge, the type of soil and cultivation and the time period for the deposition. In general the percentage of sludge deposited must be according to its humidity content.

- The use of sludge is not recommended for the following cases:
  - In areas where it is possible to cause impacts on, or the degradation of, the quality of surface waters (dams, water sources, rivers, etc.).
  - In areas where it is possible to cause impacts on, the degradation of, the quality of underground water bodies (e.g. underground water beds).

- The use of sludge is forbidden in the following cases:
  - In places of pasture or in the cases where stock-breeding plants are cultivated and will be harvested in less than three weeks from the time of the sludge deposition.
  - On soil where the cultivation of fruits and vegetables is in process with the exception of fruit-bearing trees.
  - On soil where there is intention to cultivate fruit and vegetables which will be in direct contact with the soil and are usually eaten raw unless the sludge is deposited at least 12 months prior harvesting the cultivations.
  - On grass, unless the sludge is deposited at least 12 months before its use.

- In order for sludge to be reused in agriculture, the consideration made are the nutritionally needs of the plants, and the avoidance of detrimental impacts on the soil and surface water quality.

- In order to use the sludge in soil where the pH is lower than 6 the increased movement of heavy metals as well as their easier uptake from the plants is taken into consideration. Not only that, but depending on the situation, the decrease of the set regulation limit values are is considered.

- The sludge and the soil for which it is used are subjected into an analysis according to the regulations:

  - SLUDGE ANALYSES
    - The sludge must be analyzed every 6 months. In cases where change is observed in the quality of the sewage the frequency of the analyses will need to be adjusted accordingly. If the analyses results do not differ significantly during the period of one whole year, the sludge can be analyzed at least every 12 months.
    - Analyses must be carried out for the following parameters:
      - Dry Matter
      - Organic Matter
      - pH
      - Nitrogen
      - Phosphorous
      - Cadmium, copper, nickel, lead, zinc, mercury, mineral oils and chromium.

  - SOIL ANALYSES
    - the frequency of the analyses will depend on the initial condition of the soil and its heavy metal content which will be verified before the use of sludge begins, as well as the quality and heavy metal content of the sludge and the frequency of sludge deposition and other relevant influencing factors.
    - The analyses frequency will be decided taking into consideration the metal concentration in the soil before the use of the sludge, the quantity and composition of the sludge to be used, as well as other relevant influencing factors.
    - Analyses must be carried out for the following parameters:
      - pH
      - Cadmium, copper, nickel, lead, zinc, mercury, chromium (Table A1.5).
    - The maximum permissible heavy metal content of the soil is shown in Table A1.6 and the maximum permissible quantity that can be deposited every year on agricultural land is shown in Table A1.7.

  - SOIL SAMPLING
    - Sampling must be carried out up to a depth of 0.25 m bellow the soil surface. Where this is difficult, sampling can be carried out for depths up to 0.10 m. A representative sample is that which is prepared by the mixture of 5 samples from different points per hectare. For smaller areas mixtures will contain samples that have been taken proportionally at 1 sample per hectare.
    - The representative samples to be analysed are consistent of a mixture of 25 different borehole locations which are places in are area less that on equal to 5 hectares and which is cultivated uniformly.
    - The sampling must take place at a depth of 25 cm unless the layer which can be cultivated is at a smaller depth, in this case the sampling must be done at a depth smaller that 10cm.

  - SLUDGE SAMPLING
    - The sludge shall undergo sampling after its treatment, and before it is delivered to its users and the samples must be representative of the batch.

  - METHOD OF ANALYSES:
    - The analyses for the heavy metals must be carried out after digestion with the use of strong oxidizing acids. The method of reference is that of atomic absorption (AAS) and the detection level for each metal must not be greater than 10% of the corresponding level value.

- For the purposes of correct management, analyses of the sludge and soil are considered useful for the following elements:

- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)
- Sodium (Na)
- Calcium (Ca)
- Magnesium (Mg)
- Iron (Fe)
- Boron (B)

TABLE A1.5: MAXIMUM PERMISSIBLE HEAVY METAL CONTENT IN SLUDGE TO BE REUSED IN AGRICULTURE

PARAMETERSI	LIMIT VALUES (mg/kg DRY MATTER)
Cadmium (Cd)	20 to 40
Copper (Cu)	1000 to 1750
Nickel (Ni)	300 to 400
Lead (Pb)	750 to 1200
Zinc (Zn)	2500 to 4000
Mercury (Hg)	16 to 25
Chromium (Cr III)	1000

TABLE A1.6: LIMIT VALUES FOR HEAVY METAL CONTENT IN THE SOIL (mg/kg DRY MATTER OF REPRESENTATIVE SAMPLE OF SOIL WITH PH 6 TO 7)

PARAMETERS	LIMIT VALUES
Cadmium (Cd)	1 to 3
Copper (Cu)	50 to 140
Nickel (Ni)	30 to 75
Lead (Pb)	50 to 300
Zinc (Zn)	150 to 300
Mercury (Hg)	1 to 1.5
Chromium (Cr III)	150

TABLE A1.7: MAXIMUM PERMISSIBLE QUANTITY OF HEAVY METALS THAT CAN BE ADDED EVERY YEAR ON AGRICULTURAL LAND, BASED ON A TEN YEAR AVERAGE (KG/HA/YR)

PARAMETERS	LIMIT VALUES
Cadmium (Cd)	0.15
Copper (Cu)	12
Nickel (Ni)	3
Lead (Pb)	15
Zinc (Zn)	30
Mercury (Hg)	0.1
Chromium (Cr III)	-

DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE 91/271/EEC

The EU Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment sets the following standards for wastewater that shall be discharged to the receiving waters:

TABLE A1.8: DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE (91/271/EEC)

PARAMETER	VALUE
BOD_5	25 mg/l
COD	90 mg/l
Suspended Solids	35 mg/l

For discharge to sensitive water bodies, the following additional limits shall apply:

TABLE A1.9: ADDITIONAL DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE FOR DISCHARGE TO SENSIBLE WATER BODIES

PARAMETERS	VALUE
Total-N	15 mg/l N (10,000 to 100,000 p.e.) 10 mg/l N (> 100,000 p.e.)
Total-P	2 mg/l (10,000 to 100,000 p.e.) 1 mg/l (> 100000 p.e.)

APPENDIX 2

WATER PRODUCTION AND EFFLUENT PRODUCTION

WATER DEMAND (CONSUMPTION), EFFLUENT PRODUCTION AND ORGANIC LOAD

The study made to estimate the water demand for the communities as well as the wastewater amount to be produced as a function of this water demand is presented in this Appendix.

CURRENT WATER CONSUMPTION

According to the information obtained from the communities, the water consumption in year 2001 was as follows:

Community	1st Period	2nd Period	3rd Period	4th Period	Total
Polis	-	-	-	-	-
Episkopi	50 000	47 367	69 633	74 850	241 850
Erimi	27 500	37 000	22 000	-	86 500
Erimi	-	-	-	-	-
Ypsonas	94 115	138 324	116 904	-	349 343
Trachoni	-	-	-	-	180 000

The permanent population and the seasonal population in the communities are given in the table hereafter. The global average water consumption has been calculated assuming that the summer houses are occupied 90 days per year.

Communities	Permanent Population in 2001	Seasonal Population in 2001	Water consumption in 2001 (m^3/year)	Average consumption in 2001 (l/cap/day)
Polis	1 847	2 244	-	-
Episkopi	3 500	273	241 850	185.7
Erimi	1 850	263	86 500	123.7
Kolossi	5 800	399	-	-
Ypsonas	7 000	739	349 343	133.2
Trachoni	5 287	175	180 000	92.5
Total	**25 284**	**4 092**		

It was not possible to obtain water consumption data that would allow for a detailed analysis of the consumption pattern in the concerned communities, i.e. data of daily or seasonal peak factors or break-down between domestic and non-domestic consumption.

LARGE CONSUMERS

There are no identified large consumers in the communities concerned by the project in the present group D. Large consumers as breweries and factories are generally located in the vicinity of Nicosia and other large cities. Water used for irrigation by farmers is not concerned by the present evaluation and this water is mostly extracted from wells.

NON-DOMESTIC CONSUMERS

In rural and semi rural areas, non-domestic consumption does not represent an important portion of the total water consumption. In large cities non-domestic users include hospitals, schools, administrative buildings, services, social facilities and hotels. For large cities non domestic water can reach 35 % of total water consumption.

The non-domestic users include also poultry livestock units, small manufacturing industries, workshops and commercial shops.

Estimates for future industries and institutional consumers have been introduced as a global estimation in the water demand simulation model. For the considered project it has been considered that the volume of water consumed by non-domestic users could be 25 % of the overall volume of water consumed by the communities. For reference, in the ongoing Greater Nicosia Sanitary Sewerage Project, the non-domestic consumption is estimated to 30%, this higher value being justified by the larger number of schools, governmental offices etc. in the capital.

ASSUMPTIONS FOR WATER DEMAND FORECASTS

Water demand forecasts are presented for years 2005, 2010, 2015 and 2030.

It was assumed for all the communities that 100% of the population would be served fully by individual connections at all target years. For new urban areas, it has also been considered that 100 % of the population will be served by individual connections. For houses built for holidays and weekend water demand per year has been estimated considering an average duration of occupation of 90 days per year. This number corresponds to 15 weekends and two months in summer.

Domestic and non domestic consumption for the villages was calculated on the basis of predicted future number of inhabitants (refer to Appendix 6).

For some of the communities with the developing tourist activities, there will be a distinct seasonal variation of water consumption. For hydraulic design purposes it was taken into account by adding the water demand of the summer houses and where applicable hotels. Number of summer houses and capacity of hotels were estimated and the relevant population is presented in the previous table for each community.

The following consumption rates in group D have been used for permanent population, for summer houses and for hotels:

Category	Unit Consumption Rate
Permanent Population	100 l/capita/day
Summer Houses	150 l/capita/day
Hotels	350 l/bed/day

Taken into consideration that public facilities such as hospitals, administration buildings and large industries will remain in large cities it has been considered that Non-domestic consumption will represent 25 % of the total water consumption for all the communities.

RESULTS OF WATER DEMAND FORECASTS

The main results of the water demand forecast are summarised in the following table.

Community	Average water demand in 2005* (m^3/day)	Average water demand in 2030* (m^3/day)
Polis	280 (1120)	604 (2363)
Episkopi	436 (436)	649 (649)
Erimi	206 (206)	334 (334)
Kolossi	539 (539)	874 (874)
Ypsonas	926 (926)	1513 (1513)
Trachoni	460 (460)	619 (619)

***(in bracket: average water demand including summer consumption)**

The estimated global water consumption, including non-domestic consumption, varies between 134 l/cap/day in year 2005 up to 141 l/cap/day in year 2030. These values are in accordance with the observed water consumption figures obtained from the communities. Detailed water demand analysis for each village is given in the end of this Appendix.

