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EXECUTIVE SUMMARY

As a future member of the European Union, Cyprus must fulfil the EU pre-accession 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 collection and treatment system. The project includes 28 communities, which have been divided into 4 groups according to their district areas. This study is concerned with the Famagusta Communities of Group C, which includes the villages of Xylotymvou, Achna, Ormideia, Avgorou, Xylofagou, Agios Georgios Acheritou, Liopetri, Frenaros, Sotira and Deryneia.

PROJECT DESCRIPTION

The project includes the design of the collection, conveyance and centralized treatment of the urban sewage effluents from the Famagusta communities. A number of schemes, including one or more sewage treatment plants and different conveyance routes have been accessed, together with various alternative sites for the plants. Following the technical, economic and environmental evaluation of the alternative schemes and sites, it was concluded that the preferred option will include the construction of a single sewage treatment plant near the Achna Dam. Sewage effluents will be transported to the STP via a collection and conveyance system consisting of gravity pipes, forcemains and a total of six pumping stations, located mainly within the village residential areas.

Regarding the treatment process, the activated sludge process combined with tertiary treatment has been suggested. This is 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. One of the advantages of the selected site is the possibility to store the treated effluent in the Achna Dam, particularly during the winter months. If this is not possible, the study has examined the possibility of constructing an additional long term storage reservoir near the plant.

The main objective for the sludge that will be produced from the process is agricultural reuse, as fertilizer. Selection of the treatment process will be based on this assumption.

EVALUATION OF IMPACTS AND MITIGATION MEASURES

Following a description of the baseline environment of the area, the environmental impacts that could result from the project have been identified and mitigation measures have been proposed to eliminate or minimise such impacts. Impacts have been examined in relation to project location and design, the project construction and operation phases, and the reuse of the treated effluent for irrigation.

A summary of the impacts that have been identified is outlined in the table below.

SUMMARY OF ENVIRONMENTAL IMPACTS

	IMPACTS
IMPACTS DUE TO PROJECT LOCATION	*Permanent land acquisition* Permanent acquisition of land for construction of the STP, the storage reservoir and the pumping stations
	Impacts on surface water hydrology Positive impacts – additional permanent flow into reservoir or additional surface water body
	Impacts on ecological values No destruction of habitats, but disturbance of wildlife, particularly birds during construction of the STP, due to proximity of site to the Achna Dam. Also, possible disturbance of wildlife during operation as a result of noise. Positive impacts through the creation of a new wetland habitat if an additional long term storage reservoir is created. If storage in Achna Dam addition permanent flow will enhance species diversity.
PROJECT DESIGN	*No significant impacts are anticipated* • 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 DUE TO 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 STP, the storage reservoirs, the pumping stations and the conveyance system.
	Soil impacts • Soil erosion: resulting from uncovered and unconsolidated materials during construction • Soil disaggregation • Soil compaction
	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
	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* Minimum impacts
	Noise impacts At STP and pumping stations. Impact at STP limited as site is at a considerable distance from residential areas, however pumping stations are within urban areas.
	Odour impacts

	IMPACTS
	Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment
	Impact of sludge production and reuse
	Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations
	Risk of insufficient treatment of effluent
	Reuse of Treated Effluent in Irrigation

ENVIRONMENTAL MANAGEMENT PROGRAMME

An Environmental Management Programme 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 future member of the European Union, Cyprus must fulfil the EU pre-accession 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 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 subsidises 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

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 Famagusta 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.

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 Labour 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, 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** concerned by 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 programs 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 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 equivalent-population 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) focussing 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. We may presently stick to this suggestion, but final presentation of documents (common or separate reports) will be decided later according to needs.

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 minimising 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; 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 publicise 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

The use of sewage sludge in agriculture is not yet practised except on an experimental basis. The disposal of sewage sludge is covered by the Water Pollution Control Law. Limit values for heavy metals are set in permits for land-spreading operations. 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

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 also 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 sites Natura 2000 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

As a future member of the European Union, Cyprus must fulfil the EU pre-accession requirements concerning the protection of the environment and therefore must meet the obligations and requirements of Council Directive 91/271/EEC on urban wastewater treatment.

The Directive 91/271/EEC 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 authorisations for all discharges of wastewater into the environment, for industrial discharges into urban wastewater systems and for the disposal of sewage sludge.

During the feasibility study a number of alternative schemes and sites were evaluated (Section 6) based on technical, financial and environmental criteria and a final selection was made. According to the preferred alternative the STP will be located to the northeast of the Achna Dam.

3.2. PROJECT LOCATION

The locations of the STP and the emergency storage reservoir, as well as the proposed site for the long term storage reservoir, are given in Drawing EIA-C-1. Drawing EIA-C-3 gives the suggested sewer routes and the location of the pumping stations, however, these are only preliminary and subject to detailed design. The STP site is at a distance of approximately 3 km from the centre of the Avgorou residential area and 5 km from the residential area in Achna.

3.3. PROJECT CHARACTERISTICS

3.3.1. SERVICED AREA

Table 3.1 lists the Famagusta Area Communities that are included in Group C.

TABLE 3.1: FAMAGUSTA AREA (GROUP C) COMMUNITIES

COMMUNITY NUMBER	COMMUNITY NAME
C1	Xylotymvou
C2	Achna
C3	Ormideia
C4	Avgorou
C5	Xylofagou

COMMUNITY NUMBER	COMMUNITY NAME
C6	Agios Georgios Acheritou
C7	Liopetri
C8	Frenaros
C9	Sotira
C10	Deryneia

The water demand analysis is summarised in the table below.

TABLE 3.2: WATER DEMAND

COMMUNITIES	AVERAGE WATER DEMAND IN 2005 (INTO BRACKET AVERAGE WATER DEMAND INCLUDING ADDITIONAL SUMMER CONSUMPTION) m3/day	AVERAGE WATER DEMAND IN 2030 (INTO BRACKET AVERAGE WATER DEMAND INCLUDING ADDITIONAL SUMMER CONSUMPTION) m3/day
Xylotymvou	480 (480)	630 (630)
Achna	280 (290)	450 (470)
Ormideia	550 (550)	690 (690)
Avgorou	580 (610)	950 (1000)
Xylofagou	690 (690)	690 (900)
Agios Georgios	240 (240)	450 (450)
Liopetri	540 (580)	800 (930)
Frenaros	450 (460)	540 (560)
Sotira	610 (770)	930 (1500)
Deryneia	730 (850)	1330 (1750)

3.3.2. SEWAGE TREATMENT PLANT

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

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.

For those communities with a developing tourist sector, 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.

According to the obtained data, groundwater levels in the study area are generally lower than the invert levels of the collection system. Furthermore, infiltration is likely to occur in winter months when water consumption is low. For these reasons, no allowance for infiltration was made in the calculations of wastewater production.

The average dry weather flow (ADWF) was calculated as a sum of domestic, non domestic and additional summer flow.

Peak factors in sewerage system 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 estimated wastewater production is given in Table 3.3 for the years 2005, 2015 and 2030.

Dry weather flow varies during the day with a major peak typically occurring in the early morning. It depends of the number of the inhabitants as well as of the size of the catchment area. As the catchment areas expand, the peak value decreases due to the superposition of different dry weather flow hydrographs and flow attenuation in the network.

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 goes to 3.8, relative to average day flow.

TABLE 3.3: WASTEWATER FLOW

COMMUNITIES	2005 ANNUAL PRODUCTION IN m3/year	2005 MAXIMUM DRY WEATHER FLOW IN m3/day	2015 ANNUAL PRODUCTION IN m3/year	2015 MAXIMUM DRY WEATHER FLOW IN m3/day	2030 ANNUAL PRODUCTION IN m3/year	2030 MAXIMUM DRY WEATHER FLOW IN m3/day
Xylotymvou	174 470	569	194 545	634	231 410	754
Achna	103 381	349	124 294	422	165 835	564
Ormideia	199 655	651	217175	708	250 025	815
Avgorou	214 493	742	259 495	893	351 089	1 199
Xylofagou	251 485	820	278 860	909	329 960	1 076
Agios Georgios Acheritou	87 965	287	111 690	364	163 520	533
Liopetri	201 975	696	237 253	854	305 660	1 147
Frenaros	166 161	553	178 314	598	199 463	674
Sotira	240 455	972	299 140	1 352	404 698	1 955
Deryneia	280 110	1 064	360 693	1 435	533 065	2 209
TOTAL	**1 920 150**	**6 703**	**2 261 458**	**8 168**	**2 934 724**	**10 926**

TABLE 3.4: SEWAGE TREATMENT PLANT

SEWAGE TREATMENT PLANT	
Nominal Capacity	10 926 m^3/d
Area Required	18 000 m^2

The area requirements for the STP 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 total area of the STP will be 17 482 m^2 (1.8 ha).

3.3.2.2. 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 3.5: 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

The resulting average and peak pollutant loads presently and at medium and long term are given in Table 3.6 for BOD which is the basic design parameter for the sewage treatment plants.

TABLE 3.6: WASTEWATER POLLUTANT LOAD ESTIMATES (BOD)

COMMUNITY	2005 ANNUAL LOAD kg BOD/year	2005 PEAK DAILY LOAD kg BOD/day	2015 ANNUAL LOAD kg BOD/year	2015 PEAK DAILY LOAD kg BOD/day	2030 ANNUAL LOAD kg BOD/year	2030 PEAK DAILY LOAD kg BOD/day
Xylotymvou	104 653	341	114 621	374	132 271	431
Achna	63 178	213	74 894	254	97 344	331
Ormideia	119 646	390	128 197	418	143 087	467
Avgorou	133 043	460	157 785	543	206 410	705
Xylofagou	150 832	492	164 449	536	188 678	615
Agios Georgios Acheritou	52 750	172	65 878	215	93 559	305
Liopetri	124 990	431	148 168	533	190 576	715
Frenaros	101 022	337	106 717	358	116 517	394
Sotira	163 505	661	215 408	973	298 368	1,441
Deryneia	183 434	697	239 541	953	354 519	1,469
TOTAL	**1 197 052**	**4 193**	**1 415 658**	**5 157**	**1 821 329**	**6 873**

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 5), and the most stringent values will be applied for the design of the wastewater treatment plant. Removal of nitrogen 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. Table 3.7 outlines the proposed limit values for the treated effluent as compared with the EU and Cyprus Standards.

TABLE 3.7: SUGGESTED DISCHARGE STANDARDS FOR THE DESIGN OF THE STP

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	< 125 mg/l
SS	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 PROCESS: ACTIVATED SLUDGE PROCESS

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 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.

3.3.2.5. SLUDGE TREATMENT AND DISPOSAL

The expected sludge production for the years 2005, 2015 and 2030 is outlined in Table 3.8.

TABLE 3.8: EXPECTED SLUDGE PRODUCTION

COMMUNITY	ANNUAL DRY SOLIDS PRODUCTION, KG DS/YEAR		
	2005	2015	2030
Xylotymvou	104 653	114 621	132 271
Achna	63 178	74 894	97 344
Ormideia	119 646	128 197	143 087
Avgorou	133 043	157 785	206 410
Xylofagou	150 832	164 449	188 678
Agios Georgios	52 750	65 878	93 559
Liopetri	124 990	148 168	190 576
Frenaros	101 022	106 717	116 517
Sotira	163 505	215 408	298 368
Deryneia	183 434	239 541	354 519
Total	*1 197 053*	*1 415 658*	*1 821 329*
Total Sludge Volume at 30% DS Content	**3 990 m^3/year**	**4 719 m^3/year**	**6 071 m^3/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 the 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 sludge will be disposed in landfills, despite objectives for reuse. Disposal will take place in the Nicosia official controlled landfill site, which will incur additional costs for the transport of sludge.

Three different steps in the sludge treatment can normally be distinguished: thickening, stabilisation and dewatering. Sometime, thickening and dewatering can be combined or stabilisation 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 very 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 can not be used if biological phosphorus removal is used, since anaerobic conditions will appear in the thickener with subsequent phosphorus release as 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 although 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.

- SLUDGE STABILISATION

The purpose of the sludge stabilisation 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 stabilisation will also reduce pathogens in the sludge to some extent. The processes used are:

- anaerobic digestion
- aerobic digestion
- lime stabilisation
- thermal treatment

Anaerobic digestion: by methane fermentation is a powerful mean 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 in 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 stabilisation: it is usually employed in open-air units provided with air diffusers or surface aerators. The aerobic stabilisation 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 stabilisation are compared in the following table (from Degrémont Water Treatment Handbook):

TABLE 3.9: ADVANTAGES AND DISADVANTAGES OF AEROBIC AND ANAEROBIC STABILISATION

	AEROBIC STABILISATION	ANAEROBIC STABILISATION
Products	CO_2 H_2O NO_3^-	CH_4 CO_2 H_2O NH_4^+

	AEROBIC STABILISATION	ANAEROBIC STABILISATION
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 of filtered supernatant	30-50 mg/l	200-400 mg/l
Resistance to inhibitors	+	-
Long-term storability	-	+
Sludge filterability	-	+

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: it is principally used for 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 time 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 matter 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 3.10: DEWATERING DEVICES AND THEIR PERFORMANCES

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 needs to be renewed at intervals.

Biological filters are now being developed more and more for odour treatment. Until recently, the biological filter was consisted by 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 does 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 storm water 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.

Inlet and pre-treatment facilities as well as sludge treatment shall be enclosed in buildings and polluted air shall be treated in chemical scrubbers to reach the requirements for “sensitive environment” according to the French Design Code “Fascicule 81 – Titre II du CCTG Travaux”, as follows:

Parameter	Limit
H_2S	< 0.1 mg/Nm^3
RSH	< 0.1 mg/Nm^3
RH_3	< 5 mg/Nm^3
R-NH	< 20 mg/Nm^3

3.3.3. EMERGENCY STORAGE

An emergency storage reservoir will be constructed next to the sewage treatment plant to provide for effluent storage in case of problems in the treatment process. The reservoir will provide emergency storage for 7 days. The depth of the reservoir will be 5 m, with a resulting area requirement of 1.4 m^2/m^3/day, thus covering a total area of 15 300 m^2 (1.5 ha).

TABLE 3.11: EMERGENCY STORAGE

EMERGENCY STORAGE	
Volume required	76 500 m^3
Area Required	15 300m^2

3.3.4. LONG TERM STORAGE

Provisions must be made for the long term storage of the treated effluent, which will be a necessity during the winter months when the demand for irrigation will be low. The proposed scheme provides two alternative options for the long term storage requirements of the STP:

- STORAGE IN ACHNA DAM

  Due to the proximity of the site to the Achna Dam, the treated effluent could be stored in the Dam and subsequently be used for irrigation. The total capacity of the Dam is 6.8 MCM, while the maximum storage for the hydrological year 2003/2003 was 2.4 MCM, which is only 35% of the total capacity of the reservoir.