WASTEWATER FLOW

Wastewater production was derived from the data on water demand taking into account
- The return rate from the water supply to the sewers.
- The flow corresponding from the summer houses
- Infiltration
- A maximum day factor
- A peak hour factor.

Concerning the return of water to the wastewater, studies made for Greater Nicosia Sanitary system indicate that approximately 85% of domestic consumption could enter into the sewerage system, assuming a connection existed. A figure like that is within the range expected and is used for this study.

For some of the communities with the developing tourist activities, there will be a distinct seasonal variation of wastewater flow. For hydraulic design purposes it was taken into account by adding the water demand of the summer houses and hotels in the community of Polis (d1) since for the remaining communities the flow including summer water demand is identical as can be seen in a table above.

According to existing data, the groundwater level is in general lower than the pipes constituting the collection and conveyance system with the exception of the groundwater in Polis and Ypsonas. In the case of these two communities, there is a possibility that some infiltration could occur and specifically in the gravity mains through connections or cracks (if any) in the pipes Furthermore, water consumption is more likely to occur during the winter months when water consumption is low and thus the groundwater level raises. In case part of the system is expected to be under the groundwater level, infiltration is calculated as a function of an infiltration rate per day per kilometer of pipe (30m^3/day/km) and the length of pipe which is expected to be below the groundwater level. The numbers for the calculated infiltration are presented in the end of this Appendix.

The average dry weather flow rate was estimated as the sum of domestic and non-domestic wastewater, the additional summer flow as well as the winter infiltration (if any). In the Greater Nicosia Sanitary Sewerage Project maximum consumption was 1.4 times larger than the average consumption. Factor “1.4” was used as a peak factor to obtain the Maximum Dry Weather Flow (MDWF). The calculated wastewater flow is presented in Table 3.3 of the main EIA for the years 2005, 2015 and 2030 but it is repeated hereafter:

COMMUNITIES	2005 YEARLY PRODUCTION m³/year	2005 MAXIMUM DRY WEATHER FLOW m³/day	2015 YEARLY PRODUCTION m³/year	2015 MAXIMUM DRY WEATHER FLOW m³/day	2030 YEARLY PRODUCTION m³/year	2030 MAXIMUM DRY WEATHER FLOW m³/day
Polis	220 313	2 485	314 875	3 747	476 157	5 499
Episkopi	135 269	519	157 607	605	201 352	772
Erimi	63 912	245	76 942	295	103 624	397
Kolossi	167 225	641	201 352	772	271 159	1 040
Ypsonas	292 152	1 264	361 440	1 816	488 848	2 448
Trachoni	142 715	547	159 779	613	192 045	737
TOTAL	**1 021 584**	**5 701**	**1 271 994**	**7 848**	**1 733 184**	**10 894**

The detailed calculations are presented hereafter.

APPENDIX 3

PUMPING STATIONS

APPENDIX 4

PROJECT IMPLEMENTATION PROGRAM

APPENDIX 5

METEOROLOGICAL DATA

APPENDIX 6

DESCRIPTION OF COMMUNITIES

EPISKOPI

GENERAL DESCRIPTION

Episkopi is located near Limassol but urbanization is constrained by the surrounding Base Area and also by the growth of the other near-by villages (Kolossi, Ypsonas and Erimi).

POPULATION TRENDS

The population of Episkopi has grown from 2,785 in 1992 to 3,076 in 2001, corresponding to an absolute growth of 10.4% (or 0.9% average per annum). This rate of growth is much below the District average rate and that of the other villages in the peri-urban Limassol zone. The village has a large refugee population living in the housing estates (about 500 houses).

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be more than sufficient to accommodate future housing needs corresponding to the current population growth. A third scenario is examined, considered more realistic, based on an increase in the growth rate resulting from the possible return of the Turkish Cypriot population in the village.

POPULATION DENSIFICATION

The spatial development pattern of Episkopi is untypical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated. Building development sprawl mainly followed the housing expansion after 1974 when about 500 refugee houses were built under the Government Programme to accommodate population with access to employment in Limassol and Paphos. The village is also bordering on the Base Area and is near the Akrotiri Salt Lake. About 36% of the housing area is predominantly empty with pockets of housing development and partly semi-developed road network. There are few scattered houses outside the designed housing development zone (about 20).

Housing development is at present controlled by the Countryside Policy recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in terms of the land stock it includes is far greater that the realistic housing needs for the foreseeable future over the next 5-10 years. The housing development zone estimated at about 272 ha corresponds to a population capacity of about 13,000 people, while the presently vacant land stock (about 36% of the area) could accommodate an additional estimated amount of 500-520 housing units.

The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha.

EMPLOYMENT TRENDS

Episkopi has very few manufacturing establishments (23). Economic activity is based mainly on the needs of the local population and partly of the population of the Base Area. There are a total of 242 employment establishments, there is one primary school with 312 pupils age 6-12.

TABLE A6.1.POPULATION FORECAST FOR EPISKOPI

SCENARIOS	POPULATION - HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Continuation of current population growth rate Average population growth rate 0.9 % per annum Population Households	 3076 923	 3489 1015	 4043 1117	 4095 1228
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for. Population Household	 3076 923	 3682 1071	 4429 1223	 4614 1385
Solution of the Cypriot Problem **Population** **Households**	 **3076** **923**	 **3489** **1015**	 **4008** **1108**	 **4614** **1385**

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The most probable scenario was found to be the final one. The main source of population growth in Episkopi is its natural population growth. Urbanization is not a factor of any significance, neither is tourism. Agriculture and commuting to Limassol are the main sources of growth.

Also:

- Further growth of Ypsonas, Kolossi and the other Limassol suburbs is likely to stimulate some population increase roughly equal to the rural rate of about 1.0%.
- There is no potential for tourism in Episkopi.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals) is unlikely to affect local growth in any major way.
- The solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) is likely to affect future growth negatively as some refugees now in the Refugee Housing Area may return to their homes in the north, thus reducing the current population growth rate but not enough to counterbalance the additional growth form commuting and agriculture. But, the Turkish-Cypriot refugees now in the north with property in Episkopi may return increasing population growth roughly to the level allowed by the capacity of the housing zone.

As a conclusion, a population of approximately 4614 inhabitants (1385 households) is projected in Episkopi at the horizon of 2030.

ERIMI

GENERAL DESCRIPTION

Erimi is located near Limassol, falls within the wider peri-urban growth corridor west of Limassol (together with Kolossi and Ypsonas) on the old road to Paphos. Urbanization is the main source of population growth.

POPULATION TRENDS

The population of Erimi has grown from 1,120 in 1992 to 1,432 in 2001, corresponding to an absolute growth of nearly 28% (or 2.5% average per annum). This rate of growth is much higher than the District average urban growth rate but below that of Ypsonas and Kolossi.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the present housing expansion zone being much larger than the foreseeable population growth and the corresponding housing development needs. A third scenario is examined, considered more realistic, based on a decreasing population growth rate. This takes into account the possibility of the return of the Turkish Cypriot population after the Solution of the Cyprus problem.

POPULATION DENSIFICATION

The spatial development pattern of Erimi is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated. Building development sprawl takes place mainly along the old road to Paphos towards Ypsonas to the east and Episkopi to the west. The village is also bordering with the Base Area to the south. About 55% of the housing area is predominantly empty with pockets of housing development and partly semi-developed road network. There are few scattered houses outside the designed housing development zone (about 20).

Housing development is at present controlled by the Countryside Policy recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in terms of the land stock it includes is far greater than the realistic housing needs for the foreseeable future over the next 5-10 years. The housing development zone estimated at about 218 ha corresponds to a population capacity of about 10,600 people, while the presently vacant land stock (about 55% of the area) could accommodate an additional estimated amount of 650-700 housing units.

The densification of the population in the residential area is estimated to be approximately 14 inhabitants/ha.

EMPLOYMENT TRENDS

Erimi has very few manufacturing establishments (11). Economic activity is based mainly on the needs of the local population. There are a total of 65 employment establishments (shops, cafes, offices) and one primary school with 114 pupils age 6-12.

TABLE A6.2: POPULATION FORECASTS FOR ERIMI

SCENARIOS	POPULATION - HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Continuation of current population growth rate Average growth rate 2.5% per annum Population Households	 1432 453	 1831 579	 2346 742	 2997 948
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for : Rather unlikely growth rate of 2.8% per annum Population Households	 1432 453	 2061 625	 2685 849	 3309 1047
Possible scenario (decreasing growth rate) **Decrease if the growth rate to the levels of the urban average: 2.0 % up to 2010 and 1.5 % for the remainder of the period until 2030** **Population** **Households**	 **1432** **453**	 **1749** **553**	 **2034** **643**	 **2371** **750**

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The most likely scenario was found to be the last one in this case as well as is shown in the table above. The main source of population growth in Erimi is urbanization (weaker trend relative to Ypsonas and Kolossi). Urbanization is a factor that will continue in the future due to the proximity of the community to Limassol.

Also:
- ❑ Further growth of Ypsonas and Kolossi will absorb much of the urbanization pressure west of Limassol thus justifying a lower growth in Erimi but not below the average urban growth rate of about 1.5%.
- ❑ There is no potential for tourism in Erimi.
- ❑ The return of Turkish Cypriot refugees to Erimi will maintain the expected population growth rate above the present Limassol overall urban growth rate
- ❑ Policy changes associated with membership to the European Union (purchase of houses by other European nationals) may affect local growth upwards as the area could offer opportunities for holiday houses for European families in Erimi located near Limassol.

As a conclusion, a population of approximately 2371 inhabitants (750 households) with an average decreasing growth rate of 2.0% to 2.5% is projected in Erimi at the horizon of 2030.

KOLOSSI

GENERAL DESCRIPTION

Kolossi is located at the western edge of Limassol's suburban area, about 10 km. from the Limassol seafront and the central business area. The community is part of the area of the Limassol Local Plan.

POPULATION TRENDS

The population of Kolossi has grown from 2,981 in 1992 to 3,745 in 2001, corresponding to an absolute growth of nearly 25.6% (or 2.3% average per annum). This rate of growth is higher than that of the Limassol Urban Area itself and that of the average urban rate of all Cyprus.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce vastly different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be developed fully in the next 10 years (2010). Given that the Countryside Policy and the housing development zones have a 5-year time horizon (2002-2007), if current population trends continue, appropriate adjustments will be made to the housing development zone. A third scenario is examined, considered more realistic, based on a declining growth rate for the period up to the year 2030

POPULATION DENSIFICATION

The spatial development pattern of Kolossi is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. About 40% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 20-25).

Housing development is at present controlled by the Countryside Policy recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in terms of the land stock it includes is far greater than the realistic housing needs for the foreseeable future over the next 5-10 years. The housing development zone estimated at about 217 ha corresponds to a population capacity of about 10,500 people, while the presently vacant land stock (about 40% of the area) could accommodate an additional estimated amount of 450 housing units.

The densification of the population in the residential area is estimated to be approximately 32 inhabitants/ha.

EMPLOYMENT TRENDS

Kolosi has very few manufacturing establishments; economic activity is based mainly on the needs of the local population. Employment growth is roughly similar to the population growth. There are a total of 184 employment establishments and two primary schools with about 400 pupils (age 6-12).

TABLE A6.5: POPULATION PROJECTIONS FOR KOLOSSI

SCENARIO	POPULATION - HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Continuation of current population growth Average growth rate of 2.3% per annum. Population Households	 3745 1084	 4681 1355	 5867 1698	 7396 2141
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for. Population Households	 3745 1084	 4213 1220	 4681 1355	 5149 1491
Possible scenario (decreasing growth rate) **Based on the assumption that the population growth rate will gradually move towards the average urban rate of 1.5%, that is 2.0% up to the year 2010 and 1.5% for the rest of the period up to 2030** **Population** **Households**	 **3745** **1084**	***2.0%*** **4588** **1328**	***1.5%*** **5305** **1536**	***1.5%*** **6219** **1800**

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Kolossi is urbanization fuelled by urban and tourism employment growth in Limassol and its tourism sector. But, the current growth rate cannot be sustained because the period 1992-2001 was the main 'urban' expansion of Ypsonas and such growth reflects a major population boom which will level off within the normal urban growth prevailing in the Limassol District and urban Cyprus.

Also:

- Further rapid retail trade and industrial development growth is unlikely to continue, justifying a trend towards a declining rate population growth.
- There is no potential for tourism in Kolossi.
- There is no significant agricultural development in the area due to urbanisation.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals) is unlikely to affect local growth in any major way. The solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) is likely to affect Kolossi as some refugees now in the Refugee Housing Areas may return to their homes in the north, thus reducing the current population growth rate.

As a conclusion, a population of approximately 6219 inhabitants (1800 households) with an average decreasing growth rate of 2.0% to 1.5% is projected in Kolossi at the horizon 2030.

YPSONAS

GENERAL DESCRIPTION

Ypsonas is located at the western edge of Limassol town, about 5 km from the Limassol seafront and the central business area. Part of the area of the Limassol Local Plan.

POPULATION TRENDS

The population of Ypsonas has grown from 4,472 in 1992 to 6,435 in 2001, corresponding to an absolute growth of nearly 44.0% (or 3.7% average per annum). This rate of growth is higher than that of the Limassol Urban Area itself and that of the average urban rate of all Cyprus.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce vastly different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be developed fully in the next 10 years (2010). Given that the Local Plan and the housing zone has a 5-year time horizon (2002-2007), if current population trends continue appropriate adjustments will be made to the housing development zone. A third scenario is examined, considered more realistic, based on a declining growth rate for the period up to the year 2030.

POPULATION DENSIFICATION

The spatial development pattern of Ypsonas is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. About 40% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 25).

Housing development is at present controlled by the Limassol Local Plan (just now revised and published). From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future over the next 5-10 years. The housing development zone estimated at about 300 ha corresponds to a population capacity of about 13,000 people, while the presently vacant land stock (about 25% of the area) could accommodate an additional estimated amount of 750 housing units.

The densification of the population in the residential area is estimated to be approximately 43 inhabitants/ha.

EMPLOYMENT TRENDS

Ypsonas has one Industrial Zone with about 60 factories, showrooms and warehouses. Employment growth is roughly similar to the population growth, partly due to areas role as suburb of Limassol and on the main national road network to Paphos. There are a total of 404 employment establishments and two primary schools with about 640 pupils (age 6-12).

TABLE A6.7: POPULATION PROJECTIONS FOR YPSONAS

SCENARIO	POPULATION HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Local Population				
Continuation of current growth rate Average growth rate 3.7% per annum Population Households	 6435 1823	 9270 2626	 13351 3782	 19299 5467
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for. Population Households	 6435 1823	 7229 2248	 8590 2500	 8858 2510
Possible scenario (decreasing growth rate) Based on the assumption that the population growth rate will gradually move towards the average urban rate of 1.5%, that is 2.0% up to the year 2010 and 1.5% for the rest of the period up to 2030 Population Households	 6435 1823	*2.0%* 7909 2241	*1.5%* 9965 2900	*1.5%* 10766 3050

JUSTIFICATION OF POSSIBLE SCENARIO

The main source of population growth in Ypsonas is urbanization fuelled by urban and tourism employment growth in Limassol and its tourism sector. But, the current growth rate cannot be sustained because the period 1992-2001 was the main expansion of Ypsonas and such growth reflects a major population boom which will level off within the normal urban growth prevailing in the Limassol District and urban Cyprus.

Also:

- Further rapid retail trade and industrial development growth is unlikely to continue, justifying a trend towards a declining rate population growth.
- There is no potential for tourism in Ypsonas.
- There is no significant agricultural development in the area due to urbanisation.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals, or the solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) are unlikely to affect local growth in any major way.

As a conclusion, a population of approximately 10766 inhabitants (3050 households) with an average decreasing growth rate of 2.0% to 1.5% is projected in Ypsonas at the horizon 2030.

TRACHONI

GENERAL DESCRIPTION

Trachoni is located near Limassol but urbanization is constrained by the surrounding Base Area and also by the growth of the other near-by villages (Kolossi, Ypsonas Erimi).

POPULATION TRENDS

The population of Trachoni has grown from 3,020 in 1992 to 3,294 in 2001, corresponding to an absolute growth of nearly 9.0% (or 0.8% average per annum). This rate of growth is much below the District average rate and that of the other villages in the peri-urban Limassol zone.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be more than sufficient to accommodate future housing needs corresponding to the current population growth. A third scenario is examined, considered more realistic, based on a small increase in the growth rate to match the average rural rate mainly due to the continued growth of the near-by villages.

POPULATION DENSIFICATION

The spatial development pattern of Trachoni is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated. Building development sprawl is very limited due to the surrounding Base Area and the Akrotiri Salt Lake. About 45% of the housing area is predominantly empty with pockets of housing development and partly semi-developed road network. There are few scattered houses outside the designed housing development zone (about 15).

Housing development is at present controlled by the Countryside Policy recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in terms of the land stock it includes is far greater that the realistic housing needs for the foreseeable future over the next 5-10 years. The housing development zone estimated at about 227 ha corresponds to a population capacity of about 11,000 people, while the presently vacant land stock (about 45% of the area) could accommodate an additional estimated amount of 500-520 housing units.

The densification of the population in the residential area is estimated to be approximately 31 inhabitants/ha.

TABLE A6.9: POPULATION PROJECTIONS FOR TRACHONI

SCENARIO	POPULATION - HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Local Population				
Continuation of current growth rate Average growth rate of 0.8% per annum Population Households	 3294 897	 3606 982	 3953 1076	 4334 1180
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for. Population Households	 3294 897	 3849 1048	 4404 1199	 5028 1369
Possible scenario(gradual increase of population growth rate) **Based on the assumption that the population growth rate will gradually move towards the average all Cyprus rural rate of about 1.0% p.a.** **Population** **Households**	 **3294** **897**	 **3641** **991**	 **4005** **1091**	 **4407** **1200**

JUSTIFICATION OF POSSIBLE SCENARIO

The most likely growth scenario is the last one as indicated. The main source of population growth in Trachoni is its natural population growth. Urbanization is not a factor of any significance, neither is tourism. Agriculture and commuting to Limassol are also two main sources of growth.

Also:

- Further growth of Ypsonas, Kolossi and the other Limassol suburbs is likely to stimulate some population increase roughly equal to the rural rate of about 1.0%.
- There is no potential for tourism in Trachoni.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals) is unlikely to affect local growth in any major way. The solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) is likely to affect future growth negatively as some refugees now in the Refugee Housing Area may return to their homes in the north, thus reducing the current population growth rate but no enough to counterbalance the additional growth form commuting and agriculture.

As a conclusion, a population of approximately 4407 inhabitants (1200 households) with an average growth rate of 1.0% is projected in Trachoni at the horizon 2030.

POLIS CHRYSOCHOUS

GENERAL DESCRIPTION

Polis is rapidly growing coastal rural town located at the north western coast of Cyprus, about 25 km. north of Paphos town. Development is controlled by the Polis Local Plan.

POPULATION TRENDS

The population of Polis (including Prodromi and Latsi) has grown from 1,252 in 1992 to 1,847 in 2001, corresponding to an absolute growth of nearly 48% (or nearly 4.0% average per annum). This rate of growth is higher than the all-Paphos District and urban growth rate.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing higher population level compared to the land capacity scenario. A middle scenario is considered more realistic envisaging a gradually declining future growth than the current population growth rate.

POPULATION DENSIFICATION

The spatial development pattern of Polis is typical of most coastal villages. It has an old village core with old houses and shops, around which new shops, restaurants and some offices are concentrated, and a spread out new housing and tourist development area. About 70% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also some scattered houses outside the designed housing development zone (about 25). There are also about 641 holiday apartments and houses in the coastal tourist zones extending from Polis to Latsi.

Housing development is at present controlled by the newly approved Polis Local Plan (2000). As in all cases, from the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing and tourism development zones is a misleading indication of the expected level of development as its population capacity in terms of the land stock it includes is far greater than the realistic housing needs for the foreseeable future. The housing development zone of 322 ha corresponds to a population capacity of about 10,000 people, while the presently vacant land stock (about 70% of the area) could accommodate an additional estimated amount of about 1,000 housing units at a low density. The tourist zones (for hotels and holiday apartments) are an area of 175 Ha that can accommodate about 4,000 bed-spaces.

The densification of the population in the residential area is estimated to be approximately 13 inhabitants/ha.

EMPLOYMENT TRENDS

Polis is a developing tourist resort and popular area for summer second-homes. It has a very small number of manufacturing units and an expanding service sector comprising of restaurants and shops primarily for tourists and visitors in the expanding coastal zone from Polis town on the east to Latsi bay and up to the boundaries with Neo Khorio to the west. Employment growth is roughly similar to the population. There is 1 primary school with about 241 pupils (age 6-12) and one secondary school with about 250 pupils (age 13-15).