  Although storage of the treated effluent in the Achna Dam is the preferred solution, no final decision has yet been reached as to its adoption. The adoption of this alternative will depend on whether the treated effluent from the Nicosia sewage plant will eventually be conveyed to the Kokkinochoria area. If this is not accepted then it will be discharged into the Achna Dam, in which case this alternative would have to be abandoned as the Dam will not be able to receive any additional volumes of treated effluent.

- LONG TERM STORAGE RESERVOIR

  If storage of the treated effluent in the Achna Dam is not possible, then a long term storage reservoir will be constructed. The proposed location of the reservoir is shown in Drawing EIA-C-1 (as this was proposed by the Water Development Department). The reservoir will provide storage for 120 days and with a depth of 5 m the resulting area requirement will be 24 m^2/m^3/day. It will cover a total area of 262 220 m^2 (26.2 ha).

  The creation of a long term storage reservoir provides the base solution for the scheme.

TABLE 3.12: LONG TERM STORAGE RESERVOIR

LONG TERM STORAGE	
Volume Required	1 311 120 m^3
Area Required	270 000 m^2

3.3.5. SEWERS AND PUMPING STATIONS

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. The following criteria will be used for the design of the collection systems:

- ⇨ A minimum diameter of 200 mm
- ⇨ A minimum depth from cover to top of pipe of 1.6 mm

The estimated total length of the sewerage collection networks is given in Table 3.13.

TABLE 3.13: ESTIMATED LENGTH OF THE COLLECTION NETWORK

VILLAGE	LENGTH (M)	MIN GROUND ELEVATION (masl)	MAX GROUND ELEVATION (masl)
Xylotymvou	21025.00	48.00	71.00
Achna	16628.00	50.00	58.00
Ormideia	18553.00	8.00	45.00
Avgorou	18527.00	28.00	45.00
Xylofagou	27273.00	35.00	68.00
Agios Georgios	10526.00	11.00	41.00
Liopetri	27833.00	33.00	49.00
Frenaros	19802.00	66.00	82.00
Sotira	17894.00	5.00	84.00
Deryneia	39772.00	40.00	77.00
TOTAL	**217833.00**		

3.3.5.2. CONVEYANCE SYSTEM AND PUMPING FACILITIES

The conveyance system and the pumping facilities consist of the pipelines and pumping stations which are needed to transfer the wastewater flow from each community to the centralized treatment system.

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 sulphide, 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 is with one single treatment plant near the Achna Dam. Wastewater from Deryneia and Sotira are conveyed to Frenaros and then to Avgorou. After connection from Liopetri, Xylofagou and Agios Georgios Acheritou, the wastewater is conveyed from Avgorou to the STP. Sewage from Xylotymvou is transferred with the pipe from Ormideia and then conveyed to the STP. The layout of the scheme and the corresponding flows are presented in Drawing EIA-C-3.

The connection between Deryneia and Frenaros is partly forcemain and partly gravity sewers. Sotira is connected by gravity pipe with Frenaros. Wastewater from Frenaros is conveyed to Avgorou mainly by gravity with a short forcemain near Frenaros. The wastewater from Agios Georgios has to be pumped to Avgorou. Part of the transfer line between Liopetri and Avgorou is forcemain.

Xylofagou is connected by gravity with Avgorou. Finally, the connection of Avgorou and the pipeline from Achna to the STP are by gravity.

The main components of the conveyance system are:

- ⇨ The total length of the gravity pipes is 37.5 km with the diameter ranging between 200 mm to 700 mm.
- ⇨ The total length of the forcemains is 14.3 km with the diameter being from 100 mm to 300 mm.
- ⇨ Eleven pumping stations, with the discharge capacity varying from 6.2 l/s to 92 l/s and installed power from 4.5 kW to 20.7 kW.

The locations of the pumping station are as follows:

TABLE 3.14 : POSITION OF PUMPING STATIONS

PUMPING STATION	LOCATION	CADASTRAL MAP	PIPE	
			From	To
CP1	Xylotympou	XLI 5 W1	Xylotympou	Achna
CP2	Ormideia	XLI 22 E1	Ormideia	Achna
CP3	Achna	XXXII 63 E2	Achna	STP
CP4	Xylofagou	XLI 24 E1	Xylofagou	Avgorou
CP5	Avgorou	XXXII 56 W2	Avgorou	STP
CP6	Agios Georgios Acheritou	XXXIII 41 W1 XXXIII 33 E1	Agios Georgios	STP
CP7	Liopetri	XLII 2 W2	Liopetri	Avgorou
CP8	Sotira	XXXIII 61 W1	Sotira	Frenaros
CP9	Sotira tourist area	XLII 27 W1	Sotira tourist area	Liopetri
CP10	Deryneia	XXXIII 44 E2	Deryneia	Frenaros
CP11	Frenaros	XXXIII 50 E2	Frenaros	Avgorou

The maximum area required for each pumping station will be 500 m^2 (0.05 ha), with a maximum total area of 6 000 m^2 (0.3 ha).

Details on the pumping stations are given in Appendix 3.

3.4. IMPLEMENTATION SCHEDULE

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

3.5. PROJECT COST

TABLE 3.15: SUMMARY OF TOTAL COSTS

	COST (CYP)
Collection Networks	17 430 000

Gravity Pipelines	3 960 000
Forcemains	993 000
Pumping Stations	1 100 000
STP near Achna Dam	8 620 000
TOTAL	32 100 000

4. DESCRIPTION OF THE ENVIRONMENTAL BASELINE

4.1. DESCRIPTION OF THE COMMUNITIES

The group C communities are located in a wide area extending over 20 km from East to West and 12 km from North to South. The distance between the villages ranges from 4 to 7 kilometres. The western part of the area presents the highest elevation: Deryneia, Frenaros and Sotira lie around 70 metres asl. Agios Georgios Acheritou is located lower (elevation 30 m) on the northern fringe of this elevated area, in an area descending towards Famagusta.

Achna, Avgorou and Liopetri lie in a vast central plain at an altitude ranging around 40 and 50 metres asl. The plain is slightly descending northwards with a very moderate slope around 2 metres per kilometres. The remaining three villages of Xylotymvou, Ormideia and Xylofagou are located on the southern fringe of the plain, two to three km away from the seaside.

Much of the plain consists of rich agricultural land, with soils of very high metal oxide content, which are used for the cultivation of vegetables, and particularly potatoes. Large areas of this land are currently irrigated. There are two large dams in the area, the Achna Dam, with a capacity of $6800x10^3$ m^3 which is used for irrigation, and the Liopetri Dam, with a capacity of $340x10^3$ m^3 which is used for recharge purposes. There are no large rivers in the area, the most important river being the Liopetri River which is a fishing refugee.

There are a number of Minor State Forests in the area, particularly near the coastal villages, including the Xylofagou Forest between Xylofagou and Ormideia towards the coastline, and the Ormideia, Xylotymvou, Achna and Sotira Forests. Part of the forest near Sotira is a Main State Forest.

Although the villages in this group share the common characteristic of being closely clustered to the main tourist development area of Paralimni and Ayia Napa, they present a varying population growth profile. Although all of them show a growth path during the period 1992-2001, some have appreciably faster growth rates than others.

Sotira is the fastest growing village, followed by Deryneia Municipality, Liopetri and Avgorou, while the remaining villages present a much lower growth pattern. At a glance, the growth experienced in the villages is largely explained by their relationship to the tourism sector and their location relative to the coast. Both these factors determine the economic base of the villages and the significance of tourism activity and labour demand for their economic base. All the villages share a common agricultural production profile based on a productive export-based crop sector (mainly potatoes), yet this common characteristic plays a declining role as a source of income and population growth and the area’s spatial development.

4.2. PHYSICAL ENVIRONMENT

4.2.1. TOPOGRAPHY, GEOLOGY AND SOILS

The location of the STP is indicated on a topographic map in Drawing EIA-C-2 together with the proposed location for the long term storage reservoir. Drawing EIA-C-4 provides a geological map of the area.

4.2.1.1. GENERAL GEOLOGICAL ENVIRONMENT IN THE GROUP C REGION

A reddish silty clay top soil referred to as terra rosa forms an extensive cover over the Group C area. The consistency of this horizon is fairly uniform and the general character of the soil is silty clay and clayey silt of moderate to light plasticity. The thickness of the soil is fairly variable but it rarely exceeds one meter.

In all investigated communities the terra rosa rests on a horizon of very dense, hard secondary limestone referred to as kafkalla. This is a product of diagenesis of the underlying rocks, including calcareous sandstones, sandy marls, gravels or limestone. The thickness of the kafkalla is variable and ranges from a few centimetres up to about one meter. The occurrence of this lithological type is fairly widespread. Exploration works showed that in certain areas, e.g. Acheritou, Xylotymvou, Ormideia, and partly Deryneia, kafkalla exhibits a more patchy development than elsewhere.

Remnants of the flat Pleistocene surfaces are best exhibited at Ormideia, while the southern part of Xylotymvou and the eastern part of Deryneia are characterized by a generally thin layer consisting of gravels and sands with cobbles with a variable degree of concentration.

Shallow valleys or topographical depressions in the investigated areas are infilled with loose superficial alluvial and colluvial deposits, products of erosion of neighbouring geological formations. Their thickness does not appear to exceed about 4 meters.

The above mentioned kafkalla layer progressively changes in depth to a horizon referred to as havara, which represents a zone of enrichment in calcium carbonate, but which in contrast to kafkalla is of a lower degree of concentration. The thickness of this horizon is variable depending on the nature of the parent rock below, but it can reach 5 – 6 meters.

The bedrock in the Group C region consists predominantly of the calcareous silty sandy facies of the late Pliocene – early Pleistocene geological periods. This horizon is represented by sub-horizontal layers of siltstones and sandstone or mixtures of both exhibiting various degrees of cementation from weakly to strongly cemented. The thickness of this horizon is variable and reaches a maximum of about 80 meters. The inhomogeneity of the horizon is further complicated by the occurrence of intercalated layers of silty – sandy marl which in places outcrop or occur very close to the surface. This variability has been observed in the recent exploratory work at Avgorou, Achna and other areas.

In the areas of Sotira – Frenaros and Xylofagou older and harder geological formations represented by limestones occur in juxtaposition with the calcareous sandy – silty formations described above. This occurrence relates to the reef limestone development in Miocene along the fringes of the tectonic horsts of Paralimni Lake and Cape Pyla. The limestones are hard and massive and their thickness is of the order of 30 meters.

The horizon representing the “basement” in the whole of the investigated are is primarily the Pliocene marl which, however, does not outcrop and has no direct relation to the scope of the current investigations. The Moni melange of Upper Cretaceous age can also be considered as representing part of the basement but the only places where this horizon is of any significance to the present investigations are occurrences in the areas to the east of Sotira and south of Deryneia.

4.2.1.2. SOIL CHARACTERISTICS AND PRESENT SANITARY SITUATION IN THE REGION

Table 4.1 gives the soil characteristics for each of the concerned communities and the present sanitary conditions. The current sewerage system consists of septic tanks and absorption pits, however, the soil conditions in most of the communities are not favourable for such a sanitation system. As a result, most communities face serious absorption problems and construction of a sewage treatment plant is viewed as a necessity.

TABLE 4.1 : SOIL CHARACTERISTICS AND PRESENT SANITARY CONDITIONS IN THE FAMAGUSTA COMMUNITIES

COMMUNITIES	SOIL CHARACTERISTICS	PRESENT SANITATION SITUATION
Xylotymvou	Silt with send and gravel layers (limited	Absorption problem : 50 to 60 %

COMMUNITIES	SOIL CHARACTERISTICS	PRESENT SANITATION SITUATION
	permeability)	of the houses empty their absorption pit every month
Achna	Fine red soil over kafkalla layer underlain by siltstone and sandstone layers followed at 40-50m by marl (limited permeability)	Absorption problem
Ormideia	Fine kafkalla over poorly cemented layers of sand, silt and some gravels followed at 7m depth by marl formation (moderate to limited permeability)	Absorption problem : 40 % of the houses empty their absorption pit every month, 60 % every 6 months
Avgorou	Red soil covers over dense kafkalla layer followed by silty havara. Bellow 2-3m continuous presence of impervious marl (very limited permeability)	Absorption problem (centre, housing estates) : overflowing of absorption pits creating health and environmental hazards
Xylofagou	Up to 1m of red soil over dense kafkalla layer extending down to 2m depth below a sequence of well cemented sandstone down to 60m depth. (low permeability)	Absorption problem: overflowing of absorption pits creating health and environmental hazards
Agios Georgios Acheritou	Thin soil over patchy kafkalla, followed by succession sandy and silty layers down to 50m where marly horizon is encountered (moderate to low permeability)	Small absorption problem : 3 to 4 absorption pits emptied every month
Liopetri	Red soils 0.5m over hard kafkalla layer down to 1.5m resting on moderate to well cemented calcareous sandstones in places marly. Marly basement at 8.5m depth. (moderate permeability)	Absorption problem: the absorption pits need to be very deep.
Frenaros	Up to 0.8m red soil over 2m thick kafkalla/havara, over up to 40m of limestone and calcareous limestone. Bellow marly basement. (low to moderate permeability)	Absorption problem : overflowing of pits creating health and environmental hazards
Sotira	Thin top soil over patchy kafkalla layer. Below there is a limestone sequence up to 8m thick, resting on clays. Permeability in limestone moderate to good while clay is impervious. Sotira coastal area – Thin soil over kafkalla and havara down to 1m followed by the moderate to well cemented sandstones and siltstones. Bellow 15m limestone (permeability moderate to low)	No problem of absorption
Deryneia	Thin top soil over kafkalla of variable thickness up to 0.5m. Bellow kafkalla a 20m limestone of moderate permeability sandstone layer thinning out to the South-East. Basement is impermeable clay.	Absorption problem : overflowing of pits creating health and environmental hazards

The need for a sewage treatment system is also supported by the high nitrate concentrations in the soils of the region, largely the result of agricultural practices.

The investigated area was studied by the Geological Survey Department in 2001 – 2002, together with other aquifers of Cyprus for the nitrate concentration of its groundwater and with the purpose of designating Nitrate Vulnerable Zones (NVZ) as required by the EC Nitrate Directive 91/676/EEC (Study of the Pollution of Waters Caused by Nitrates from Agricultural Sources According to the Directive 91/676/EEC, Contract No. GSD/11/2000). Determinations of nitrates in the groundwater prior to 2001 had shown concentrations in excess of 50mg/l NO_3 both along the coast and inland. Nitrate levels of less than 25mg/l NO_3 had been found in only a few locations.

During the 2001 – 2002 nitrate study, sampling at a smaller number of stations confirmed the results of previous sampling campaigns. It was not easy though to provide a precise delineation of polluted and not polluted groundwaters. The application of fertilizers over long periods has been considered to have led to the accumulation of nitrate in the soil, which could cause further degradation of water quality in the future. It was at present considered to designate the South-eastern Mesaoria Aquifer, which includes the investigated area, as a Nitrate Vulnerable Zone (groundwater contains more than 50mg/l NO_3 or could contain more than 50mg/l NO_3 if action is not taken). This should ensure that additional nitrate inputs would be minimized, which should gradually result in an improvement of water quality.