TABLE A6.11: POPULATION PROJECTIONS FOR POLIS

SCENARIO	POPULATION - HOUSEHOLDS			
	2001	**2010**	**2020**	**2030**
Local Population				
Continuation of current growth rate Average growth rate of 4.0% per annum Population Households	 1847 623	 2510 920	 3870 1360	 5930 2000
Housing land-stock scenario The capacity of additional development which the specified residential zone allows for.: this includes a yearly average growth rate of 3.2%, which will probably last until 2030. Population Households	1847 623	2590 950	3780 1330	4830 1630
Possible scenario – decreasing growth rate **Declining growth of down 3.5% p.a. average (equal to the Paphos urban rate in the next 10 years and 2.5% average p.a. for the rest of the period, about equal to the Paphos District average)** **Population** **Households**	**1847** **623**	**2400** **880**	**3212** **1130**	**4300** **1450**
Seasonal Population				
Scenario based on current growth rate Number of summer houses: Summer houses increased from 395 to 641 from 1992: approximately 25 unit increase as a yearly average (Number of beds)	641 *1900*	890 *2670*	1140 *3420*	1 400 *4200*
Tourist zone land-stock capacity Capacity of about 25 units as an average per year (Number of beds)	641 *1900*	890 *2670*	1140 *3420*	1400 *4200*
Realistic Scenario **The two scenarios coincide: approximately 25 houses per year as an average, or an equivalent of 75 beds** **Population (3.5 inhabitants per house)** **Houses (number of)** **Number of beds (Approximately 3 beds per house)**	 **-** **641** ***1900***	 **3150** **890** **2670**	 **3990** **1140** **3420**	 **4900** **1400** **4200**
Tourist beds in hotels and apartments (number of) Approximately 75 additional beds per year up to 2015, 50 additional beds per year from 2015 until 2030 Population (1 person per bed)	1200 1200	1800 1800	2425 2425	2925 2925

JUSTIFICATION OF POSSIBLE SCENARIO

The main source of population growth in Polis is tourism and holiday housing development due to its high quality coastal location and preserved rural landscape. Current population growth will most probably decrease because the period 1992-2001 has the main growth boom in Polis and cannot continue at the same rate.

Also:

- The development of holiday houses will continue. The land allocation seems a realistic assessment of future land needs although for the 30-year period and not for nay shorter horizon (says 5 or 10 years). It is realistic to expect that some 25 new holiday units (or about 75 beds) will be added every year on average.
- The community is close to the Akamas Peninsula which is an area of biodiversity that will attract national and foreign tourism.
- There is also agricultural development in the wider area and an expanding tourism market for fruits and vegetables.
- Policy changes associated with membership to the European Union (such as purchase of houses by other European nationals, is likely to boos up local growth in the future justifying the expectation of for increase in the number of holiday houses

As a conclusion, a population of approximately 4,300 inhabitants (1,450 households) with an average decreasing growth rate of 3.5% to 2.5% is projected in Polis at the horizon 2030.

APPENDIX 7

AGRICULTURAL LAND IN THE AREA

AGRICULTURAL LAND IN THE AREA OF THE LIMASSOL COMMUNITIES

AGRICULTURAL LAND PER COMMUNITY

TABLE A7.1 : AGRICULTURAL LAND PER COMMUNITY (1994)

COMMUNITY	AREA (DONUMS)		
	Irrigable	Non- irrigable	Total
Episkopi	3 419	1 931	5 350
Erimi	831	1 231	2 062
Kolossi	2 494	327	2 821
Trachoni	1 136	67	1 203
Ypsonas	3 500	6 653	10 153
TOTAL	**11 380**	**10 209**	**21 589**

TABLE A7.2: USE OF AGRICULTURAL LAND PER COMMUNITY (1994)

COMMUNITY	LAND USE (DONUMS)			
	Temporary cultivation	Permanent Cultivation	Fallow land	Not cultivated, Forested & Barren Land
Episkopi	2 851	972	361	1 167
Erimi	422	632	202	806
Kolossi	631	1 664	207	319
Trachoni	152	984	26	42
Ypsonas	1 903	2 933	630	4 688
TOTAL	**5 959**	**7 185**	**1 426**	**7 022**

TABLE A7.3: AREA OF TEMPORARY CROPS PER COMMUNITY (1994)

COMMUNITY	AGRICULTURAL LAND (DONUMS)					
	Cereal	Pulses	Industrial Crops	Fodder crops for grain	Potatoes	Vegetables
Episkopi	1 240	104	2	1 001	383	239
Erimi	173	15		179	55	10
Kolossi	215	19		328	46	24
Trachoni	45	1		50	3	58
Ypsonas	789	30		831	122	110
TOTAL	**2 462**	**169**	**2**	**2 389**	**609**	**441**

TABLE A7.4: PERMANENT CROPS PER COMMUNITY (1994) (NUMBER OF TREES)

COMMUNITY	VINES (DONUMS)	CITRUS	FRUIT	DRY NUTS	OLIVES	CAROB S
Episkopi	259	17 407	2 129	87	2 147	1 513
Erimi	8	12 784	1 320	1 221	2 226	4 208
Kolossi	523	37 839	1 143	259	2 524	395
Trachoni	251	32 085	338	84	958	41
Ypsonas	948	40 362	3 440	1 536	8 338	8 270
TOTAL	**1 989**	**140 477**	**8 370**	**3 187**	**16 193**	**14 427**

AGRICULTURAL LAND IN POLIS AREA

TABLE A7.5: AGRICULTURAL LAND IN POLIS CHRYSOCHOUS (1994)

COMMUNITY	AREA (DONUMS)		
	Irrigable	Non-irrigable	Total
Polis	6 088	2 343	8 431

TABLE A7.6: LAND USE IN POLIS (1994)

COMMUNITY	LAND USE (DONUMS)			
	Temporary Cultivation	Permanent Cultivation	Fallow land	Not Cultivated, Forest & Barren Land
Polis	4 318	1 713	940	1 460

TABLE A7.7: AREAS OF TEMPORARY CROPS IN POLIS (1994)

COMMUNITY	AGRICULTURAL LAND (DONUMS)					
	Cereal	Pulses	Industrial Crops	Fodder Crops for grain	Potatoes	Vegetables
Polis	2 850	223	333	489	130	256

TABLE A7.8: PERMANENT CROPS IN POLIS (NUMBER OF TREES)

COMMUNITY	VINES (DONUMS)	CITRUS	FRUIT	DRY NUTS	OLIVES	CAROBS
Polis	103	30 479	2 957	6 644	4 388	299

All the above information was obtained from the Agriculture Census which was performed by the Department of Research and Statistics of the Ministry of Economy in 1994.

APPENDIX 8

SLUDGE COMPOSITION AND QUALITY

SLUDGE QUALITY

Sewage sludge contains several plant macronutrients, principally nitrogen (N) and phosphorus (P), and, in most cases, varying amounts of micronutrients, such as boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn), making its use relevant as an organic fertiliser. However, since at high concentrations several of these components, and in particular the heavy metals and organic chemicals, as well as the pathogens present in sludge could be toxic, the use of sludge in agriculture should be carried out following the procedures set out in the Code of Practice for the Use of Sludge for Agricultural Purposes, and regularly monitored, including the monitoring of sludge and soil quality, to ensure that no adverse impacts result from improper practices and insufficient sludge treatment.

The composition of the untreated sludge will depend on the sewage treatment process. Typical compositions are given in Tables A8.1 and A8.2.

TABLE A8.1: IMPACT OF TREATMENT ON THE SEWAGE SLUDGE COMPOSITION AND PROPERTIES

		A	B1	B2	C	D
Dry matter (DM)	**g/L**	12	9	7	10	30
Volatile matter (VM)	**%DM**	65	67	77	72	50
pH		6	7	7	6,5	7
C	**% VM**	51,5	52,5	53	51	49
H	**% VM**	7	6	6,7	7,4	7,7
O	**% VM**	35,5	33	33	33	35
N	**% VM**	4,5	7,5	6,3	7,1	6,2
S	**% VM**	1,5	1	1	1,5	2,1
C/N	**-**	11,4	7	8,7	7,2	7,9
P	**% DM**	2	2	2	2	2
Cl	**% DM**	0,8	0,8	0,8	0,8	0,8
K	**% DM**	0,3	0,3	0,3	0,3	0,3
Al	**% DM**	0,2	0,2	0,2	0,2	0,2
Ca	**% DM**	10	10	10	10	10
Fe	**% DM**	2	2	2	2	2
Mg	**% DM**	0,6	0,6	0,6	0,6	0,6
Fat	**% DM**	18	8	10	14	10
Protein	**% DM**	24	36	34	30	18
Fibres	**% DM**	16	7	10	13	10
Calorific value	**kWh/t DM**	4 200	4 100	4 800	4 600	3 000

A	Primary Sludge
B1	Biological Sludge (low load)
B2	Biological Sludge from clarified water (low and medium load)
C	Mixed sludge(A and B2 types)
D	Digested sludge

TABLE A8.2: PHYSICOCHEMICAL CHARACTERISTICS OF SEWAGE SLUDGE

PARAMETER		ANAEROBIC SLUDGE		AEROBIC SLUDGE	
		Average	STD	Average	STD
Dry Matter	%	20.29	8.18	22.12	12.39
Humidity	%	79.71	8.18	77.15	12.73
Ash	%	40.22	11.97	45.22	8.41
Organic Matter	%	59.85	11.97	55.05	8.11
Organic C	%	30.4	7.56	26.57	3.92
Total N	%	4.08	1.58	3.21	1.13
Total P	%	0.9	0.51	2.08	1.39

PARAMETER		ANAEROBIC SLUDGE		AEROBIC SLUDGE	
		Average	STD	Average	STD
Total K	%	0.39	0.21	0.37	0.12
pH		7.42	0.41	7.1	0.66
Cd	mg/kg	2.52	2.07	3.86	5.06
Ολικό Cr	mg/kg	414.57	355.27	113.58	76.27
Hg	mg/kg	21.69	29.98	0.98	0.5
Ni	mg/kg	164.04	248.18	76.02	50
Pb	mg/kg	196.53	80.44	221.11	114.68
Cu	mg/kg	414.18	350.49	367.09	201.23
Zn	mg/kg	1619.92	887.04	1228.48	576.77
As	mg/kg	2.82	2.15	6.51	10.19
Se	mg/kg			0.92	0.7
B	mg/kg			51.48	51.05

The average sludge composition in Cyprus is given below.

TABLE A8.3: AVERAGE SLUDGE COMPOSITION IN CYPRUS

	CYPRUS
Time Period	1995 – 1999
Dry Matter (DM) (%)	22 – 73
Organic Matter (% DM)	67 – 72
N % DM	3.75 – 4.53
P % DM	1.97 – 2.27
K % DM	0.25 – 0.26
mg/kg DM	
Cd	1.85 – 3.5
Cr	22 – 133
Cu	129 – 202
Hg	0.4
Ni	30 – 32
Pb	44 – 70
Zn	659 – 1173
nb/g wm	
Enteric Viruses	4.3×10^4/100g
Viable Helminth eggs	0

The sludge characteristics for the Limassol Sewage Treatment Plant are given below..

TABLE A8.4: LIMASSOL SEWAGE TREATMENT PLANT: SLUDGE CHARACTERISTICS

PARAMETER	CONCENTRATION
Nitrogen %	1.4
Phosphorus %	0.2
Potassium %	2.5
Organic Matter %	72
Sodium %	0.14
Boron (B), mg/l	31
Zinc (Zn), mg/l	605
Copper (Cu), mg/l	128
Cadmium(Cd), mg/l	3
Nickel (Ni), mg/l	17

PARAMETER	CONCENTRATION
Lead (Pb), mg/l	28
Chromium (Cr III), mg/l	22

SEWAGE SLUDGE COMPONENTS

⇩ PH

The pH of sewage sludge can affect crop production at land application sites by altering the pH of the soil and influencing the uptake of metals by soil and plants. Low pH sludge (< 6.5) promotes leaching of heavy metals, while high pH sludge (> 11) kills many bacteria and, in conjunction with soils of neutral or high pH, can prohibit movement of heavy metals through the soils.

⇩ ORGANIC MATTER

The relatively high level of organic matter in sewage sludge allows it to be used for soil improvement, including the improvement of the physical properties of soil, such as structure; the retention capacity of minerals and water; the soil bearing strength; and the reduction of the potential for surface runoff and water erosion.

The table below compares the content of organic matter of different types of sludge and other wastes that have been used as fertilisers.

TABLE A8.5: CONTENT OF ORGANIC MATTER IN SLUDGE AFTER DIFFERENT TREATMENTS AND IN OTHER URBAN WASTE AND ANIMAL MANURE

	ORGANIC MATTER CONTENT(% OF DM)
Urban Sludge	
Aerobic digestion	60 – 70
Anaerobic digestion	40 – 50
Thermal Treatment	< 40
Lime Treatment	< 40
Composting	50 – 85
Urban Compost	40 – 60
Animal Manure	45 – 85

⇩ NUTRIENTS

Nutrients present in sewage sludge, such as nitrogen (N), phosphorus (P) and potassium (K), are essential for plant growth. Nutrient levels are key determinants of sludge application rates, as excessive levels due to high application rates may result in groundwater or surface water pollution. The proportion of phosphorus and nitrogen in sewage sludge is given in Table A8.6.

TABLE A8.6: CONTENT OF NITROGEN AND PHOSPHORUS IN SLUDGE AFTER DIFFERENT TREATMENTS AND IN OTHER URBAN WASTE AND ANIMAL MANURE

	TOTAL N % OF DRY MATTER	N – NH_4 % OF TOTAL **N**	P % OF DRY MATTER
Urban Sludge			0.9 – 5.2
Liquid	1 – 7	2 – 70	

Semi-solid	2 – 5	< 10	
Solid	1 – 3.5	< 10	
Composted	1.5 – 3	10 – 20	0.2 – 1.5
Urban Compost	0.96		0.39
Litter	2.2 – 4.4	10	0.61 – 1.61
Manure	4 – 7	50 – 70	0.91 – 3.3

⇨ Nitrogen

Nitrogen is mostly found under organic form in sludge, and to a lesser extent under ammoniac form. As plants can assimilate only mineral nitrogen, the agricultural value of the sludge is also determined by the aptitude of its organic N to be mineralised. Loss of nitrogen may also result from volatilisation of the ammoniac, or if nitrates are leached. This may represent a risk of groundwater pollution and can occur when the amount of sludge applied is in the excess of the plant needs in nutrients or because of the fast degradation of sludge-borne organic matter which could give rise to a peak of nutrient in the soil. Table A8.8 gives the nitrogen availability of different sludge types.

TABLE A8.7: INFLUENCE OF TREATMENT ON THE NITROGEN CONTENT OF SOME SEWAGE SLUDGE

	TOTAL N (% OF DRY MATTER)	$N\text{-}NH_4^+$ (% OF TOTAL N)
Liquid sludge		
Aerobic digestion, gravity thickening	5 – 7	5 – 10
Aerobic digestion, mechanical thickening	4 – 7	2 – 8
Anaerobic digestion	1 – 7	20 – 70
Lagooning	1 – 2	N/A
Semi-solid sludge		
Aerobic digestion, mechanical dewatering	3 – 5.5	< 5
Anaerobic digestion, mechanical dewatering	1.5 – 3	< 5
Lime treatment	3.4 – 5	< 10
Solid Sludge		
Aerobic digestion, lime treatment	2.5	< 10
Composted	1.5 – 3	10 – 20
Aerobic, dewatered on drying beds	2 – 3.5	< 10
Anaerobic, dewatered on drying beds	1.5 – 2.5	< 10
Dried Sludge	3.5 – 6	10 – 15

TABLE A8.8: NITROGEN AVAILABILITY ACCORDING TO LABORATORY TESTS

SLUDGE TYPE	AVAILABILITY (%)
Aerobically digested sludge	24 – 61 %
Anaerobically digested sludge	4 – 48 %
Digested composted sludge	7 %
Composted raw sludge	4 %
Thermally dried sludge	7 – 34 %

⇨ Phosphorus

Phosphorus is used by the plants for growth, cell wall rigidity and the development of root systems. Sludge-borne phosphorus is of particular value as phosphorus is a limited natural resource. Phosphorus in sludge is mostly present under mineral form.

TABLE A8.9: INFLUENCE OF TREATMENT ON THE PHOSPHORUS CONTENT OF SEWAGE SLUDGE

	P_2O_5 (% OF DRY MATTER)	P (% OF DRY MATTER)
Liquid Sludge: aerobic digestion	4.9 – 6.9	2.1 – 3
Aerobic Digestion	2.5 – 12.65	1.1 – 5.5
Primary sludge, lime-treated	2.5 – 12	1.1 – 5.2

⇨ Other Compounds

Other compounds present in sludge, such as potassium, sulphur, magnesium and sodium, may also be of interest in crop production, however, they are present in sludge under various forms and their efficiency will depend on their availability.

⇩ HEAVY METALS

Sewage sludge may contain varying amounts of heavy metals, some of which are nutrients needed for plant growth. However, at high concentrations they may be toxic to plants, animals and humans, affecting plant health and growth, soil properties and micro-organisms, livestock and human health, and accumulate in the environment. The average content of 7 heavy metals in the member states is given below.

TABLE A8.10: AVERAGE CONTENT IN SEWAGE SLUDGE OF 7 HEAVY METALS IN THE MEMBER STATES

	DIRECTIVE 86/278/EEC mg/kg DRY MATTER	RANGE IN THE MEMBER STATES mg/kg DRY MATTER
Cd	20 – 40	0.4 – 3.8
Cr	.-.	16 – 275
Cu	1 000 – 1 750	39 – 641
Hg	16 – 25	0.3 – 3
Ni	300 – 400	9 – 90
Pb	750 – 1 200	13 – 221
Zn	2 500 – 4 000	142 – 2 000

⇩ ORGANIC POLLUTANTS

A wide variety of organic chemicals with diverse physical and chemical properties may be present in sewage sludge. However, most sludge contains low levels of these chemicals and does not pose a significant risk on humans or the environment.

⇩ PATHOGENS

Stabilisation greatly reduces the number of pathogens in sewage sludge, including bacteria, parasites, protozoa and viruses, together with odour potential. However, even stabilised sludge will usually contain some pathogens. Following land application, generally none of these micro-organisms will leach through the soil system to pollute the receiving groundwaters. Where surface runoff occurs though, buffers should be used to filter out pathogens and prevent entry into the receiving water bodies.

APPENDIX 9

LAND REQUIREMENTS FOR IRRIGATION

APPENDIX 10

ALTERNATIVE SCHEMES

APPENDIX 11

ENVIRONMENTAL SCREENING OF ALTERNATIVE OPTIONS

SCHEME		D1(a), D2(a), D5							
SITE ALTERNATIVE	WEIGHT	1(A). NEAR EPISKOPI (UPSTREAM OF ROAD BRIDGE)				1(B): NEAR EPISKOPI (DOWNSTREAM OF ROAD BRIDGE)			
AREA REQUIRED (HA))				S	W			S	W
STP			8 700 m^2				8 700 m^2		
EMERGENCY STORAGE			7 550 m^2				7 550 m^2		
LONG-TERM STORAGE	2		129 480 m^2 (reservoir requires but suitable geomorphology)	-1	-2		129 480 m^2 (reservoir needed , but recharge basins present that can be expended and used)	1	2
AREA DESCRIPTION									
LAND COVER	3		Barren land, however site is on river bed so possible impacts on river flow (further investigation necessary)	-2	6		Barren land (site next to river)	2	6
LAND OWNERSHIP	3		Governmental / Private	1	3		Governmental / Private	1	3
ZONE	3		SBA (no zones)	0	0		SBA (no zones)	0	0
BUILT-UP PROPERTIES	3		None	2	6		None	2	6
CONSERVATION AREAS	3		Close to proposed Natura 2000 sites	-2	-6		Close to proposed Natura 2000 sites (Episkopi area)	-2	-6
DISTANCE FROM NATURAL STREAM / COASTLINE	1		Near Kourris River	1	1		Near Kourris River	1	1
DISTANCE TO RESIDENTIAL ZONE BOUNDARY (km)	3		≈ 1 km	1	3		≈ 1.4 km	1	3
ACCESS ROAD	1	☑	Track road up to site	1	1	☑	Track road up to site	1	1
DISTANCE TO ELECTRIC LINE	1		≈ 300 m (66 kV)	1	1		≈ 700 m (66 kV)	-1	-1
DRINKING WATER SUPPLY	2		Boreholes near site	-2	-4		Boreholes near site	-2	-4
USE OF TREATED WATER IN IRRIGATION	2	☑		1	2	☑		1	2
LANDSCAPE AND VISUAL IMPACTS	3	☑	Some landscape and visual impacts as area undeveloped	-1	-3	☑	Some landscape and visual impacts as area undeveloped	-1	-3
OPINION OF THE COMMUNITIES	3		Accepted	2	6		Accepted	2	6
TOTAL WEIGHTED SCORE					**2**				**16**

S: Score, **W**: Weighted Score (Weight x Score)

SCHEME	D1(b), D2(b), D5			D1(c), D2(a), D2(b)			D1(a), D2(a), D5		
SITE ALTERNATIVES	2: NEAR TRACHONI (AREA SOUTH OF VILLAGE))			3: EXISTING LIMASSOL STP			4: NEAR KOLOSSI		
AREA REQUIRED (HA)		S	W		S	W		S	W
STP	8 700 m²			8 700 m²			8 700 m²		
EMERGENCY STORAGE	7 550 m²			7 550 m²			7 550 m²		
LONG-ERM STORAGE	129 480 m² (reservoir needed, but no suitable formations and restricted land availability due to cultivations)	-2	-4	129 480 m² (extension of existing STP)	-2	-4	129 480 m² (reservoir needed, no suitable geomorphology)	-2	-4
AREA DESCRIPTION									
LAND COVER	Irrigated agricultural land: orchards and olive plantations (intensive agriculture)	-3	-9	Existing STP	2	6	Agricultural land: temporary crops, some olive and fruit trees	-2	-6
LAND OWNERSHIP	Private	-1	-3	Governmental	2	6	Private	1	3
ZONES	Z1 Protected Zone	-1	-3	Industrial	2	6	SBA (no zones)	0	0
BUILT-UP PROPERTIES	None	2	6	Existing STP	2	6	None	2	6
CONSERVATION AREAS	No	2	6	No	2	6	No	2	6
DISTANCE TO NATURAL STREAM/COASTLINE	Few small streams east of the area in question	1	1	Close to coastline	2	2	≈ 200 m	1	1
DISTANCE TO RESIDENTIAL ZONE BOUNDARY	≈ 400 – 600 m	-2	-6	≈ 300 m,but existing STP already in operation	-1	-6	≈ 700 m	-2	-6
ACCESS ROAD	☑	1	1	☑	1	1	☑	1	1
DISTANCE TO ELECTRIC LINE	11 kV line passes through the area	2	2	Electricity available at site	2	2	≈ 50 m (66 kV)	2	2
DRINKING WATER SUPPLY	No	2	4	No	2	4	No	2	4
DISTANCE TO ELECTRIC LINE	☑	1	2	☑	1	2	☑	1	2
LANDSCAPE AND VISUAL IMPACTS	☑ Area undeveloped, cultivated with trees and visible from surrounding regions and main road	-2	-6	☒ Limited– STP already present at site	2	6	☑ Some landscape impacts as area is flat. Some visual impacts as site is near road	-1	-3
OPINION OF COMMUNITIES	Not accepted	-3	-9	Accepted	2	6	Accepted	2	6
TOTAL WEIGHTED SCORE			**-18**			**43**			**12**