The situation regarding nitrate concentration in the soils of the area emphasizes the need for nitrogen removal from the treated effluent.

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.

4.2.2.2. TEMPERATURE

The average annual temperature for the Achna region was approximately 19.2 ^oC for the period 1981 – 1990, and 19.9 ^oC for 1991 – 2000. Mean monthly temperatures were in the range of 10.1 ^oC, in January, and 27.85 ^{o}, in August, for 1981 – 1990; and 10.7 ^{o} to 28.8 ^oC for the same months during the period 1991 – 2000. The maximum mean monthly temperature was approximately 38 ^oC for both periods (August), with the minimum mean monthly temperature being just above 1 ^oC (January).

Average temperatures for the period 1981 – 2000 are as follows:

Mean annual temperature	19.5 ^oC
Mean annual maximum temperature	30 ^oC
Mean annual minimum temperature	9 ^oC
Mean monthly temperature	10.4 ^oC (January) – 28.3 ^oC (August)
Mean monthly maximum temperature	19.6 ^oC (January) – 38.1 ^oC (July and August)
Mean monthly minimum temperature	1.2 ^oC (January) – 18.6 ^oC (August)

4.2.2.2. PRECIPITATION

The mean annual precipitation in the Achna region for the period 1991 – 2000 was 312.1 mm, with normal precipitation (1961 – 1990) being 329.5 mm. The average monthly precipitation ranged between 0 mm (August) to 77.1 mm (December), while the normal average monthly precipitation is in the range of 0 mm (August) to 83.8 mm (December).

Average precipitation values for the Achna region are as follows:

1991 – 2000	Mean monthly precipitation	0 – 77.1 mm
	Mean annual precipitation	0 – 83.8 mm
1961 – 1990	Normal monthly precipitation	312.1 mm
	Normal annual precipitation	329.5 mm

4.2.2.2. EVAPORATION

The mean daily evaporation for the period 1991 – 2000 was between 1.1 mm (December) and 8.5 mm (July), with the average being 4.6 mm.

Average values for the Achna region during the period 1991 – 2000 are as follows:

Mean daily evaporation	1.1 – 8.5 mm
Annual mean daily evaporation	4.6 mm

4.2.2.3. RELATIVE HUMIDITY (RH)

The mean annual RH (at 08:00 hrs LST) during the period 1981 – 1990 was 67% for the Achna area, while for 1991 – 2000 it was 68%. Monthly averages were between 56% (May and June) and 80% (January and February) during 1981 – 1990, and between 59% (June) and 82% (December) for 1991 – 2000.

For RH at 13:00 hrs LST, the annual average for the period 1981 – 1990 was 52%, with monthly means ranging between 46% (October) to 60% (January). No data is available for the period 1991 – 2000.

Average values for Relative Humidity in the Achna area are as follows:

1981 – 2000	Mean RH at 08:00 hrs LST	57.5% - 80.5%
	Mean annual RH at 08:00 hrs LST	67.5%
1981 – 1990	Mean RH at 13:00 hrs LST	46% - 60%
	Mean annual RH at 13:00 hrs LST	52%

4.2.2.4. WIND SPEED

- ANEMOGRAPH, HEIGHT: 7M

  The average annual wind speed for the Achna region, during the period 1982 – 1992, was 3 m/s, with monthly averages being in the range of 2.7 m/s (November and December) to 3.4 m/s (July).

- ANEMOMETRE, HEIGHT: 2M

  The mean annual wind speed, measured at a height of 2m, for the period 1982 – 1992 was 1.4 m/s, with monthly averages between 1.3 m/s (November and December) and 1.5 m/s (March, June and August).

4.2.2.5. WIND DIRECTION

Between September and May the prevailing winds in the Achna region have a northwest direction, with angles between 300^o – 330^o. South to southwest winds also have a relatively high percentage of occurrence, except during the months of November and December, as do north winds in the months between November to January.

During the period between June to August the prevailing winds have a south direction, with angles of 180^o. There is also a high percentage of southwest and some northwest winds.

Climatic data for the Achna region are given analytical in Appendix 5.

4.2.3. SURFACE WATER RESOURCES

4.2.3.1. EXISTING RESERVOIRS

The proposed STP site is to the northeast of the Achna Dam, at a distance of approximately 300 m. The Achna Dam was constructed in 1987 as part of the Southern Conveyor Project. It serves as a terminal reservoir for the storage of the water that is conveyed from the Kouris Dam to the Kokkinochoria region, and which is used primarily for irrigation purposes. The Dam has a capacity of 6.8 MCM. More analytically, the design parameters of the Dam are as follows:

Type	Earthfill
River	Off-stream
Height above lowest formation	23 m
Length of crest	272 m
Volume	220 x 10^3 m^3
Reservoir area	1250 x 10^3 m^2
Spillway discharge	35 m^3/s

The maximum storage for the hydrological year 2002/2003 was 2.4 MCM, which is 35% of the total storage capacity of the Dam. As the Dam is off-stream there is no inflow, with water being supplied by the southern conveyor from the Kouris Dam. As the maximum storage in the Dam is very low compared to the total capacity available, it is possible to accommodate the additional flow of treated effluent from the sewage treatment plant. However, a study is required to assess whether the available capacity can accommodate both the effluents from the Famagusta and the Nicosia STPs, in case it is decided to transfer the Nicosia treated effluents to the Achna Dam.

TABLE 4.2 : STORAGE DATA FOR ACHNA DAM

	MCM	PERCENTAGE OF TOTAL CAPACITY
Maximum storage for 2000	0.082	1.2%
Maximum storage for 2002/2003	2.4	35.0%
Total flow since 1/10/2000	0.00	0.0%
Total flow since 1/10/2002	0.00	0.0%
Storage on 27/4/2000	0.065	1.0%
Storage on 27/4/2001	0.05	0.7%
Storage on 4/8/2002	0.998	14.7%
Storage on 4/8/2003	2.35*	34.6%
Storage on 25/8/2002	0.884	13.0%
Storage on 25/8/2003	2.33*	34.3%

*the increase in storage is not inflow but water transfer from the southern conveyor

4.2.3.2. NATURAL CHANNEL FOR TEMPORARY STREAM

To the northeast of the site, at a distance of approximately 900 m, there is a natural stream, with a north flow towards the occupied areas. This can be used temporarily for the release of the treated effluent in case of an emergency. The location of the stream is given in Drawing EIA-C-2.

4.2.4. GROUND WATER RESOURCES

The area under consideration is mainly covered by Pliocene-Pleistocene-Recent sediments consisting of a lower marly section and an upper sandy one. The upper sandy section comprises several rock types changing laterally by interfingering or forming more or less extensive lenses. The rock types are: calcareous sands and sandstones, fluviatile gravel lumachelle, grey sandy marls, brown clay, sand dunes and beach rocks, capped by an extensive layer of kafkalla (hard pan) and havara. The materials are more or less consolidated, bound by secondary calcite. The thickness of the sandy section varies from 0m to 80m. Limestones of Miocene age also outcrop over certain parts of the area under consideration. These have developed over the fringes of the horst structures of Cape Pyla and Paralimni and are observed in the areas of Xylofagou, Sotira and Dherynia.

The sandy aquifer is the most important aquifer of the region and corresponds to the upper sandy section of the Plio-Pleistocene sequence. Since there is no impervious layer on the top, the aquifer is phreatic. The thickness of the aquifer, measured from the ground surface, is shown on the map of Fig. 5 (from 2nd Report on the Hydrogeology of South-Eastern Mesaoria. The aquifer is absent on the Paralimni horst and very thin or absent to the south of Avgorou. In the Sotira, Dherynia and Frenaros areas it is shown to have a thickness of 0 – 10m. However, from a study of the borehole and other information during the present work it is evident that the aquifer is somewhat thicker than originally indicated (the aquifer thickness is measured from the surface and includes both the saturated zone and the permeable unsaturated horizon above it). At Dherynia the thickness is zero in the southeast on the margin of Paralimni Lake and increases to the north and west to about 20m. At Sotira the thickness is again zero in the east at Paralimni Lake and increases to over 20cm about one km to the west of the village. In between the thickness varies from 3m to 12m. At Frenaros the thickness of the permeable layers of limestone and calcareous sandstone exceeds 40m especially in the west and south. However, to the Northeast of the village bentonitic clay is reported in certain boreholes below a 4m thick limestone. Elsewhere the total thickness of permeable layers is shown to be in excess of 10m attaining its maximum thickness of about 80m in the Ormideia – Liopetri – Four Mile Camp area.

The water table map of the area for December 2002 shows that water levels are below mean sea-level in the central and southern part of the area. The permeability of the aquifer according to information provided by the Water Development Department (fig. 5.4 of the Kokkinochoria Aquifer report) varies mainly between 0m/d and 8m/d (0 – $9.3x10^{-5}$ m/s) although some higher values are obtained in the Xylofagou area. The specific yield of the aquifer varies mainly between 0.1% and 10%.

Over the past years, the groundwater aquifers in the region have been excessively pumped, particularly during periods of drought, to satisfy mainly the water demand for irrigation, as well as domestic water demand. This has led to a severe diminishment of underground water resources.

4.3. ECOLOGICAL ENVIRONMENT

4.3.1. VEGETATION

The site of the STP and the area proposed for the construction of the long term reservoir are mainly used as agricultural land for the cultivation of temporary crops, including cereals and fodder. There are also two expanses planted with olive trees, one next to the STP site to the northeast, and the other within the proposed reservoir.

4.3.2. WILDLIFE

Typical of wetland ecosystems, the Achna reservoir is characterized by a rich diversity of bird species. Each year it provides shelter for a wide number of migratory birds (Table 4.3) on passage, as well as summer or winter visitors, while also attracting several resident and endemic species (Table 4.4). For many of these species the reservoir offers suitable breeding grounds. Some rare bird species have also been recorded, but only on passage (Table 4.5).

TABLE 4.3: LIST OF MIGRATORY BIRD SPECIES REPORTED AT ACHNA DAM

	COMMON NAME	SCIENTIFIC NAME	STATUS
1.	Little Bittern	*Ixobrychus minutus*	Passage Migrant
2.	Squacco Herron	*Ardeola ralloides*	Passage Migrant
3.	Cattle Egret	*Bubulcus ibis*	Passage Migrant
4.	Little Egret	*Egretta garzetta*	Passage Migrant
5.	Grey Heron	*Ardea cinerea*	Passage Migrant, Winter Visitor
6.	Purple Heron	*Ardea purpurea*	Passage Migrant
7.	Glossy Ibis	*Plegadis falcinellus*	Passage Migrant
8.	Common Teal	*Anas crecca*	Passage Migrant, Winter Visitor
9.	Mallard	*Anas platyrhynchos*	Passage Migrant, Winter Visitor
10.	Garganey	*Anas querquedula*	Passage Migrant
11.	Northern Shoveler	*Anas clupeata*	Passage Migrant, Winter Visitor
12.	Ferruginous Duck	*Aythya nyroca*	Winter Visitor
13.	White-headed Duck	*Oxyura leucocephala*	Passage Migrant
14.	Pallid Harrier	*Circus macrourus*	Passage Migrant
15.	Montagu's Harrier	*Circus pigargus*	Passage Migrant
16.	Red-footed Falcon	*Falco vespertinus*	Passage Migrant
17.	Northern Hobby	*Falco subbuteo*	Passage Migrant
18.	Little Crake	*Porzana parva*	Passage Migrant
19.	Baillon's Crake	*Porzana pusilla*	Passage Migrant
20.	Eurasian Coot	*Fulica atra*	Passage Migrant, Winter Visitor, Breeds
21.	Black-winged Stilt	*Himantopus himantopus*	Passage Migrant, Summer Visitor, Breeds
22.	Little Stint	*Calidris minuta*	Passage Migrant
23.	Stone Curlew	*Burhinus oedicnemus*	Passage Migrant, Breeds
24.	Black-winged Pratincole	*Glareola nordmanni*	Passage Migrant
25.	Little Ringed Plover	*Charadrius dubius*	Passage Migrant
26.	Ringed Plover	*Charadrius hiaticula*	Passage Migrant
27.	Spur-winged Plover	*Vanellus spinosus*	Passage Migrant
28.	Curlew Sandpiper	*Calidris ferruginea*	Passage Migrant
29.	Great Snipe	*Gallinago media*	Passage Migrant
30.	Marsh Sandpiper	*Tringa stagnatilis*	Passage Migrant

	COMMON NAME	SCIENTIFIC NAME	STATUS
31.	Greenshank	*Tringa nebularia*	Passage Migrant
32.	Green Sandpiper	*Tringa ochropus*	Passage Migrant
33.	Wood Sandpiper	*Tringa glareola*	Passage Migrant
34.	Common Sandpiper	*Actitis hypoleucos*	Passage Migrant
35.	Slender-billed Gull	*Larus genei*	Passage Migrant
36.	Little Tern	*Sterna albifrons*	Passage Migrant
37.	White-winged Black Tern	*Chlidonias leucopterus*	Passage Migrant
38.	Common Swift	*Apus apus*	Summer visitor
39.	Common Kingfisher	*Alcedo atthis*	Passage Migrant, Winter visitor
40.	Barn Swallow	*Hirundo rustica*	Passage Migrant
41.	House Martin	*Delichon urbica*	Passage Migrant
42.	Pied (White) Wagtail	*Motacilla alba*	Passage Migrant, Breeds (irregularly)
43.	Whinchat	*Saxicola rubetra*	Passage Migrant
44.	Cyprus Pied Wheatear	*Oenanthe cypriana*	Summer visitor
45.	Reed Warbler	*Acrocephalus scirpaceus*	Summer visitor
46.	Eastern Olivaceous Warbler	*Hippolais pallida*	Summer visitor, Breeds
47.	Spectacled Warbler	*Sylvia conspicillata*	Summer visitor, Breeds
48.	Cyprus Warbler	*Sylvia melanothorax*	Summer visitor
49.	Willow Warbler	*Phylloscopus trochilus*	Passage Migrant
50.	Spotted Flycatcher	*Musciapa striata*	Passage Migrant, Breeds
51.	Masked Shrike	*Lanius nubicus*	Passage Migrant, Breeds

TABLE 4.4: LIST OF RESIDENT BIRD SPECIES REPORTED AT ACHNA DAM

	COMMON NAME	SCIENTIFIC NAME	STATUS
1.	Common Kestrel	*Falco tinnunculus*	Resident
2.	Chukar Partridge	*Alectoris chukar*	Resident
3.	Moorhen	*Gallinule chloropus*	Resident, Breeds
4.	Woodpigeon	*Columba palumbus*	Resident
5.	Calandra Lark	*Melanocorypha calandra*	Resident, Breeds
6.	Crested Lark	*Galerida cristata*	Resident, Breeds
7.	Cetti’s Warbler	*Cettia cetti*	Resident
8.	Fan-tailed Warbler	*Cisticola juncidis*	Resident, Breeds
9.	Linnet	*Carduelis cannabina*	Resident
10.	Corn Bunting	*Emberiza calandra*	Resident, Breeds

TABLE 4.5: LIST OF RARE BIRD SPECIES REPORTED AT ACHNA DAM

	COMMON NAME	SCIENTIFIC NAME	STATUS
1.	White Pelican*	*Pelecanus onocrotalus*	Very rare, Passage Migrants
2.	Citrine Wagtail*	*Motacilla citreola*	Passage Migrant
3.	Dusky Thrush*	*Turdus (naumanni) eunomus*	Vagrant
4.	Isabelline Shrike*	*Lanius isabellinus*	Vagrant

4.3.3. PROTECTED OR RESTRICTED AREAS

4.3.3.1. PROTECTION ZONES

The Achna Dam and the surrounding area to the southwest of the STP site are a designated Z3 Protection Zone and a Protected Landscape site. Areas designated as Protection Zones include archaeological sites, sites of natural beauty, forests, protected landscapes, geological formations, rivers, good agricultural land, drinking water supply borehole areas, etc. As in the case of Achna Dam, all Dams are designated as Z3 Protection Zones. For the Famagusta District, protection zones are classified as Z1, Z2 or Z3, with the associated construction provisions being most restrictive for Z3 zones. Although no other restrictions apply, the requirements imposed for these zones, and in particular Z3 sites, generally discourage development. In the case of Z3 zones the following construction parameters are applicable:

Maximum Construction Coefficient	0.01 : 1
Maximum Number of Floors	1
Maximum Height	5.0 m
Maximum Percentage of Land Coverage	0.01 : 1

The 1% land coverage that is permitted for these sites significantly increases the land requirements for a construction, thus diverting development away from such sites.