S: Score, **W**: Weighted Score (Weight x Score)

SCHEME		POLIS CHRYSOCHOUS					
SITE ALTERNATIVES	WEIGHT	4(A): NEAR LIMNI			4(B): WITHIN STENI		
AREA REQUIRED (HA)			S	W		S	W
STP		8 900 m^2			8 900 m^2		
EMERGENCY STORAGE		7 700 m^2			7 700 m^2		
LONG-ERM STORAGE	2	131 970 m^2 (reservoir required, suitable geomorphology)	-1	-2	131 970 m^2 (reservoir required, suitable geomorphology)	-1	-2
AREA DESCRIPTION							
LAND COVER	3	Mostly agricultural land with some barren plots	-1	-3	Agricultural Land	-1	-3
LAND OWNERSHIP	3	Private	-1	-3	Private	-1	-3
ZONES	3	Agricultural	1	3	Agricultural	1	3
BUILT-UP PROPERTIES	3	None	2	6	Farm next to location	-1	-3
DISTANCE TO STREAMS/COASTLINE	3	≈ 1.4 km	1	3	≈ 1.7 km	1	3
ACCESS ROAD	1	☑	1	1	☑ Track road to location	1	1
DISTANCE TO ELECTRIC LINE	1	≈ 75 m (11 kV)	2	2	≈ 650 m (66kV)	-1	-1
DRINKING WATER SUPPLY	2	No	2	4	No	2	4
USE OF TREATED WATER IN IRRIGATIONH	2	☑	1	2	☑	1	2
LANDSCAPE AND VISUAL IMPACTS	3	☒ Some impacts on the landscape which will not be visible.	1	3	☒ Some impacts on the landscape which will not be visible	1	3
OPINION OF THE COMMUNITIES	3		2	6	Within the boundaries of a different community	2	6
TOTAL WEIGHTED SCORE		**22**			**10**		

S: Score, **W**: Weighted Score (Weight x Score)

SCORE	ENVIRONMENTAL PARAMETER	
	LONG-TERM STORAGE	
2	Existing dam for storage – no need for additional land for a reservoir	
1	Existing dam for storage of part of the treated wastewater – smaller piece of land required	
- 1	Reservoir required but geomorphology appropriate for its construction	
- 2	Reservoir required, unsuitable geomorphology, restricted land availability	
	LAND COVER	
2	Barren Land / Existing STP	
1	Mostly barren land, only with a few non-irrigated crops.	
- 1	Mostly agricultural land with some barren plots.	
- 2	Agricultural land, natural vegetation, other characteristics (e.g.: river bed, etc)	
- 3	Forest, park, protected habitat	
	LAND OWNERSHIP	
2	Governmental Land	
1	Governmental and Private Land	
- 1	Private Land	
- 2	Buffer Zone (Implications for licensing, for the completion of the studies and the construction)	
	ZONES	
2	Animal husbandry, industrial	
1	Agricultural	
- 1	Z1* protected area	* 5% land cover permitted
- 2	Z3* protected area, landscape	*1% land cover permitted
-3	Residential/Tourist Area	
0	SBA / Buffer Zone	
	BUILT-UP PROPERTIES IN OR NEAR THE SITE	
2	None	
1	Farms/ other agricultural facilities, industrial units near the location	
-1	Farms / other facilities, industrial units at the location	
-2	Recreation areas, archeological areas, historic buildings near location	
-3	Houses or tourist resorts, archeological monuments, other buildings at site	
	PROXIMITY TO CONSERVATION AREAS	
2	No indicated protected area near the site	
-2	Close to/At an indicated protected area, e.g. Natura 2000 site	
	DISTANCE TO STREAMS/ COASTLINE	
2	Close to coastline (Option for effluent disposal to the sea)	
1	Close to natural streams and or to the shore	
- 1	Far away from natural streams and or to the shore	
	DISTANCE TO THE CLOSEST HOUSE	
2	≥ 2 km	
1	≥ 1.5 km	
- 1	≥ 0.8 km	
- 2	< 0.8 km	
- 3	≤ 0.5 km	

	ACCESS ROAD
1	Exists
- 1	Does not exist
	DISTANCE FROM AN ELECTRIC LINE
2	≤ 100 m
1	≤ 500 m
- 1	≤ 1000 m
- 2	> 1000 m
	PROXIMITY TO BOREHOLES
2	None near location
-2	Close to location
- 3	Drinking water borehole at location
	USE OF TREATED WASTEWATER FOR IRRIGATION
1	Possible since there exists agricultural land in the area
- 1	No agricultural land for irrigation near the area
	LANDSCAPE AND VISUAL IMPACTS
2	No impact on the landscape (degraded or low value landscape, location not visible)
1	Some impacts on the landscape but the location not visible from surrounding areas
-1	Some impacts on the landscape (undeveloped land), visible from surrounding areas
-2	Important impacts on landscape (important, protected or conservation area, visible from the surrounding areas which can be tourist or residential)
	OPINIONS OF THE COMMUNITIES
2	Location is accepted from the communities
-3	Not accepted by the communities/ Within the administrative boundaries of a community which is not covered by the scheme

APPENDIX 12

DRAWINGS

APPENDIX 13

CONSULTATION LETTERS

APPENDIX 14

SITE PICTURES

APPENDIX 15

REFERENCES

1. Recycling and Disposal of Sewage Sludge, European Commission, 2001
2. Pollutants in Urban Waste Water and Sewage Sludge, European Commission, 2001
3. Evaluation of Sludge Treatments for Pathogen Reduction, European Commission, 2001
4. Extensive Wastewater Treatment Practices: Adapted to Small and Medium Sized Communities
5. Census of Agriculture 1994, Department of Research and Statistics, Ministry of Economy
6. Agricultural Statistics 2001, Statistical Services.
7. The Assessment of Water Demand of Cyprus, Ministry of Agriculture, Natural Resources and the Environment, FAO, 2001
8. Pescod M.B., 1992. "Wastewater treatment and use in Agriculture – FAO – irrigation and Drainage Paper 47", FAO, Rome, Italy

APPENDIX 16

ADDITIONAL INFORMATION

ADDITIONAL INFORMATION

This Appendix includes information which was requested during a meeting which took place at the Environmental Services between Mrrs Charalambos Hadjipakkos, Michalis Pantis, Georgios Koumouris, Christos Hadjantoni, Chrystalla Costa, Antonis Charalambides, Pantelis Sophocleous, Georgia Katsounotou, Aggelos Odysseos, Kyriakos Tsiaousis, Michalakis Efthymiou, Stella Fysentzou, Christoforos Christoforou and Magnus Holmer. The minutes of the meeting are included hereafter. The corrections which are included here (Part One) are also included in the main text. The meeting took place on the 22nd of November 2004.

After the completion of another meeting on the 16th of February, even more information was requested (Part Two). It is therefore mentioned here that additional information on the content of the sludge in heavy metals was requested from the treatment plants in Larnaca, Limassol and Paralimni/Ayia Napa. The information which was obtained is also included at the end of this Appendix.

PART ONE

EPISKOPI SEWAGE TREATMENT PLANT (STP)

IMPACTS ON THE GROUNDWATER AND THE NEIGHBOURING AQUIFER FROM THE OPERATION OF THE STP

As Mrs Georgiou had indicated during the meeting, the work to be completed, i.e. the Sewage Treatment Plant at Episkopi, will reduce the risk of groundwater pollution in the area, as it will eliminate the use of septic tanks and thus their overspills. The plant will have storage ponds, with the appropriate waterproof construction. Not only that, but the treated sludge will be confined within a concrete structure, as is customary, and will be covered. As a result of that, any risk of seepage to the surrounding ground and thus infiltration to the groundwater table is minimal, as the sludge will not be rained upon. All these are in the case of proper and instructed operation of the plant. In the case of mismanagement of the sludge while transported to the storage facility, and therefore a probable accidental spill, could easily be mitigated by the immediate re-collection of the spilt material and proper transport.

Certain mitigation actions for emergency-situations are normally included in Sewage Treatment Plants during construction. It is most often the case, that the various treatment units of plants are interconnected, but also allowed to function independently by the incorporation of valves. A malfunctioning unit can be by-passed and normal operation can still occur. This is so because the units are normally designed for higher capacities than the average load capacity due to various reasons, one of them being, as a mitigation measure for emergency cases. The existence of storage ponds providing for emergency storage is also another measure included, as is mentioned in the EIA presented. These ponds are meant for temporary storage until re-circulation of the sludge through the appropriate unit for proper treatment. The ponds shall be waterproof and shall fully contain the wastewater preventing any leaks. Depending on the final design of the plant, the transportation of the untreated wastewater to and from the storage pond should follow an alarm which should sound at a time appropriate for the personnel to be alerted of the emergency incident and take the appropriate action to minimize potential impacts to the environment and restore the apt operation of the STP.

INFORMATION ON THE NEIGHBOURING AQUIFER AND POSSIBLE IMPACTS IN CASE OF GROUNDWATER RECHARGE WITH TREATED EFFLUENT

This is a matter that shall be addressed through a different study from the Water Development Department for the reuse of treated wastewater..