4.3.3.2. GAME RESERVES

The Achna Dam and the surrounding areas, including the STP site, are a Permanent Game Reserve.

Two categories of game reserves, where no hunting is permitted, are used to ensure the effective protection of habitats. Certain habitats, including all wetlands, like the Achna Dam, and significant migration corridors, have been designated as Permanent Game Reserves. Additionally, some reserves are specifically designated for the conservation of certain species.

The second category of reserves is the Game Reserve Areas which act as reservoirs allowing wild-bred fauna to disperse into neighbouring areas thus ensuring the sustainability of the species stock. During the hunting of migratory species additional areas are designated for the protection of corridors and passage migrants.

4.3.3.3. SOVEREIGN BASE AREA

The main road next to the site is within the Sovereign Base Area, which borders the occupied areas lying to the north of the STP site.

Drawing EIA-C-7 shows the SBA areas in the vicinity of the site, as well as the Z1 and Z3 Protected Zones.

4.4. PLANNING ZONES AND LAND USE

4.4.1. ADMINISTRATIVE BOUNDARIES

The STP site is located within the administrative area of Achna, to the far northeast side, next to the border between the Achna and the Avgorou communities. The Achna community covers a total area of approximately 37.90 square kilometres. The administrative boundaries and the location of the STP site are given in Drawing EIA-C-5.

4.4.2. URBAN PLANNING ZONING

The STP site is within a G2 Agricultural Zone. The following provisions apply for constructions within this zone:

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

The planning zones for the Achna and Avgorou communities are given in Drawing EIA-C-6.

4.4.3. LOCAL FACILITIES

The STP site is at a distance of approximately 350 m from the nearest main road, which is a single lane road that provides access to the Achna Dam. The main road, also a single lane one, which is within the Sovereign Base Area and borders the occupied areas, is at a distance of 1.2 km from the STP site and 350 m from the proposed site for the long term storage reservoir. A track road passes through the STP site, giving access to the site from the asphalt road of the Dam.

The STP site is approximately 1 km from the nearest electricity transmission line (11 kV). The pumping station for the Achna Dam is next to the STP site towards the side of the Dam, at a distance of 250 m. To the northeast of the STP site there is an irrigation pump.

4.4.4. LAND OWNERSHIP

The land where the STP and the emergency and long term storage reservoirs will be constructed is private land. The exact locations for the pumping stations will be determined after the detailed design of the sewage system.

4.4.5. LAND USE

The site of the STP and the long term storage reservoir is agricultural land. The pumping stations will be constructed within the urban areas, with the exception of the one in Frenaros which is within an agricultural area.

4.4.6. BUILT UP PROPERTIES

The only built up property which might be affected is a house which is within the area that will potentially be used for the construction of the long term storage reservoir, provided that the storage of the treated effluent in the Achna Dam is not possible. In such a case full compensation or relocation will be necessary.

4.5. SOCIO-ECONOMIC PROFILE

4.5.1. POPULATION DISTRIBUTION

4.5.1.1. POPULATION PROFILE

A summary of the population figures for the communities, according to the 2001 Census of Population, is given in Table 4.6.

TABLE 4.6 : POPULATION FIGURES

COMMUNITY	HOUSING UNITS			HOUSEHOLDS		INSTITUTIONS		TOTAL POPULATION
	Total	Used as Usual Residence	Vacant or Temporary Residence	Number	Population	Number	Population	
Achna	764	630	134	631	1 952			1 952
Avgorou	1 291	1 111	180	1 111	3 985	2	17	4 002
Xylofagou	1 615	1 464	151	1 464	4 957			4 957
Xylotymvou	1 104	1 028	76	1 030	3 434	1	4	3 438
Ormideia	1 346	1 196	150	1 200	3 960			3 960
Frenaros	1 046	994	52	994	3 305			3 305
Sotira	1 393	1 167	226	1 167	4 258			4 258
Deryneia	1 847	1 568	279	1 570	4 950	1	4	4 954
Agios Georgios	593	531	62	532	1 646			1 646
Liopetri	1 179	1 085	94	1 085	3 832	1	5	3 837

TABLE 4.7: DISTRIBUTION OF POPULATION IN THE FAMAGUSTA DISTRICT

	1992 (CENSUS)	1995	1996	1997	1998	1999	2000	2001 (CENSUS)
Population in urban areas	–	–	–	–	–	–	–	–
Population in rural areas	31 513	34 400	35 100	35 800	36 500	37 100	37 800	38 371
Households	9 151	10 000	10 300	10 600	10 900	11 200	11 500	11 814

4.5.1.2. POPULATION PROJECTIONS

TABLE 4.8 : POPULATION PROJECTIONS

VILLAGE	2001	2005	2010	2015	2020	2025	2030
Xylotymvou	3438	3569	3739	3918	4105	4301	4506
Achna	1952	2088	2273	2473	2691	2928	3186
Ormideia	3960	4075	4224	4378	4537	4702	4874
Avgorou	4002	4300	4704	5146	5629	6158	6736
Xylofagou	4957	5138	5375	5622	5880	6151	6433
Agios Georgios	1642	1799	2017	2261	2535	2841	3185
Liopetri	3837	4048	4329	4628	4949	5292	5658
Frenaros	3305	3374	3463	3553	3647	3742	3840
Sotira	4258	4527	4888	5277	5697	6151	6641
Deryneia	4954	5417	6057	6772	7572	8466	9466
TOTAL	**36305**	**38335**	**41069**	**44028**	**47242**	**50732**	**54525**

TABLE 4.9 : PROJECTED NUMBER OF HOUSES

MAJOR GRAWTH FACTOR	COMMUNITY	ANNUAL GROWTH RATE (1992 – 2001)	FUTURE GROWTH RATE	COMMENTS
Urbanisation	Avgorou	1.1%	Variable	Cyprus problem
	Achna	1.0%	Variable	Cyprus problem
Tourism	Sotira	1.8%	1.5%	Reduced growth
	Deryneia	1.7%	Variable	Cyprus problem
Local growth	Liopetri	1.4%	1.4%	Current growth rate
	Frenaros	0.5%	0.5%	Current growth rate
	Vrysoulles	0.0%	Variable	Cyprus problem
	Ormideia	0.7%	0.7%	Current growth rate
	Xylofagou	0.9%	0.9%	Current growth rate
	Xylotymvou	0.9%	0.9%	Current growth rate

4.5.2. SOCIO-ECONOMIC INDICATORS

4.5.2.1. AGRICULTURAL LAND IN THE KOKKINOCHORIA REGION

The only data available regarding the agricultural land in the region comes from the 1994 Census of Population, and particularly in the case of the areas reported as irrigated or non-irrigated agricultural land the information is considered to be outdated as a result of the considerable extension of the Kokkinochoria Irrigation Scheme, which now covers an area of approximately 9 270 hectares. Detailed information from the Census is given in Appendix 7.

According to the Census, for the Kokkinochoria region, which includes the villages of Achna, Avgorou, Liopetri, Sotira, Frenaros, Xylofagou, Xylotymvou, Ormideia and Agios Georgios Acheritou, the total agricultural area in 1994 was reported as follows:

Number of holdings (agricultural land)	2 877
Number of plots	11 030
Total cultivated area (donums)	84 055
Total area (donums)	88 032

TABLE 4.10: LAND USE IN THE KOKKINOCHORIA REGION (1994)

	TOTAL AREA (DONUMS)	PERCENTAGE OF TOTAL AGRICULTURAL LAND
Temporary crops	77 397	87.9 %
Permanent crops	4 782	5.4 %
Fallow land	1 873	2.1 %
Grazing land	90	0.1 %
Forest land	474	0.5 %
Uncultivated land	2 503	2.8 %
Scrub land	909	1.0 %
TOTAL AGRICULTURAL LAND	**88 032**	**100.0 %**

TABLE 4.11: AREA OF TEMPORARY CROPS IN THE KOKKINOCHORIA REGION (1994)

TEMPORARY CROPS	TOTAL AREA (DONUMS)	PERCENTAGE OF TOTAL AREA OF TEMPORARY CROPS
Cereals	40 808	49.0 %
Pulses	583	0.7 %
Industrial crops	150	0.18 %
Aromatic plants	1	0.001%
Fodder crops for grain	2	0.002 %
Green fodder for grazing	3035	3.6 %
Green fodder for hay	3057	3.7 %
Vegetables (including potatoes)	35 639	42.8 %
TOTAL	**83 275**	**100.0 %**

TABLE 4.12: AREA OF PERMANENT CROPS IN THE KOKKINOCHORIA REGION (1994)

CROPS	TOTAL AREA (DONUMS)	PERCENTAGE OF TOTAL AREA OF PERMANENT CROPS
Table grapes	18	0.4 %
Wine grapes	0	0.0 %
Citrus	3 459	72.4 %
Dry nuts	40	0.8 %
Fruits	518	10.8 %

CROPS	TOTAL AREA (DONUMS)	PERCENTAGE OF TOTAL AREA OF PERMANENT CROPS
Olives	678	14.2 %
Carobs	66	1.4 %
TOTAL	**4 779**	**100.0 %**

Most of the agricultural land in the region is cultivated with temporary crops, and mainly cereals. In terms of treated effluent reuse, all temporary crops, with the exception of vegetables, and permanent crops can be irrigated. Approximately 43 % of the agricultural land in the region is cultivated with vegetables, including potatoes. With the exception of potatoes, it is recommended that vegetables are not irrigated with treated effluent, particularly in the case of those vegetables eaten raw, so as to avoid any risk of health hazards . The suggested effluent standards allow for the irrigation of all other temporary and permanent crops.

4.5.2.2. AGRICULTURAL LAND BY VILLAGE

TABLE 4.13: AGRICULTURAL LAND BY VILLAGE (1994)

VILLAGE	TOTAL AREA (DONUMS)
	Total
Achna	7 660
Avgorou	14 674
Agios Georgios	3 470
Deryneia	6 009
Liopetri	8 960
Sotira	9 971
Frenaros	9 926
Xylotymvou	9 362
Xylofagou	15 688
Ormideia	9 130
TOTAL	**94 850**

TABLE 4.14: AGRICULTURAL LAND USE BY VILLAGE (1994)

VILLAGE	TEMPORARY CROPS		PERMANENT CROPS		FALLOW LAND		UNCULTIVATED FOREST AND SCRUB LAND	
	Donums	%	Donums	%	Donums	%	Donums	%
Achna	6 956	**90.8 %**	493	**6.4 %**	39	**0.5 %**	172	**2.2 %**
Avgorou	12 965	**88.3 %**	1 057	**7.2 %**	229	**1.6 %**	424	**2.9 %**
Agios Georgios	2 600	**74.9 %**	710	**20.5 %**	9	**0.3 %**	152	**4.4 %**
Deryneia	5 126	**85.3 %**	458	**7.6 %**	75	**1.2 %**	351	**5.8 %**
Liopetri	7 166	**80.0 %**	364	**4.1 %**	294	**3.3 %**	1 137	**12.7 %**
Sotira	8 580	**86.0 %**	236	**2.4 %**	405	**4.1 %**	753	**7.5 %**
Frenaros	8 146	**82.1 %**	942	**9.5 %**	351	**3.5 %**	487	**4.9 %**

VILLAGE	TEMPORARY CROPS		PERMANENT CROPS		FALLOW LAND		UNCULTIVATED FOREST AND SCRUB LAND	
	Donums	%	Donums	%	Donums	%	Donums	%
Xylotymvou	8 896	**95.0 %**	247	**2.6 %**	63	**0.7 %**	157	**1.7 %**
Xylofagou	14 213	**90.6 %**	299	**1.9 %**	156	**1.0 %**	1 019	**6.5 %**
Ormideia	6 758	**74.0 %**	1 027	**11.3 %**	610	**6.7 %**	733	**8.0 %**

TABLE 4.15: AREA OF TEMPORARY CROPS BY VILLAGE (1994), % OF TOTAL AGRICULTURAL LAND IN VILLAGE

VILLAGE	CEREALS (DONUMS)	PULSES (DONUMS)	INDUSTRIAL (DONUMS)	FODDERS (DONUMS)	POTATOES (DONUMS)	VEGETABLES (DONUMS)
Achna	60.2 %	0.1 %	10.0 %	28.3 %	1.4 %	0.0 %
Avgorou	48.7 %	0.8 %	5.0 %	44.2 %	1.4 %	0.0 %
Agios Georgios	75.4 %	0.0 %	17.5 %	3.7 %	3.1 %	0.2 %
Deryneia	71.4 %	2.5 %	6.1 %	6.7 %	13.3 %	0.0 %
Liopetri	32.7 %	0.6 %	4.4 %	52.9 %	9.4 %	0.0 %
Sotira	32.1 %	3.0 %	2.2 %	53.4 %	9.4 %	0.0 %
Frenaros	58.6 %	0.5 %	7.4 %	31.4 %	2.1 %	0.0 %
Xylotymvou	83.7 %	0.0 %	0.0 %	9.0 %	6.5 %	0.7 %
Xylofagou	34.7 %	0.2 %	0.0 %	8.9 %	51.9 %	4.2 %
Ormideia	37.5 %	0.5 %	0.0 %	7.7 %	46.9 %	7.4 %
	Main crop cultivated			Second most widely cultivated crop		

According to recent data (WDD), the total irrigated area within the Kokkinochoria Irrigation Scheme is approximately 69 300 donums (9 270 hectares). Assuming the total agricultural area has not changed significantly since the 1994 Census, then about 80 % of the total land in the region is connected to the current irrigation network, with water being supplied from the Kouris Dam, as part of the Southern Conveyor Project.