SLUDGE HEAVY METAL CONTENT

Information on the sludge content in heavy metals can be found in Table 6.6 of the main text of the EIA. The sludge content in heavy metals depends on the treatment process to take place but mostly on the source of the sludge. Following is a table found in a study completed for the Swedish Environmental protection agency where samples from 48 Sewage treatment plants were taken and analysed for their content in 61 elements, among them being the following heavy metals of interest:

Content in mg/kg Dry Matter		
Metal	**Average**	**Mean Deviation**
Arsenic	4.7	6.2
Cadmium	1.4	1.5

Content in mg/kg Dry Matter		
Metal	**Average**	**Mean Deviation**
Chromium	33	16
Cobalt	6.2	5.3
Copper	390	300
Iron	4900	3800
Lead	33	16
Manganese	280	220
Mercury	1.1	0.8
Molybdenum	6.7	3.5
Nickel	20	23
Selenium	1.3	0.5
Tin	22	9
Zinc	550	320

The sludge samples consisted of both secondary and tertiary sludge products including Nitrogen removal. The actual heavy-metal content of the treated sludge produced in Episkopi and Polis is going to vary depending on the sources of wastewater. In general terms, the sludge produced is expected to have heavy metals in concentrations along the lines as shown in the above table but also within the limits of the standards which are described in Table A8.10 in Appendix 8 and is updated as the following.

	DIRECTIVE 86/278/EEC mg/kg DRY SOLIDS	RANGE OF AVERAGE CONCENTRATION mg/kg DRY SOLIDS
Cd	20 – 40	0.4 – 3.8
Cr	---	16 – 275
Cu	1 000 – 1 750	39 – 641
Hg	16 – 25	0.3 – 3
Ni	300 – 400	9 – 90
Pb	750 – 1 200	13 – 221
Zn	2 500 – 4 000	142 – 2 000

Additionally, a reference is made in Appendix 1, Table A1.5 for the allowable heavy metal content of the sludge. Appendix 1 includes a reference of the quality standards in Cyprus and the EU and Table A1.5 is presented hereafter::

PARAMETERS	MAXIMUM VALUE (mg/kg DRY MATTER)
Cadmium (Cd)	20 - 40
Copper (Cu)	1000 - 1750
Nickel (Ni)	300 - 400
Lead (Pb)	750 - 1200
Zinc (Zn)	2500 - 4000
Mercury (Hg)	16 - 25
Chromium (Cr III)	1000

SLUDGE VOLUME CALCULATION

The following correction should be made:

COMMUNITY	YEARLY PRODUCTION OF SOLIDS, KG DS/YEAR		
	2005	2015	2030
Poli Chrysochous Sewage Treatment Plant			
Poli Chrysochous	*65 423*	*91 664*	*136 403*
Volume of sludge 30% Dry Solids (DS)	216 m³/year	302 m³/year	450 m³/year
Episkopi Sewage Treatment Plant			
Episkopi	71243	81944	101083
Erimi	33619	40003	51922
Kolosi	87958	104766	136188
Ypsonas	151294	180674	235779
Trachoni	75093	83020	96506
Total	*419 207*	*490 407*	*757 882*
Volume of Sludge 30% Dry Solids (DS)	1 383 m³/year	1 618 m³/year	2 051 m³/year
Total			
Total Volume of Sludge 30% Dry Solids (DS)	1 600 m³/year	1 920 m³/year	2 501 m³/year

COMMENTS AND QUESTIONS OF THE AGRICULTURAL DEPARTMENT

A. "ADVANCED" VS "CONVENTIONAL" TREATMENT (TABLE 6.7)

This table is taken from a working document presented in the EU "sludge website" for consultation purposes (http://europa.eu.int/comm/environment/waste/sludge/index.htm) and the definition of advanced and conventional treatment is also given in that same paper. According to the paper, the treatment processes considered advanced (undergoing hygienisation) are described as follows:

- Thermal drying ensuring that the temperature of the sludge particles is higher than 80^{o}C with a reduction of water content to less than 10% and maintaining a water activity above 0.90 in the first hour of treatment;

- Thermophilic aerobic stabilisation at a temperature of at least 55°C for 20 hours as a batch, without admixture or withdrawal during the treatment;
- Thermophilic anaerobic digestion at a temperature of at least 53°C for 20 hours as a batch, without admixture or withdrawal during treatment;
- Thermal treatment of liquid sludge for a minimum of 30 minutes at 70°C followed by mesophilic anaerobic digestion at a temperature of 35°C with a mean retention period of 12 days;
- Conditioning with lime reaching a pH of 12 or more and maintaining a temperature of 55°C for two hours;
- Conditioning with lime reaching and maintaining a pH of 12 or more for three months

The process shall be initially validated through $6Log_{10}$ reduction of a test organism such as *Salmonella Senftenberg W 775.*

The treated sludge shall not contain *Salmonella spp* in 50 g (wet weight) and the treatment shall achieve at least a $6Log_{10}$ reduction of *Escherichia Coli* to less than $5*10^2$ CFU/g.

The conventional treatments the table refers to are as follows:

- Thermophilic aerobic stabilisation at a temperature of at least 55°C with a mean retention period of 20 days;
- Thermophilic anaerobic digestion at a temperature of at least 53°C with a mean retention period of 20 days;
- Conditioning with lime ensuring a homogenous mixture of lime and sludge. The mixture shall reach a pH of more than 12 directly after liming and keep a pH of at least 12 for more than 24 hours
- Mesophilic anaerobic digestion at a temperature of 35°C with a mean retention time period of 15 days;
- Expended aeration at ambient temperature as a batch, without admixture or withdrawal during the treatment period;
- Simultaneous aerobic stabilisation and temperature;
- Storage in liquid form at ambient temperature as a batch, without admixture or withdrawal during the storage period;

B. SOURCE OF INFORMATION OF TABLE 6.12

The information summarized in Table 6.12 was obtained from a paper published in 1992 by the Food and Agriculture Organization (FAO) of the United Nations (UN) entitled “Wastewater treatment and use in Agriculture – FAO irrigation and drainage paper 47”. It was written by M.B. Pescod.

C. BIOAVAILABLE ELEMENTS

Refers to elements that are in the form (chemical form) that can be utilized by living organisms in any biological process.

D. ON WHAT INFORMATION ARE THE RECOMMENDED LIMITS IN TABLE 8.7 BASED ON?

The limits presented in table 8.7 were taken from a working document presented in the EU "sludge website" (http://europa.eu.int/comm/environment/waste/sludge/index.htm) for consultation purposes. This information is taken from the working document last updated in April 2000 and as posted on the EU website.

E. WHICH CROPS CONCENTRATE HEAVY METALS?

When one reads through various published work on the matter will come to the conclusion that the uptake of heavy metals by various plants does not only depend on the plants themselves, it also depends on the treatment of the sludge which might have an effect on the bio-availability of these elements. Not only that, but the soil type and heavy-metal content, on which the sludge is to be applied on has an effect, as well as the rate of its application on it. The specification needs to be made based on the exact sludge treatment (whether advanced or conventional), on the soil type on which the crop is grown and on the crop type. A case-specific study needs to be made to accurately assess the effect and level of uptake of each crop depending on the area and type of soil it is grown on and not only the type of crop.

As far as the liquid waste produced and used for irrigation, a table is given hereafter, taken from a paper published in 1992 by the Food and Agriculture Organization (FAO) of the United Nations (UN) entitled "Wastewater treatment and use in Agriculture – FAO irrigation and drainage paper 47" which describes the potential effect of the various trace elements (heavy metals) on various crops under various conditions (different soil types, and pHs).

	Element	**Recommended maximum concentration (mg/l)**	**Remarks**
Al	(aluminium)	5.0	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
As	(arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Be	(beryllium)	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cd	(cadmium)	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co	(cobalt)	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr	(chromium)	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Cu	(copper)	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solutions.
Fe	(iron)	5.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li	(lithium)	2.5	Tolerated by most crops up to 5 mg/l; mobile in

	Element	Recommended maximum concentration (mg/l)	Remarks
			soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron.
Mn	(manganese)	0.20	Toxic to a number of crops at a few-tenths to a few mg/l, but usually only in acid soils.
Mo	(molybdenum)	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Ni	(nickel)	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Pd	(lead)	5.0	Can inhibit plant cell growth at very high concentrations.
Se	(selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/l and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. As essential element to animals but in very low concentrations.
Sn	(tin)		
Ti	(titanium)	-	Effectively excluded by plants; specific tolerance unknown.
W	(tungsten)		
C	(vanadium)	0.10	Toxic to many plants at relatively low concentrations.
Zn	(zinc)	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

[1] The maximum concentration is based on a water application rate which is consistent with good irrigation practices (10 000 m^3 per hectare per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10 000 m^3 per hectare per year. The values given are for water used on a continuous basis at one site.

E. FLOW RATES, ANNUAL WASTEWATER PRODUCTION, VOLUME OF STORAGE PONDS

The following updating shall be made (replace Table 3.3, page 11 in the EIA with this table):

COMMUNITY	2005 YEARLY PRODUCTION m³/year	2005 MAXIMUM DRY WEATHER FLOW m³/year	2015 YEARLY PRODUCTION m³/year	2015 MAXIMUM DRY WEATHER FLOW m³/year	2030 YEARLY PRODUCTION m³/year	2030 MAXIMUM DRY WEATHER FLOW m³/year
Polis	220,313	2,485	314,875	3,747	476,157	5,499
Episkopi	135,269	519	157,607	605	201,352	772
Erimi	63,912	245	76,942	295	103,624	397
Kolossi	167,225	641	201,352	772	271,159	1,040
Ypsonas	292,152	1,264	361,440	1,816	488,848	2,448
Trachoni	142,715	547	159,779	613	192,045	737
TOTAL	**1,021,584**	**5,701**	**1,271,994**	**7,848**	**1,733,184**	**10,894**

The capacity of the Episkopi STP will be 5,395 m^3/day instead of 6,378 m^3/day as was mentioned in the EIA. Therefore the volume of the storage ponds, both the emergency storage ponds and the long-term storage ponds will also change as follows:

SEWAGE TREATMENT PLANT	EMERGENCY STORAGE POND CAPACITY(**m^3**)	AREA FOR EMERGENCY STORAGE POND (**m^2**)
Episkopi STP	37,764	7,553
Polis STP	38,491	7,698

And for the long-term storage ponds

SEWAGE TREATMENT PLANTS	LONG-TERM STORAGE POND CAPACITY (**m^3**)	AREA FOR LONG-TERM STORAGE POND (**m^2**)
Episkopi STP	647,389	129,478
Polis STP	659,841	131,968

IMPACTS ON PUBLIC HEALTH

The connection of the communities to the sewerage system will result in the elimination of any risk of overflow from septic tanks to streams or its' infiltration in groundwater. The risk of waterborne bacterial infection from this source is thus eliminated. Dangers incorporated in the transport and handling of waste coming from septic tanks will also be eliminated.

The only ones that would be exposed to any amount of danger would be the workers at the STP. If they abide with the rules and regulations encompassing health and safety within the Plant, then the risk is minimized. It is expected that by conforming to health and safety regulations they not only protect themselves but whoever they come in contact with and thus public health is protected.

LIMITS OF TOTAL NITROGEN (TN) AND CHEMICAL OXYGEN DEMAND (COD)

The suggested concentration limit of Total Nitrogen is mentioned in the EIA and is 15 mg/L. However, most wastewaters undergoing secondary treatment can usually reach a Total Nitrogen effluent concentration of 10 mg/L. As far as COD, the suggested limit is < 125 mg/L according to Regulation 517/2002 (for irrigation of all crops) and the EU standards are 90 mg/L as indicated in Table 3.8 of the presented EIA.

SCHEMES FOR THE STP CONSTRUCTION

A. LOCATION SELECTION METHOD

The possible locations were chosen during the preliminary stage of the Feasibility Study based on the following criteria:

- Location at a low point in order to reduce pumping facilities for the conveyance of the wastewater flow
- Location at the barycentre of the group of communities in order to reduce the length of pipeline to transfer the wastewater flow
- Environmental criteria, including proximity to housing areas, landscape and visual impacts, land use impacts, and opinions of the concerned communities
- Vicinity of existing storage capacities for treated effluent such as a dam

It is requested that you consider the recommended location for the situation of the Episkopi STP as location 1(b). The reasons for the selection of this location were both technical and operational as well as environmental. The final choice had to be made between locations 1(a) and 1(b). This was so because location 2, near Kolossi was rejected by the Antiquity Department because a bronze age habitat was located in the area. Location 3, near Trachoni was rejected by the community and therefore the extension of the existing plant in Limassol was also rejected since it required the concurrent use of this site, or the economically unfeasible construction of very long sewer lines to connect the communities to the existing STP (refer to schemes D1c and D2b). Hence the final choice had to be made between locations 1(a) and 1(b). Technically, the choice of location 1(b) was made, due to the risk of flooding if the STP were situated in the river basin, as would be done, had location 1(a) were chosen. Had location 1(a) been chosen additional measures would have to be taken for flood protection.

In addition to this, location 1(b) was the preferred alternative of the representative of the community council of Episkopi that presented these locations. Another important factor that lead to the choice of this location was the fact that it was made apparent that the procedure for the acquisition of private land to be undertaken by the WDD as well as the compensation procedure would be more straightforward than for location 1(a).

From an environmental point of view, the comparison of the two alternatives was made based on the Tables that are presented in the EIA. As can be seen from the marks given to the two locations based on the criteria listed, the impact on surface water quality and in ground water quality are expected to be more acute if the STP is located in location 1(a). A possible flood at the STP due to unexpected river flow would have more detrimental effects on water quality than the recharge of the aquifer with the treated wastewater (which is one of the recommendations for location 1(b)), since recharge will be regulated.

The location of the STP which will serve the Polis Chrysochous community was chosen based on the same criteria. The two locations presented as alternatives to host the STP for the community were technically similar and choice of location 1 was made because it was backed by the community.

B. ALTERNATIVE SCHEMES

All information on the Schemes that were examined during the Feasibility Study and which were taken into consideration during the decision stage of the process are presented in the EIA. The final choice of Schemes was also based on the acceptance or rejection of the alternative locations.

At this stage, the choice of location 1(a) for the STP which would serve the Limassol communities, lead to the final comparison to take place between Scheme D1a and D1c. Scheme D1c was rejected after it became apparent that only the community of Ypsonas could be connected to the sewer system as is and thus to the existing Limassol STP. Therefore, the connection of the remaining communities to the system would not be feasible economically, due to the large distances the wastewater would have to travel (the STP is located on the other side of the city of Limassol to the east, near the Moni community). As a result, Scheme D1a was technically and economically more practical.

From an environmental perspective, the extension of the Limassol STP in comparison with the construction of a new STP in Episkopi seems better, at a first glance.

The existing system in Limassol is of limited capacity and could only receive additional wastewater from the community of Ypsonas, and therefore a new conveyance system would have to be constructed. The large distances that would have to be spanned by the conveyance system would require temporary acquisition of land along long lengths of land. This would have a negative impacts on the soil quality, it would cause large areas to be cleared of vegetation and the risk for land and air pollution would also be higher. Not only that, but during the operation of the plant, the large retention time the wastewater would have to stay within the conveyor pipes increases the likelihood of odour problems as it would allow more time for the creation of hydrogen sulphide (H_2S) to take place.

The Akrotiri aquifer is being recharged as of two months ago with treated wastewater from the existing Limassol STP. If the communities were connected to this STP the additional treated water resulting from this connection would be used for the recharge of the aquifer as well. The creation of a new STP in Episkopi and recharge of the aquifer with the treated waste coming from that STP is expected to have the same effect.

As a result, the environmental impacts of both these Schemes are similar with the exception of the requirement of additional land to be acquired for the construction of a new plant.

REFERENCES

EU, 2000. "Working Document on Sludge, 3rd Draft". EU Sludge website: http://europa.eu.int/comm/environment/waste/sludge/sludge_en.pdf

Eriksson Jan, 2001 "Concentrations of 61 trace elements in sewage sludge, farmyard manure, mineral fertilizer, precipitation and in oil and crops", Swedish Environmental Protection Agency, Stockholm, Sweden

Pescod M.B., 1992. "Wastewater treatment and use in Agriculture – FAO – irrigation and Drainage Paper 47", FAO, Rome, Italy.

PART TWO

REFERENCE TO LETTER 70/94/Δ (DATED: 24/02/05) OF THE ENVIRONMENTAL SERVICES

SLUDGE PRODUCTION IN COMPARISON WITH THE ORGANIC BOD_5 LOAD

The ration which was used for the calculation of sludge was 1 kg BOD per 1 kg of sludge as 30% dry matter (solids). According to the German design standards ATV – DVWK – Standards (Standard ATV – DVWK – A 131E, Dimensioning of Single-Stage Activated Sludge Plants) the ratio of the amount of organic load to the sludge produced depends on the sludge age (the residence time in the aeration reactor) along with X_{SS}/C_{BOD} (the ratio of the concentration of Suspended solids to the concentration of the BOD). Following Table 5 of the Standards which were published in May 2000 is shown:

X_{SS}/C_{BOD}	Sludge Age					
	4 days	8 days	10 days	15 days	20 days	25 days
0.4	0.79	0.69	0.65	0.59	0.56	0.53
0.6	0.91	0.81	0.77	0.71	0.68	0.65
0.8	1.03	0.93	0.89	0.83	0.80	0.77
1.0	1.15	1.05	1.01	0.95	0.92	0.89
1.2	1.27	1.17	1.13	1.07	1.04	1.01

In order for nitrification and denitrification to take place, the sludge must have an age of 10 – 15 days. In Cyprus, a ratio X_{SS}/C_{BOD} which ranges from0.8 to 1.2 has been observed (and actually more in the proximity of 1.0). Bearing these in mind, according to the above table it can be deduced the ratio of the organic BOD load to the produced sludge ranges from 0.83 to 1.13. The selection of this ration was made based on these assumptions

Additionally, it is mentioned that after phosphorous removal (which increases the volume of sludge by 20% to 30%) 95 g DS per population equivalent are produced. This amount can be reduced to 70 g DS per population equivalent per day when anaerobic digestion takes place (TRAITER et VALORISER LES BOUES, Collection OTV, 1994). It is known that the organic load (BOD) amounts to 60 g per population equivalent per day. Therefore based on these facts, the ratio ration of the sludge produced (in dry solids) to the organic load will vary between 1.17 and 1.50. If it is considered that the volume of sludge produced increases in the case of phosphorous removal then the ration of the sludge produced to the organic load is again very close to 1.0.

In order to further verify this assumption (or not) letters were sent to the Sewage treatment plants of Larnaca, Limassol and Ayia Napa/Paralimni through which the following information was requested:

1. An average BOD loading (kg BOD/yr) encountered at the STPs.
2. An average number for the sludge production (kg DS/yr) encountered at the STPs as well as the proportion of sludge produced which is reused for agricultural purposed and how the rest of it is disposed of
3. Data with the sludge content in heavy metals.

Some information for the Larnaca and Limassol STPs were received and are presented hereafter. The following table includes information obtained from the Larnaca STP. The letter sent from the STP includes information based on which the mass of sludge (as kg DS) was calculated along with the organic load in kg BOD. The information about the flow rate of the STP was obtained from an older letter from the STP and might not contain representative information of the relevant year for which the latest information was obtained. This might have an impact on the calculation of the organic BOD load and therefore the large ratio obtained in the following table might be attributed to that.

LARNACA SEWAGE TREATMENT PLANT
C_{BOD} = 400 mg/L
Q_H = 6 000 m^3/day, therefore Q_x = 2 190 000 m^3/year.
Load = C_{BOD} Q_H = 876 000 kg BOD/ year
The produced sludge of 9000 m^3 with 80% relative humidity (20% solids) also means a mass of
1 800 000 kg DS/year ,
Therefore:
1 800 000 kg DS **:** 876 000 kg BOD = ***2.05***

More information is needed about the STP in order to draw a conclusion about the high ratio of kg DS to kg BOD (organic load) found. The relevant letters are included.

As far as the sludge content in heavy metal is concerned, information from the Larnaca STP were sent for a date in 2005 (28/1/2005) and are presented hereafter. Information on the sludge heavy metal content were also obtained for the Limassol STP as 2004 yearly averages.

LIMASSOL SEWAGE TREATMENT PLANT
Load = 2 555 878 kg BOD/year
The sludge produced, according to the information obtained is 9026 m^3 (18% solids) which also means a mass of
1 624 680 kg DS/year
Therefore:
1 624 680 kg DS **:** 2 555 878 kg BOD = ***0.64***
50% of the sludge produced is reused in agriculture. 17% us used in cement factories and the remainder is disposed of.

Information on the Ayia Napa/Paralimni STP were not obtained.

The following table summarizes the information received on the sludge heavy metal content along with other sludge characteristics.

Parameter	**Larnaca STP (28/1/2005)**	**Limassol STP(Avg. 2004)**
pH	7.62	6.8
Electrical Conductivity	3.54 **mS/cm**	
Dry Matter	17.9**%**	75**%**
Organic Matter	73.1**%**	
Total Nitrogen **N**	5.48**%** (Kjeldhahl)	26.0 **kg/t DS**
Total Phosphorus **P**	2.98**%**	40.0 **kg/t DS**
Potassium **K**		1.0 **kg/t DS**
Calcium **Ca**		60.0 **kg/t DS**
Manganese **Mn**		353.6 **kg/t DS**
Iron **Fe**		34.0 **kg/t DS**
Boron **B**		58.3 **kg/t DS**
Cadmium **Cd**	1.19 **mg/kg**	2.0 **mg/kg DS**
Copper **Cu**	173.0 **mg/kg**	137.0 **mg/kg DS**
Nickel **Ni**	24.5 **mg/kg**	25.0 **mg/kg DS**
Lead **Pb**	19.3 **mg/kg**	28 **mg/kg DS**
Zinc **Zn**	741 **mg/kg**	1315 **mg/kg DS**
Chromium **Cr**	26.1 **mg/kg**	52 **mg/kg DS**
Mercury **Hg**	2.17 **mg/kg**	<10 **μg/kg DS**

As far as the rest of the comments, they are addressed in the main text of the EIA.

APPENDIX 17

OPINION OF THE PUBLIC AUTHORITY