If the treated effluent is stored in the Achna Dam, then it can be used for the irrigation of these areas connected to the current network. In the case when the treated effluent is stored separately in a long term storage reservoir, then it can be used for the irrigation of the areas outside the scheme (EIA – C – 11: Agricultural Land in the STP Region).

4.5.2.3. UNIT CROP IRRIGATION WATER DEMAND

TABLE 4.16: UNIT CROP IRRIGATION WATER DEMAND BY VILLAGE (m^3/DONUM/YEAR, 2001)

CROPS	ACHNA m^3/donum/year	AVGOROU m^3/donum/year	AGIOS GEORGIOS m^3/donum/year	SOTIRA m^3/donum/year	LIOPETRI m^3/donum/year	XYLOFAGOU m^3/donum/year
Permanent Crops						
Citrus	1003	936	936	1070	936	1003
Deciduous	1070	936	870	1070	936	1003
Olives	629	535	535	629	535	602

CROPS	ACHNA m³/donum/year	AVGOROU m³/donum/year	AGIOS GEORGIOS m³/donum/year	SOTIRA m³/donum/year	LIOPETRI m³/donum/year	XYLOFAGOU m³/donum/year
Table grapes	355	308	334	334	361	308
Fodders	1605	1538	1405	1472	1472	1538
Almonds	736	602	535	736	602	669
Annual Crops						
Tomatoes GH[1]	1204	1137	1003	1070	1070	1137
Cucumbers GH	1204	1137	1003	1070	1070	1137
Beans GH	870	803	669	736	736	803
Peppers GH	1204	1137	1003	1070	1070	1137
Melons GH	870	803	669	736	736	803
Strawberries GH	1003	936	803	870	870	936
Flowers GH	1338	1271	1137	1204	1204	1271
Potatoes	468	401	268	334	334	401
Tomatoes OF[2]	870	803	669	736	736	803
Cucumber OF	870	803	669	736	736	803
Beans OF	870	803	669	736	736	803
Squash	535	468	334	401	401	468
Onions	669	602	468	535	535	602
Peppers OF	870	803	669	736	736	803
Groundnuts	803	736	602	669	669	736
Cabbage	669	602	468	535	535	602
Parsley	1070	1003	870	936	936	1003
Carnation	1271	1204	1070	1137	1137	1204
Artichoke	1003	936	803	870	870	936
Kolokasse	2809	2729	2569	2649	2649	2729
Spices	535	468	334	401	401	468
Carrots	642	589	482	535	535	589
Beets	401	334	201	268	268	334
Watermelon	669	602	468	535	535	602
Broad beans	201	134	–	67	67	134

4.5.2.4. LIVESTOCK PRODUCTION

TABLE 4.17: LIVESTOCK NUMBERS BY VILLAGE (1994)

VILLAGE	SHEEP	GOATS	CATTLE	PIGS	CHICKEN
Achna	2 827	1 110	3 399	1 047	2 212
Avgorou	3 338	1 047	1 027	2 436	23 528
Agios Georgios	4 211	431	257	2 801	1 823
Deryneia	2 441	889	335	119	32 970
Liopetri	1 744	468	30	46	2 408
Sotira	3 929	1 494	120	22	4 649
Frenaros	3 301	731	0	2 086	1 928
Xylotymvou	2 708	905	3 847	1 338	51 107
Xylofagou	4 817	1 363	24	52	4 338
Ormideia	4 226	1 034	731	1 410	1 847
TOTAL	**33542**	**9472**	**9770**	**11357**	**126810**

4.5.2.5. EMPLOYMENT

TABLE 4.18: EMPLOYMENT IN THE BROAD AGRICULTURAL SECTOR IN THE FAMAGUSTA DISTRICT (1994)

	HOLDERS OF AGRICULTURAL LAND AND FAMILY MEMBERS			EMPLOYEES			TOTAL		
	Males	Females	Total	Males	Females	Total	Males	Females	Total
Crop production	1 194	796	1 990	161	461	622	1 355	1 257	2 612
Livestock production	231	116	347	60	19	79	291	135	426
Forestry	0	0	0	4	1	5	4	1	5
Fishing	119	0	119	156	2	158	275	2	277
TOTAL	**1 544**	**912**	**2 456**	**381**	**483**	**864**	**1 925**	**1 395**	**3 320**

TABLE 4.19: EMPLOYMENT IN CROP AND LIVESTOCK IN THE KOKKINOCHORIA REGION (1994) (FULL-TIME EQUIVALENT NUMBER OF PERSONS)

	HOLDERS OF AGRICULTURAL LAND AND FAMILY MEMBERS	EMPLOYEES (PERMANENT AND CASUAL)	TOTAL
Males	1 620	227	1 847
Females	990	589	1 579
TOTAL	2 610	816	3 426

4.5.3. CULTURAL AND ARCHAEOLOGICAL VALUES

There are no archaeological or historic sites in the area of the STP or the long term storage reservoir. The only historic structure in the vicinity of the plant is the church of Agios Georgios which is at a distance of 1.3 km from the STP site, to the south-southwest.

4.6. PUMPING STATIONS

	Community	Location in the Area and the Conveyance Network
CP1	Xylotymvou	⇨ Pipe from Xylotymvou to Achna The proposed plot is within the residential zone, east of the community.
CP2	Ormideia	⇨ Pipe from Ormideia to Achna The proposed plot is within the SBA. It is within the residential area, northeast of the community, near the housing estate and the cemetery. There is a clump of cypress trees at the site.
CP3	Achna	⇨ Pipe from Achna to the STP The proposed plot is within the SBA, within the residential area to the east of the community, and near the industrial area.
CP4	Xylofagou	⇨ Pipe from Xylofagou to Avgorou The proposed plot is within the SBA, on the Xylofagou – Avgorou road (north of Xylofagou and at a sufficient distance from the residential area).
CP5	Avgorou	⇨ Pipe from Avgorou to the STP The proposed plot is within the housing area, on the Avgorou – Achna road, to the west of the village, and is within a Z1 Zone which borders with the residential zone.
CP6	Agios Georgios Acheritou	⇨ Pipe from Agios Georgios to the STP The proposed plots are within the SBA, next to the Achna – Vrysoulles road, and at a considerable distance from housing areas. The first plot is to the west of the village and the second to the north of the STP site.
CP7	Liopetri	⇨ Pipe from Liopetri to Avgorou Although the proposed plot is within the residential zone, it is at some distance from the housing area, to the northwest of the village, and on the Liopetri – Avgorou road.
CP8	Sotira	⇨ Pipe from Sotira to Frenaros The proposed plot is within the residential zone, H2, and is at the center of the village.
CP9	Sotira Tourist Area	⇨ Pipe from the Sotira tourist area to Liopetri The proposed plot is within the tourist zone, T2b
CP10	Deryneia	⇨ Pipe from Sotira to Frenaros The proposed plot is within the agricultural zone, Ga2, to the northwest of the community, near the waste compaction unit, and at a sufficient distance from the residential area.
CP11	Frenaros	⇨ Pipe from Frenaros to Avgorou

5. IMPACT ANALYSIS

5.1. 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 operation phases. Table 5.1 outlines the probable impacts that have been identified.

TABLE 5.1 : SCREENING TABLE

	IMPACTS
IMPACTS DUE TO PROJECT LOCATION	*Permanent land acquisition* Permanent acquisition of land for construction of the STP, the storage reservoir and the pumping stations
	Impacts on surface water hydrology Positive impacts – additional permanent flow into reservoir or additional surface water body
	Impacts on ecological values No destruction of habitats, but disturbance of wildlife, particularly birds during construction of the STP, due to proximity of site to the Achna Dam. Also, possible disturbance of wildlife during operation as a result of noise. Positive impacts through the creation of a new wetland habitat if an additional long term storage reservoir is created. If storage in Achna Dam addition permanent flow will enhance species diversity.
IMPACTS DUE TO PROJECT DESIGN	*No significant impacts are anticipated* - 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 DUE TO 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 STP, the storage reservoirs, the pumping stations and the conveyance system.
	Soil impacts - Soil erosion: resulting from uncovered and unconsolidated materials during construction - Soil disaggregation - Soil compaction

	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
	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* Minimum impacts
	Noise impacts At STP and pumping stations. Impact at STP limited as site is at a considerable distance from residential areas, however some of the pumping stations are within urban areas.
	Odour impacts At the STP and the pumping stations. Limited impacts due to the distance of the STP site from residential areas. however, some of the pumping stations are within housing areas.
	Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment
	Impact of sludge production and reuse
	Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations
	Risk of insufficient treatment of effluent
	Reuse of Treated Effluent in Irrigation

5.2. ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION

5.2.1. IMPACTS DUE TO PROJECT LOCATION

5.2.1.1. 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.
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 publish 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.
        - (c) Is of an almost equal value with the compensation finally determined.

❑ PERMANENT LAND ACQUISITION FOR THE STP

Table 5.2 outlines the land requirements for the STP, the emergency and long term storage reservoirs, and the pumping stations for the sewage treatment network. The figures given account for the additional land that will be required for sludge storage, parking space, offices and the vegetated buffer zone around the facilities.

TABLE 5.2 : PROJECT LAND REQUIREMENTS

STP		18 000 m^2 (1.8 ha)
Emergency storage		15 300 m^2 (1.6) ha)
Long term storage		270 000 m^2 (27 ha)
Pumping stations	Each	500 m^2
	Total area	3 000 m^2
Total		306 300 m^2 (31 ha)

The STP and the emergency and long term storage reservoirs are located within private land. Furthermore, if storage of the treated effluent in the Achna Dam is not possible, then the construction of the long term storage reservoir will require the acquisition of a house present on the site, as well as the destruction of an olive plantation and a vegetable cultivation next to the house. It is, however, recommended that the olive plantation next to the proposed STP is not destroyed and this should be taken into account during the detailed design of the STP. The remaining land in the area is agricultural land for the cultivation of temporary crops, such as cereals and fodder. Compensation will be required for all private land that will be acquired and for any crop trees destroyed, as well as for any possible loss of income that will result from the take up of the agricultural land. In the case of the house, provided construction of the reservoir proves necessary, fair compensation must be paid to the owner, and resettlement provisions must be considered.

❑ PUMPING STATIONS

The conveyance system for the transfer of sewage water from the communities to the sewage treatment plant includes 12 pumping stations, the locations of which are indicated in Table 4.20 and in the cadastral maps in Appendix 3.

The land area required for each pumping station will depend on the discharge capacity of the station, while the maximum area extent has been estimated to be 500 m^2, including the land that will be taken up for landscaping. The maximum total land area that will be aquired for the pumping stations will be approximately 6 000 m^2.

The proposed locations for the construction of the pumping stations consist of private land, therefore the necessary compensations must be paid to the owners for their acquisition, in accordance with the law, as well as for any loss of income that might result.

5.2.1.2. IMPACT ON SURFACE WATER HYDROLOGY

The project will result in positive impacts for surface water hydrology, due to the low storage percentage on the Achna Dam (35%) compared to its total available capacity. If the treated effluent is stored in the Achna Dam, it will provide an additional permanent water flow into the reservoir, particularly during drought years when the Dam reserves are low. If a long term storage reservoir is constructed then this would create an additional reservoir in the area satisfying the irrigation demand, particularly of areas not included in the Kokkinochoria Irrigation Scheme.

5.2.1.3. IMPACT ON ECOLOGICAL VALUES

No significant adverse impacts are expected on the ecology of the area as a result of project location. The STP site, although being next to the Achna Dam which is a Z3 Protection Zone, is within an agricultural zone. The actual construction of the STP will result in the take up of agricultural land, however, there will be no destruction of any ecologically sensitive sites or habitats.

During the construction phase of the STP there could be some short term impacts on the ecology of the Dam, particularly bird species, as a result of machinery operation and vehicle movement, where construction activity and noise may lead to a reduction of sensitive species or a disruption in migratory and breeding patterns. Such impacts, however, will be only temporary, while no long term impacts are anticipated to result from construction of the STP.

During operation of the STP no significant adverse effects are expected to arise. Noise from the site could potentially disturb the wildlife of the area, however, the use of low noise processes and the adoption of all necessary mitigation measures (as outlined in Section 5.3.4.2.) will eliminate the risk of such impacts arising.

On the other hand, the operation of the STP will also have a beneficial effect on the ecology of the area. If the treated effluent is stored in the Achna Dam it will provide an additional permanent flow into the reservoir, thus improving the development of trees and enhancing the diversity of fauna and flora. In the case where a new reservoir would need to be constructed, this would lead to the creation of a new habitat by turning grassland into a permanent wetland.

If the treated effluent is stored in the Achna Dam, disposal will be according to the Code of Practice for the Disposal of the Treated Sewage Water in Surface Waters, to minimise the risk of any adverse impacts on fish populations.

5.2.2. IMPACTS RELATED TO PROJECT DESIGN

No significant impacts are anticipated in relation to the design of the STP and the conveyance system.

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, while provisions will also be made for the future removal of phosphorus. Therefore, in terms of performance, the process will ensure the adequate treatment of wastewaters, thus minimising the risk of any impacts arising as a result of insufficient treatment of the effluents.

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

The treatment of the sludge is covered in Sections 3.3.2. and 5.3.4.4. The process selection for the sludge treatment though will be based on the assumption that the treated sludge will be reused in agriculture as fertilizer in accordance with the specified standards.

The design of the conveyance system will ensure that there will be no problem of creation of sulphides along the forcemains.

5.2.3. IMPACTS RELATED TO PROJECT CONSTRUCTION

5.2.3.1. TEMPORARY LAND ACQUISITION

During the construction phase land will be required for the 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 will be taken up to ensure that such sites are limited to the minimum possible area required, and as far as possible within the areas of the STP site that will be later planted and used as a buffer zone. Following the construction stage all land which was acquired temporarily must be rehabilitated.

5.2.3.2. VEGETATION CLEARING

The crop cultivations at the STP site will inevitably be destroyed as a result of project construction. This will also be the case at the proposed reservoir site, provided that the treated effluent will not be accepted in the Achna Dam and provisions will need to be made for long term storage. Construction of the reservoir will also flood the olive plantation and vegetable plantation at the site. Whether this will also be the case for the olive plantation to the northeast of the STP site will be determined during the detailed design of the STP and the emergency storage reservoir.

There is a possibility that during the construction of the conveyance system, vegetation including cultivations and trees, 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 construction phase. In the case of pumping stations, the possibility of vegetation destruction is more limited as the sites for the stations are within the urban areas of the villages, with the exception of the one outside Frenaros.

In all cases, where cultivations are destroyed compensation will be required to the owner. In the case of non-agricultural vegetation along the conveyance system routes, attempts should be made to restore this after the pipes have been installed.

5.2.3.3. EROSION OF UNCONSOLIDATED MATERIALS

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 minimise 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 tyres 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.

5.2.3.4. DUST, FUMES AND NOISE

⇩ IMPACTS ON AIR QUALITY DURING CONSTRUCTION

During the construction phase of the STP 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 vehicle movement and construction activities.

To minimise 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 IMPACTS DURING CONSTRUCTION

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

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.

TABLE 5.3: TYPICAL MAXIMUM NOISE LEVELS PERMITTED FROM CONSTRUCTION PLANT

CONSTRUCTION EQUIPMENT 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 5.4: NOISE VALUE OF THE MAIN MACHINERY USED AT VARYING DISTANCES

	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

	EQUIPMENT	15 m	30 m	50 m	100 m	200 m
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
8.	Truck	77	70	65	59	53

Noise impacts during the construction phase will arise mainly from the construction of the collection system, as works will take place within the residential areas, and partly from construction of the conveyance system. In the case of the STP, there will be no noise impacts on the resident population as the site is at a sufficient distance from housing areas, although there will be some impacts on the people using the Achna Dam for recreation.

Although during the construction phase noise control measures can be incorporated in the contract with the constructors, such measures are rather restricted. Construction takes place in the open with the use of heavy machinery and only limited control measures are feasible.

The 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 minimise 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.

5.2.3.5. ON-SITE SAFETY

Health and safety measures must be implemented on the construction sites by the contractor to ensure the avoidance of accidents in relation to the work force and the environment. 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.

5.2.3.6. 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.

5.2.3.7. 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 minimise 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.

5.2.3.8. OFF-SITE PUBLIC SAFETY AND INCONVENIENCE

During the construction of the sewage treatment plant there will be increased vehicle movement to and from the site 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 or roads during the excavation and pipe-laying stages will lead to traffic congestions, especially along the main roads, and increase the risk of car accidents.

Mitigation measures are rather restricted. In the case of increased vehicle movements, these should be restricted to avoid hours of peak traffic. Good site management during the construction stage and the adoption and adherence to road safety measures will, to some extent, minimise these impacts.

5.2.4. IMPACTS RELATED TO PROJECT OPERATION

5.2.4.1. LANDSCAPE IMPACT

No significant landscape or visual impacts are anticipated as a result of the construction of the STP, largely due to the nature and topography of the location. The STP site is within a valley of lower elevations than the surrounding areas, thus the STP will be largely hidden from views. The plant will not be visible from the side of the Achna Dam, which is of particular importance as it is used for recreation purposes, including bird watching, and any visual impacts would have been significant and the plant would have posed an intrusion on the views and landscape of the reservoir. On the other side, the STP site is bordered by agricultural land with much higher elevations, thus, similarly, visual impacts will be limited. Additionally, to ensure the minimisation of any landscape or visual impacts the buffer zone around the STP and the reservoirs will be planted and landscaped.

Regarding the pumping stations, some visual impacts will arise since some of these will be constructed within the residential areas of the communities, or next to main roads in the project area, however these impacts will be reduced through the appoprate landscaping of the sites that will be carried out.

5.2.4.2. IMPACTS ON THE QUALITY OF LIFE

No significant noise or odour impacts are expected on the resident population as a result of the operation of the Sewage Treatment Plant.

The site for the STP is at a distance of approximately 1.8 km from the nearest houses, which are in Avgorou, to the southeast of the site. Furthermore, it is at a distance of 1.4 km from the boundary of the Avgorou residential zone, which ensures limited risk with regards to noise and odours even after taking into account the future development of the community.

Between the months of September and May the prevailing winds in the area have a northwest direction, with angles between 300^o to 330^o, which means that they will be directed from the plant site towards the Avgorou housing area. However, the distance of the site from the village will ensure that there will be limited risk of odour or noise impacts.

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. 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 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 OPERATION OF THE STP

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 minimised. 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 OPERATION OF THE STP AND CONVEYANCE SYSTEM

During the operation of the STP and the conveyance systems, odours can potentially arise from a number of sources, including screenings and grit removal facilities, primary settling tanks, organically overloaded biological treatment processes, 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 10 km, which corresponds to a transfer time of approximately 3 hours.

5.2.4.3. IMPACT ON UNDERGROUND RESOURCES

The project is anticipated to have a significantly positive impact on underground water resources, as a result of the reduction in the concentrations of nitrogen and phosphorus that is currently released in soils from septic tanks. The volumes of treated water that will be produced from the STP in 2005, 2015 and 2030 are as follows:

YEAR	WASTEWATER FLOW (m^3/ year)
2005	1 920 150
2015	2 261 458
2030	2 934 724

This water will potentially be used for irrigation purposes, thus providing an additional permanent water resource for the region. This will result in a reduction in the amount of water pumped from the groundwater bodies, therefore reducing the risk of aquifer depletion. Furthermore, to avoid the release of large quantities of nitrogen and phosphorus the treatment process will be designed for their removal.

Additionally, the project will result in a reduction of nitrates and phosphorus which are currently released into the soil from the existing sanitary system (septic tanks) in the project area.

5.2.4.4. RISK OF SYSTEM OVERLOAD

The risk of system overload is minimum. 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. Any accidental overload from equipment failure will be mitigated though the construction of the emergency storage reservoir.

5.2.4.5. RISK OF INSUFFICIENT TREATMENT OF EFFLUENT

A combination of the standards specified by both the EU Directive 91/271/EEC and the Cyprus Standards for the reuse of the treated effluent for irrigation purposes will be used for the design of the STP, and the most stringent values will be applied. Thus removal of nitrogen and phosphorus will be governed by the EU standards, whereas the limits for BOD, Suspended Solids and micro-organisms will follow the Cyprus standards. This will ensure the sufficient treatment of the effluent. However, regular monitoring of the quality of the treated effluent is required to ensure that the process is carried out according to design parameters and any emergency situations are detected.

5.2.5. IMPACT OF SLUDGE PRODUCTION

The expected quantities of sludge to be produced are given in the following table.

TABLE 5.5: EXPECTED SLUDGE QUANTITIES

	SLUDGE QUANTITY, M^3/YEAR		
	2005	2015	2030
Total Sludge Volume at 30% DS Content	**3 990**	**4 179**	**6 071**

Table 5.6 gives the average sludge composition in Cyprus. Detailed information regarding sludge quality and constituents are outlined in Appendix 8.

TABLE 5.6: AVERAGE SLUDGE COMPOSITION IN CYPRUS

	CYPRUS
Date	1995 – 1999
Dry Matter (%)	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	4.3×10^4/100g
Viable Helminth eggs	0

5.2.5.1. DISPOSAL AND REUSE OF SLUDGE

Particularly during the first years of operation of the STP, 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 Nicosia official controlled landfill site, or,
- A site will be identified within the region to be serviced by the STP for the creation of a new controlled landfill, designed to accommodate such waste as sewage sludge, in addition to the solid waste from the villages.

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 near the STP.
- Identify possible locations for a new landfill site
- 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 site. 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 fertilisers, 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.

5.2.5.2. SEWAGE 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 favour 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 minimise 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.

5.2.5.3. 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 ⇨ Favour 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 (especially in offal and milk)
Human contamination
⇩ Limit pollutant transfer in the food chain (see above)
⇩ 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 5.7: 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

5.2.5.4. 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 Code of Practice for the Use of Sludge for Agricultural Purposes.

TABLE 5.8: 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 5.9: 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

TABLE 5.10: 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

5.2.5.5. MONITORING PROGRAMME

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.

5.2.6. DISPOSAL OF THE TREATED EFFLUENT

5.2.6.1. TREATED EFFLUENT QUANTITIES

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

2005	1 920 150 m^3
2015	2 261 458 m^3
2030	2 934 724 m^3

5.2.6.2. 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 of 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 effluent for irrigation purposes is recommended, since it will provide an additional water resource. Additionally, since the regulations regarding the disposal of treated effluents in water bodies in essence prohibit discharges in dry river courses, 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.

A significant proportion of the agricultural land in the project region is within the Kokkinochoria Government Irrigation Scheme, with approximately 9 270 hectares (69 300 donums) being irrigated with water from the Achna Dam and which is being conveyed by the Southern Conveyor from the Kouris Dam. During periods of drought when the water supplied is below the irrigation demands of these areas, the remaining water demand is satisfied by groundwater.

Although groundwater is still the main source for the irrigation demands of the areas outside the Irrigation Scheme, the resource has been mismanaged over the past years and, on many occasions, nearly depleted through over pumping. This is despite the fact that groundwater plays a key role in supplementing and balancing the water shortages during drought years for areas within the Scheme and should thus be conserved to secure adequate water supply during periods of shortage. Reuse of the treated effluent for irrigation purposes will not only provide an additional water resource, it will also significantly reduce pumping, and, in turn the depletion of groundwater bodies.

For the reuse of the treated effluent in agriculture, two options are available:
- Direct Irrigation, and
- Groundwater recharge

5.2.6.3. TREATED EFFLUENT QUALITY

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 5.11: SUGGESTED LIMIT STANDARDS FOR TREATED EFFLUENT QUALITY

PARAMETER	LIMIT VALUE
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

5.2.6.4. LAND REQUIREMENTS FOR THE REUSE OF THE TREATED EFFLUENT FOR IRRIGATION

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	FLOW (m^3)	LAND REQUIRED (DONUMS)
2005	1 920 150	2 400
2015	2 261 458	2 827
2030	2 934 724	3 668

5.2.6.5. ALTERNATIVES FOR THE REUSE OF THE TREATED EFFLUENT FOR DIRECT IRRIGATION

- STORAGE OF THE TREATED EFFLUENT IN ACHNA DAM

Approximately 69 300 donums (9 270) hectares of land, which constitute about 80 % of the total agricultural land in the region, are within the Kokkinochoria Irrigation Scheme. Water for the irrigation of these areas is supplied from the Achna Dam which is part of the Southern Conveyor Project.

With the maximum storage percentage recorded for the hydrological year 2002/2003 being 35 % of the 6.8 MCM total storage capacity of the Achna Dam, there is a potential for the storage of the treated effluent in the Dam. In this case, the treated effluent will be diluted with the freshwater from the Kouris Dam and will subsequently be used for the irrigation of the areas covered by the Irrigation Scheme.

Storage of the treated effluent in the Achna Dam and use for the irrigation of the cultivated areas within the Kokkinochoria Irrigation Scheme is the preferred option for the agricultural reuse of the effluent due to the significant advantages it entails:

- The land requirements for the project will decrease substantially as there would be no need for the construction of a long term storage reservoir
- There will be no need for an additional distribution network as the effluent will be used for the irrigation of those areas already connected under the current irrigation scheme. Additionally, the extension of the network to cover more areas would be possible as a result of the additional permanent water flow in the Achna Dam, as well as easier and less costly compared to the construction of a new separate network

- ⇨ This option will lower costs both for the construction of the STP and for the reuse of the treated effluent (no long term storage reservoir or irrigation water distribution network)
- ⇨ There will be increased acceptance of the treated effluent by farmers as it will be mixed with freshwater from the Kouris Dam
- ⇨ The treated effluent will provide an additional permanent water flow, thus reducing the amount of groundwater pumped to supplement water demands during periods of shortage.

However, for the adoption of the alternative, it is recommended that the following studies be carried out:

- ⇩ A Feasibility Study examining
  - ⇨ The current situation regarding the possibility of conveyance and storage of the Nicosia treated effluents to the Achna Dam
  - ⇨ The potential for the additional storage of the STP's treated effluents in the Dam in case the conveyance and storage of the Nicosia effluents is finally decided, taking into consideration the capacity of the Dam and the total volume of effluents
  - ⇨ The potential of reducing the water conveyed from the Kouris Dam to satisfy the storage requirements of both effluent sources.

- ⇩ A Management Study for the Achna Dam, incorporating
  - ⇨ Adjustments in the design of the Dam to prevent the possibility of odours which may occur if water intake is at the bottom, including:
    - Adjustable water intake, so that inflow occurs at the surface,
    - Design water outfall to create a hydraulic circulation,

    thus avoiding the creation of anoxic conditions in the bottom layers.
  - ⇨ Monitoring of water quality (EMP)

Regarding the risk of eutrophication, this will be minimised through the removal of nitrogen and phosphorus as is recommended by the suggested effluent standards.

MITIGATION MEASURES FOR STORAGE OF THE TREATED EFFLUENT IN THE ACHNA DAM
❑ Eutrophication
⇨ Phosphorus and nitrogen removal
❑ Capacity considerations
⇨ Feasibility Study to be carried out examining storage potential
❑ Odours from anoxic conditions in bottom layers, eutrophication
⇨ Management study to be carried out, incorporating design adjustments ⇩ Adjustable water intake ⇩ Design of water outfall too create hydraulic circulation
⇨ Regular monitoring of effluent quality and water quality

❑ STORAGE OF THE TREATED EFFLUENT IN A LONG TERM STORAGE RESERVOIR

Alternatively, the treated effluent will be stored in the long term storage reservoir and subsequently be used for the irrigation of areas that are not included in the Irrigation Scheme. Approximately 19000 donums, which comprise 20 % of the total agricultural land in the region, are outside the scheme and irrigation demand for these areas is satisfied mainly by groundwater.

Although this option will reduce the amount of groundwater pumped to satisfy the requirements of cultivated areas not included in the Irrigation Scheme, in comparison it has a number of disadvantages:

- ⇨ A new distribution network will be required for the treated effluent
- ⇨ Construction of the long term storage reservoir entails considerable land requirements
- ⇨ Suitable land for irrigation must be identified
- ⇨ Increased costs of construction

5.2.6.6. EFFLUENT REUSE FOR IRRIGATION: REGIONAL MANAGEMENT PLAN

To ensure the efficiency and sustainable reuse of the treated effluent for irrigation the drafting of a Regional Management Plan is recommended, aimed at optimising 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.

A number of constituents in treated effluents are of concern in connection with its reuse for agricultural irrigation, including 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 5.12 gives the relative salt tolerance of certain agricultural 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 5.12: RELATIVE SALT TOLERANCE OF AGRICULTURAL CROPS

Tolerant	
Fibre, Seed and Sugar Crops	
Barley	*Hordeum vulgare*
Cotton	*Gossypium hirsutum*
Jojoba	*Simmondsia chinensis*
Sugarbeet	*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	
Fibre, Seed and Sugar Crops	
Cowpea	*Vigna unguiculata*
Oats	*Avena sativa*
Rye	*Secale cereale*
Safflower	*Carthamus tinctorius*
Sorghum	*Sorghum bicolor*
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 tuberosa*
Panic grass, blue	*Panicum antidotale*
Rape	*Brassica napus*
Rescue grass	*Bromus unioloides*
Rhodes grass	*Chloris gayana*
Grasses and Forage Crops	
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	
Fibre, 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 stabilising ions in contrast to the destabilising 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.

TABLE 5.13: RELATIVE TOLERANCE OF SELECTED CROPS TO EXCHANGEABLE SODIUM

Sensitive	Semi-tolerant	Tolerant
Avocado	Carrot	Alfalfa

Sensitive	Semi-tolerant	Tolerant
(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)*
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 (peanut)	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). Of particular concern are cadmium, copper and molybdenum as they can be toxic to animals at concentrations too low to affect plants.

⇩ 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 sever damage to most plants.

TABLE 5.14: CHLORIDE TOLERANCE OF SOME FRUIT CROP CULTIVARS AND ROOTSTOCKS

Crop	Rootstock or Cultivar	Maximum permissible Cl^- without leaf injury[1]	
		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.

TABLE 5.15: 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

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.

⇩ Crop 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.

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 optimisation 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.

5.2.6.7. MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENT IN AGRICULTURE

MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENT IN IRRIGATION
❑ Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality
⇨ Drafting of Reuse Management Plan, incorporating:
⇩ Appropriate site identification (for reuse in areas outside the Irrigation Scheme) ⇩ 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
	⇨ Minimise 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	
	⇨ Implements treated effluent quality monitoring programme to ensure compliance with the set standards
	⇨ Implement soil quality monitoring programme
	⇨ Monitoring of irrigation methods and practices

5.2.6.8. GROUNDWATER RECHARGE AND INDIRECT IRRIGATION

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:

- 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.

Although groundwater recharge is currently not a common practice yet in Cyprus, in the case of the Limassol sewage treatment plant part of the treated wastewater that is not used for direct irrigation is expected to be used for the recharge of the Akrotiri aquifer, and subsequently for irrigation purposes. Additional water quality standards have been set for the effluent that will be recharged, particularly regarding nitrogen removal.

6. PROJECT ALTERNATIVES

6.1 ALTERNATIVE SEWAGE TREATMENT PROCESSES

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 (Section 3.3.2.4.)
- ❑ Trickling filters
- ❑ Bio aerated filters
- ❑ Membrane bio reactors
- ❑ Stabilization ponds
- ❑ Anaerobic reactors

6.1.1. 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 to 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.

6.1.2. 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.

6.1.3. 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 fibre 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.

6.1.4. STABILISATION PONDS

Aerobic stabilisation 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 metabolise organic matter and reduce the BOD.

Stabilisation 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 maximise 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 stabilisation ponds are therefore not retained in this case.

6.1.5. 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.

6.1.6. COMPARISON OF PROCESSES

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 6.1 summarises the advantages and disadvantages of these processes.

TABLE 6.1: COMPARISON OF TREATMENT PROCESSES

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

6.2. SCREENING OF OPTIONS AND ALTERNATIVES

6.2.1. ALTERNATIVE SCHEMES

6.2.1.1. INITIAL SCREENING OF ALTERNATIVE SCHEMES

Fourteen alternative schemes were initially examined, based on a different number of STPs, locations and conveyance routes. These are outlined in Table 6.2.

TABLE 6.2: FAMAGUSTA AREA (GROUP C) SCHEMES

SCHEME	LOCATION OF STPS	COMMENTS
C1a	One single STP located near Liopetri dam	Agios Georgios Acheritou, Deryneia and Sotira connected to Frenaros. From Frenaros water is conveyed to Liopetri and then to STP. Avgorou connected to Liopetri. Achna and Xylotymvou connected to Ormideia and then through Xylofagou wastewater conveyed to STP.
C1b	One single STP: Existing Paralimni STP	Achna and Xylotymvou connected to Ormideia and then through Xylofagou wastewater conveyed to Liopetri, where the flow from Avgorou is conveyed. From Liopetri wastewater is conveyed to Sotira. Transfer of sewage from Agios Georgios Acheritou is through Frenaros. Deryneia and Frenaros conveyed to Sotira and from Sotira to existing STP.
C1c	One single STP near Agios Georgios Acheritou	Wastewaters from Deryneia and Sotira are conveyed Frenaros and then to Agios Georgios Acheritou and to STP. Sewage from Liopetri and Xylofagou flows to Avgorou, and after connection with transfer pipes from Achna, Ormideia and Xylotymvou wastewater is transferred to STP.
C1d	One single STP near Achna dam	Wastewaters from Deryneia and Sotira are conveyed to Frenaros and then to Avgorou. After connection from Liopetri, Xylofagou and Agios Georgios Acheritou wastewater is conveyed to STP. Sewerage from Xylotymvou is transferred to Achna, where it is connected with the pipe from Ormideia and then conveyed to STP.
C2a	Two STPS: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Liopetri dam	❑ Wastewaters from Sotira, Deryneia and Frenaros are conveyed to Agios Georgios Acheritou and to STP in the vicinity of this community. Avgorou is also connected to the same STP. ❑ Sewerage from Xylotymvou, Achna, Ormideia, Xylofagou and Liopetri are treated at the STP near Liopetri.
C2b	Two STPS: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Achna dam	❑ Wastewaters from Sotira, Deryneia and Frenaros are conveyed to Agios Georgios Acheritou and to STP in the vicinity of this community ❑ Sewerage from Xylotymvou, Achna, Ormideia, Xylofagou, Avgorou and Liopetri are treated at the STP near Achna dam.
C2c	Two STPS: ❑ 1 STP near Achna dam ❑ 1 STP near Liopetri dam	❑ Wastewaters from Agios Georgios Acheritou, Sotira, Deryneia, Frenaros and Liopetri are conveyed to STP in the vicinity of Liopetri. Xylofagou is also connected to the same STP. ❑ Sewerage from Xylotymvou, Achna, Ormideia and Avgorou are treated at the STP near Achna dam.
C2d	Two STPS: ❑ 1 STP near Achna dam ❑ 1 STP near	❑ Wastewaters from Sotira, Deryneia, Frenaros and Agios Georgios Acheritou are conveyed to STP near Achna dam. Avgorou and Liopetri are also connected to the same STP.

SCHEME	LOCATION OF STPS	COMMENTS
	Dhekelia Power station	❑ Sewerage from Xylotymvou, Achna and Ormideia are treated at the STP near Dhekelia power station as well as the wastewater from Xylofagou.
C2e	Two STPS: ❑ 1 STP near Liopetri ❑ 1 STP near Dhekelia Power station	❑ Wastewaters from Sotira, Deryneia, Frenaros and Agios Georgios Acheritou are conveyed to Liopetri and to STP near this community. Avgorou and Xylofagou are also connected to the same STP. ❑ Sewerage from Xylotymvou, Achna and Ormideia are treated at the STP near Dhekelia power station.
C3a	Three STPs: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Xylofagou ❑ 1 STP near Ormideia	❑ Wastewaters from Sotira, Deryneia and Frenaros are conveyed to Agios Georgios Acheritou and to STP in the vicinity of this community ❑ Sewerage from Xylofagou, Avgorou and Liopetri is conveyed to the STP near Xylofagou, ❑ Sewage from Achna, Ormideia and Xylotymvou sewerage is treated at STP near Ormideia.
C3b	Three STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Ormideia	❑ Wastewaters from Agios Georgios Acheritou, Sotira, Deryneia and Frenaros are conveyed to existing Paralimni STP ❑ Sewerage from Xylofagou, Avgorou and Liopetri is conveyed to the STP near Xylofagou. ❑ Achna, Ormideia and Xylotymvou sewerage is treated at STP near Ormideia
C3c	Three STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Achna dam	❑ Wastewaters from Sotira, Deryneia and Frenaros are conveyed to existing Paralimni STP ❑ Sewerage from Xylofagou and Ormideia is conveyed to the STP near Xylofagou. ❑ At the STP near Achna dam the wastewater from Agios Georgios Acheritou, Avgorou, Liopetri, Achna and Xylotymvou is treated
C4	Four STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Achna dam ❑ 1 STP near Agios Georgios Acheritou	❑ Existing Paralimni STP would treat wastewater from Frenaros and Sotira. ❑ Sewerage from Xylofagou and Ormideia is conveyed to the STP near Xylofagou. ❑ At the STP near Achna dam the wastewater from Avgorou, Liopetri, Achna and Xylotymvou is treated. ❑ Wastewater fro Deryneia and from Agios Georgios Acheritou is treated at STP in the vicinity of Agios Georgios Acheritou
C10	One STP for each village	Each community has its own treatment plant.

Schematic presentations of the schemes are included in Appendix 10.

An initial screening of the schemes was carried out and a number of these had to be eliminated. A summary of the initial screening results is given in Table 6.3.

TABLE 6.3: INITIAL SCREENING OF FAMAGUSTA AREA (GROUP C) SCHEMES

SCHEME	LOCATION OF STPS	COMMENTS
C1a	One single STP located near Liopetri dam	Economical evaluation of the scheme was carried out.
C1b	One single STP: Existing Paralimni STP	Existing Paralimni STP can not accommodate the wastewater flows from the communities under design even after extension. The scheme was cancelled.
C1c	One single STP near Agios Georgios Acheritou	Economical evaluation of the scheme was carried out.
C1d	One single STP near Achna dam	Economical evaluation of the scheme was carried out.
C2a	Two STPs: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Liopetri dam	Economical evaluation of the scheme was carried out.
C2b	Two STPs: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Achna dam	Economical evaluation of the scheme was carried out.
C2c	Two STPs: ❑ 1 STP near Achna dam ❑ 1 STP near Liopetri dam	Economical evaluation of the scheme was carried out.
C2d	Two STPs: ❑ 1 STP near Achna dam ❑ 1 STP near Dhekelia Power station	Economical evaluation of the scheme was carried out.
C2e	Two STPs: ❑ 1 STP near Liopetri ❑ 1 STP near Dhekelia Power station	Economical evaluation of the scheme was carried out.
C3a	Three STPs: ❑ 1 STP near Agios Georgios Acheritou ❑ 1 STP near Xylofagou ❑ 1 STP near Ormideia	The scheme was cancelled as there are no available sites for treatment plants near Xylofagou and near Ormideia. The only available site in the coastal area is the site near Dhekelia power station. This leads to the scheme with two STP sites. The scheme was cancelled.
C3b	Three STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Ormideia	Existing Paralimni STP can not accommodate the wastewater flows from the communities under design even after extension. The scheme was cancelled.

SCHEME	LOCATION OF STPS	COMMENTS
C3c	Three STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Achna dam	Existing Paralimni STP can not accommodate the wastewater flows from the communities under design even after extension. The scheme was cancelled.
C4	Four STPs: ❑ Existing Paralimni STP ❑ 1 STP near Xylofagou ❑ 1 STP near Achna dam ❑ 1 STP near Agios Georgios Acheritou	Existing Paralimni STP can not accommodate the wastewater flows from the communities under design even after extension. The scheme was cancelled.
C10	One STP for each village	Economical evaluation of the scheme was carried out.

In the process of the initial screening the possibility to accommodate additional flow at the existing Ayia Napa – Paralimni STP was examined. The plant was designed for 12 000 m^3/d and is today operated at a maximum of 7 000 m^3/d during the summer. However, only around 40% of Ayia Napa and 65% of Paralimni are currently covered by a collection system. Extension of the collection systems is ongoing and will lead to full load of the STP in 5 – 10 years. According to the Paralimni/Ayia Napa Sewerage Boards it is possible to extent the capacity of the STP to 14 000 m^3/d without any problems. Therefore, the available capacity for connecting additional villages to the plant would be approximately 2 000 m^3/d. However, the estimated wastewater production for the Famagusta communities shows that the capacity of the extended Paralimni Treatment Plant can be used only as the temporary solution for some of the villages. This led to the conclusion that the existing plant should not be used for the communities under study and, therefore, schemes C1b, C3b, C3c and C4 were eliminated. Scheme C3a was also cancelled as there are no available sites in the coastal area near Ormideia and Xylofagou.

For the remaining schemes further environmental and economic comparisons were carried out.

6.2.1.2. BRIEF DESCRIPTION OF THE COMPONENTS OF ALTERNATIVE SCHEMES

❑ SCHEME C1A

Scheme C1a is a scheme with one single STP in the vicinity of the Liopetri Dam. The layout of the scheme is presented in Appendix 10.

The main components of the system are as follows:
⇩ Total length of gravity pipes is 23.1 km with the diameter from 200mm to 600 mm.
⇩ Length of forcemains is 23.3km with the diameter from 150mm to 200mm
⇩ Six pumping station are estimated with the discharge capacity varying from 6,5 l/s to 24.2 l/s and installed power from 1 kW to 12.7 kW.
⇩ Location of STP is in the vicinity of Liopetri dam, with the nominal capacity of 10370 m3/d. Required area for STP and emergency storage is 4.6 ha. The existing Liopetri dam can be used as the long term storage for reuse of water.

❑ SCHEME C1C

Scheme C1c is a scheme with one single STP near Agios Georgios Acheritou. The layout of the scheme and corresponding flows are presented in Appendix 10.

The main components of the system are as follows:

- Total length of gravity pipes is 39.5 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 10.8 km with the diameter from 150mm to 250mm
- Seven pumping station are estimated with the discharge capacity varying from 9,5 l/s to 61.7 l/s and installed power from 4 kW to 13.0 kW.
- Location of STP is near the Agios Georgios Acheritou. Two alternative sites are available, one near the existing dam while the other is in the vicinity of buffer zone. The nominal capacity of 10370 m^3/d. Required area for STP and emergency storage is 4.6 ha. The existing dam can be used as the long term storage for reuse of water.

SCHEME C2A

Scheme C2a is a scheme with two STPs, one near the Liopetri Dam and the other near Agios Georgios Acheritou. The layout of the scheme and the corresponding flows are given in Appendix 10.

The main components of the system are as follows:

- Total length of gravity pipes is 28.8 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 14.6 km with the diameter from 150mm to 250mm
- Six pumping station are estimated with the discharge capacity varying from 9,5 l/s to 59.0 l/s and installed power from 1 kW to 13.0 kW.
- For the location of the treatment plant near the Agios Georgios Acheritou two alternative sites are available, one near the existing dam while the other is in the vicinity of buffer zone. The nominal capacity is 6253 m^3/d. Required area for STP and emergency storage is 2.9 ha. The existing dam can be used as the long term storage for reuse of water. Location of the second STP is near Liopetri dam. The nominal capacity is 4119 m^3/d, while the required area for STP and emergency storage is 1.8ha.

SCHEME C2B

Scheme C2b has two STPs, one near Agios Georgios Acheritou and the other near the Achna Dam. The layout of the scheme and the corresponding flows are presented in Appendix 10.

The main components of the system are as follows:

- Total length of gravity pipes is 34.1 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 8.1 km with the diameter from 100mm to 250mm
- Five pumping station are estimated with the discharge capacity varying from 9,5 l/s to 61.7 l/s and installed power from 4 kW to 13.0 kW.
- For the location of the treatment plant near the Agios Georgios Acheritou two alternative sites are available, one near the existing dam while the other is in the vicinity of buffer zone. The nominal capacity is 5070 m^3/d. Required area for STP and emergency storage is 2.5 ha. The existing dam can be used as the long term storage for reuse of water. Location of the second STP is near Achna dam. The nominal capacity is 5302 m^3/d, while the required area for STP and emergency storage is 2.4ha. The existing dam can be used as long term storage.

SCHEME C2C

Scheme C2c has two STPs, one near Liopetri Dam and the other near the Achna Dam. The layout of the scheme and the flows are presented in Appendix 10.

The main components of the system are:

- Total length of gravity pipes is 28.1 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 11.2 km with the diameter from 100mm to 150mm
- Four pumping station are estimated with the discharge capacity varying from 9,5 l/s to 24.2 l/s and installed power from 2.8 kW to 13.0 kW.
- Location of one of the STP is near Liopetri dam. The nominal capacity is 7252 m^3/d, while the required area for STP and emergency storage is 3.2ha. The existing dam can be used as long

term storage. Location of second STP is near the Achna dam. Two alternative sites are available, one downstream of the dam and other in the vicinity of the dam. The nominal capacity of 3120 m3/d. Required area for STP and emergency storage is 1.4 ha. The existing Achna dam can be used as long term storage for reuse of water.

❑ SCHEME C2D

Scheme C2d is a scheme with two STPs, one near the Achna Dam and the other near the Dhekelia Power Station. The layout of the scheme and the corresponding flows are presented in Appendix 10.

The main components of the system are as follows:
- Total length of gravity pipes is 29.4 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 18.2 km with the diameter from 100mm to 250mm
- Nine pumping station are estimated with the discharge capacity varying from 6,5 l/s to 79.5 l/s and installed power from 1 kW to 36.0 kW.
- Location of one of the STPs is near the Achna dam. Two alternative sites are available, one downstream of the dam and other in the vicinity of the dam. The nominal capacity of 7360 m^3/d. Required area for STP and emergency storage is 3.2ha. The existing Achna dam can be used as long term storage for reuse of water. The second STP is located near Dhekelia power station. Nominal capacity of STP is 3012 m^3/d, and the required area for the STP, emergency storage and long term storage is 8.6ha.

❑ SCHEME C2E

Scheme C2e has two STPs, one near the Liopetri Dam and the other near the Dhekelia Power Station. The layout of the scheme is given in Appendix 10.

The main components of the scheme are:
- Total length of gravity pipes is 23.0 km with the diameter from 200mm to 600 mm.
- Length of forcemains is 14.9 km with the diameter from 100mm to 200mm
- Five pumping station are estimated with the discharge capacity varying from 6.5 l/s to 24.2l/s and installed power from 2.7 kW to 13.0 kW.
- Location of one of the STP is in the vicinity of Liopetri dam, with the nominal capacity of 8436 m^3/d. Required area for STP and emergency storage is 3.7 ha. The existing Liopetri dam can be used as the long term storage for reuse of water. The second STP is located near Dhekelia power station. Nominal capacity of STP is 1936 m^3/d, and the required area for the STP, emergency storage and long term storage is 5.5ha.

❑ SCHEME C10

Scheme C10 is a scheme with a STP for each of the communities. The layout of the scheme is given in Appendix 10.

Location of the STPs is predicted to be at the lowest area of the community. The nominal capacity of the STPs is as follows:

⇨ Xylotymvou	563 m^3/d
⇨ Achna	558 m^3/d
⇨ Ormideia	815 m^3/d
⇨ Avgorou	1184 m^3/d
⇨ Xylofagou	1076 m^3/d
⇨ Agios Georgios Acheritou	533 m^3/d
⇨ Liopetri	1107 m^3/d
⇨ Frenaros	688 m^3/d
⇨ Sotira	1786 m^3/d
⇨ Deryneia	2083 m^3/d

6.2.2. ALTERNATIVE SITES

A number of alternative sites have been investigated, including 3 sites near the Achna Dam for schemes C1d, C2b, C2c, C2d, and C10; 3 sites near Agios Georgios for schemes C1c, C2a, C2b, and C10; one site near the Dhekelia Power Station for schemes C2d, C2e and C10; and one site near the Liopetri Dam for schemes C1a, C2a, C2c, C2e, and C10. The results of the preliminary environmental evaluation and comparison of these alternative sites are given Appendix 11.

6.2.2.1. ALTERNATIVE 1: NEAR ACHNA DAM

The main advantage of constructing the treatment plant at this site is that the Dam offers the possibility for the discharge and storage of any excess treated water, particularly during the winter months when the demand for irrigation will be lower. The storage capacity of the Dam will significantly limit the amount of land which will be required for the construction of the plant as no additional land will be taken up for storage facilities.

The disadvantage though with this location is that the Dam is a designated Protected Landscape site as well as a Protected Area (Zone Z3). Moreover, the area around the Dam is not developed. As a result, the landscape, visual and ecological impacts that will arise from the construction of the treatment plant will be significant, with landscape and visual impacts being more pronounced in the case of Alternative 1(b), which is upstream from the Dam.

- ALTERNATIVE 1 (A)

The first alternative site is to the ENE of the Achna Dam, and is at a distance of approximately 1.3 km from the nearest houses. This will ensure that no noise or odour impacts will arise in residential areas. The site is mostly a flat barren area, with only a few cultivated plots. One advantage of this location is that the land is not irrigated. The proximity of agricultural land to the site, and especially the non-irrigated areas, will enable the use of the treated water for irrigation, especially during the summer period. During the winter months when the demand for irrigation will be lower, the excess water can be stored in the Dam. As a result no additional land will be taken up for long-term reservoirs, thus significantly reducing the land-use impacts arising from the treatment plant.

The Dam is used for recreation purposes, such as fishing and bird-watching. Sitting the plant next to the Dam may result in landscape and visual impacts, while, in addition, during the winter months the northwest winds will direct odours from the site to the Dam, resulting in negative impacts on area users. Moreover, the proximity of the site to the Dam will result in permanent noise impacts which will adversely affect the recreational habits in the area, including fishing and bird-watching. Such impacts will also generate opposition from the users of the area. Additionally, the Dam area is largely a natural habitat, with considerable amenity value. Due to this natural state of the area the construction of the plant will result in landscape and visual impacts. Such impacts will be enhanced by the undeveloped character of the surrounding areas. On the other hand, these impacts will be to some extent minimized by the fact that the site is higher than the Dam area and located to the far northeast corner of the Dam, so the plant will only be visible to people coming to the area. Moreover, the facilities for bird watchers are on the other side of the Dam so the plant will not result in any visual intrusion to bird-watching practices.

The construction of the treatment plant near the Dam can potentially lead to significant adverse impacts on the ecology of the Dam. Odours and noise from the construction and operation of the plant may have an impact on the bird species present in the Dam area, including their reproductive and migratory patterns, as well as on any other flora and fauna species present. Further investigations will be required to establish the extent and significance of any such impacts that may result. Furthermore, any impacts on fish population from the discharge of treated effluent must be considered and the adherence to strict quality standards must be ensured to avoid these.

- ALTERNATIVE 1 (B)

The second alternative site is to the south of the Achna Dam, approximately 1.5 km from the nearest houses, which is sufficient for the avoidance of any noise and odour impacts on the resident populations.

The area upstream from the Dam is relatively flat, consisting mainly of irrigated agricultural land, with only very sparse, low structures present at some distance from the site. Next to the site are the facilities for the bird watchers. The site (or a significant part of the site) will be in a Z3 Protected Zone and a Protected Landscape area. The land next to this Zone is a G2 Agricultural Zone. This imposes building restrictions which will significantly increase the land which will be required for the plant. Furthermore, the landscape, visual and ecological impacts will be more significant.

The proximity of agricultural land to the site will enable the use of the treated water for irrigation, especially during the summer period. During the winter months when the demand for irrigation will be lowered, the excess water can be stored in the Dam, thus considerably reducing the land requirements for the plant and in turn the impacts resulting from land take-up, particularly since the site is within a Protection Zone.

These are similar as for Alternative 1(a), however, in this case, the landscape and visual impacts could potentially be more significant as the site is directly next to the plant and there are direct views from the road and some parts of the Dam area to the site, although again the higher elevation of the site will, to some extent, conceal views of the plant thus minimising impacts. Visual impacts will be more significant in the case of bird watchers as their facilities are next to the site and on the same level. As for Alternative 1(a), landscape impacts will also be further enhanced by the natural state of the Dam area and the undeveloped character of the surrounding lands.

- ALTERNATIVE 1(C)

The Alternative 1(c) site is next to Alternative 1(a), however having a much lower elevation, it is largely hidden from views, therefore landscape and visual impacts will be limited.

6.2.2.2. ALTERNATIVE 2: NEAR AGIOS GEORGIOS ACHERITOU

- ALTERNATIVE 2(A)

The first alternative site is located to the east-northeast of Agios Georgios Acheritou. It is within the SBA and next to the buffer zone. The site is at a distance of approximately 0.8 km from the nearest houses, thus no noise or odour impacts are expected on the resident population.

The area of the site is flat and undeveloped consisting mostly of rocky barren land with some agricultural plots and greenhouses.

The proximity of agricultural land and greenhouses to the site will ensure the take up of the treated water for irrigation purposes. Downstream from the site there is a gauge that can be used for the construction of the storage facilities. This will reduce some of the impacts arising from the construction of a long-term reservoir, particularly land-use impacts as the gauge is mostly barren land, however these are not eliminated as there are some orchards present on the banks of the gauge and land will still be taken-up from previous uses.

- ALTERNATIVE 2 (B)

The second site is the northwest of Agios Georgios village next to a disused Dam, and at a distance of about 0.6 km from the nearest houses. One advantage over the Alternative 2(a) site is that it is not as near to the buffer zone. However, the site is relatively close to the village housing areas, and development is moving towards the proposed site. This proximity may potentially result in noise and odour impacts on the resident population.

The area is largely agricultural land, with only sparse, low constructions, while the actual site is next to a disused Dam. Another disadvantage is there is that the nearby land that is currently used for the expansion of the village residential areas, as well as the current developments will lose economic value as a result of the proximity of the site.

Regarding water discharge, during the summer period the treated water can be used for irrigation purposes in the nearby agricultural lands. Any excess water, particularly during the winter period, can be stored in the Dam thus reducing the land requirements for the construction of storage facilities, and the associated land-use impacts.

The landscape and visual impacts that will arise from the construction of the plant will be more significant due to the fact that there are direct views from the village housing areas to the site. No significant ecological or other environmental impacts are expected.

- ALTERNATIVE 2(C)

The Alternative 2(c) site is at a distance of approximately 1.8 km from the village of Agios Georgios to the southeast and it lies within the buffer zone. It is a relatively flat area, consisting mainly of agricultural and barren land.

Two major disadvantages of the site are the additional administrative complications that could result from its position within the buffer zone, as well as the geomorphology of the area which is not suitable for the construction of the long term storage reservoir. In terms of landscape impacts, together with noise or odour impacts, these will be limited due to its distance from any housing areas and the low landscape value of the area.

6.2.2.3. ALTERNATIVE 3: NEAR XYLOFAGOU

- ALTERNATIVE 3 (A)

The first alternative site is located downstream from the village of Xylofagou, at a distance of approximately 0.5 km from the nearest houses. The main advantage of sitting the plant at this location is its proximity to the sea which will provide for the discharge of the treated water that is not taken up for irrigation particularly during the winter months. This will reduce the land requirements for the plant as there will be no need for additional storage facilities. However, discharge into the sea does not allow for actual storage of the treated effluent and its later use during the months when irrigation requirements are high. The region largely consists of agricultural land therefore the optimal solution would be one of storing the treated effluent.

Nevertheless, the proximity of the site to the housing areas is one of the major disadvantages of this site, as this could lead to significant noise and odour impacts for the resident population. Furthermore, the village residential area is developing towards the coastline and the proposed site, thus in the future such impacts will be even more enhanced.

The area is a Minor State Forest a Communal/Municipal Forest, consisting largely of forest expansions, covered by thick low vegetation, and due to its natural beauty it has a significant amenity value, particularly for the community residents who use part of the area as a park for recreation purposes, while access roads have been recently constructed and the area is used as a community park. Moreover, apart from a church, there are no other structures in the area. Due to this natural state of the site the landscape impacts will be significant. The plant will diminish the amenity and landscape value of the site, while its structure will impose on the area, altering its character. Additionally, at the site, views to the sea are clear due to absence of any man-made structures and the decreasing elevations. The plant will considerably obstruct such views leading to significant visual impacts for the area. Regarding the recreational habits in the area, these will also be impacted by any odours and noise from the plant.

The construction of the plant will lead to the destruction of large expanses of forest vegetation. Also, the resulting impacts from the plant construction and operation on migratory bird species and other fauna and flora present in the area will need to be addressed.

Overall, the impacts that will result from the construction of the plant will be significant, therefore the site must be eliminated.

- ALTERNATIVE 3 (B)

The second alternative site lies to the northwest of the Xylofagou village, at a distance of approximately 1.3 km from the nearest houses. As a result no significant noise and odour impacts are expected on the resident population. Another advantage of this site is that it can easily connect the villages of Xylofagou, Ormideia, Liopetri, Avgorou and Achna, thus potentially reducing the length of the collection systems.

The major disadvantage of this site, however, is that the area consists primarily of prime agricultural land, used mainly for the production of potatoes. The construction of the treatment plant will result in the permanent destruction of some of the country's richest agricultural land. This is enhanced by the requirements for long-term storage facilities, as no other discharge option are available for any excess treated water not taken up for irrigation. As a result, the land requirements for the plant will be significant.

The construction of the plant at this site will result in landscape and visual impacts as the area is flat, with no other developments present and clear views from the road and the surrounding area. Apart from these no other significant environmental impacts are expected.

In conclusion, the land-use impacts that will arise from the construction of the plant will be significant, therefore the site must be eliminated.

6.2.2.4. ALTERNATIVE 4: NEAR DHEKELEIA POWER PLANT

The site is near the Dhekeleia Power Plant, to the southwest of Ormideia and within the SBA. It is at a distance of about 1.8 km from the nearest houses in Ormideia, therefore no noise or odour impacts are expected on the resident population. The main advantage of this site is the nature of the area in terms of development character, landscape and environment. However, the presence of the desalination plant in the area inhibits the discharge of the treated water in the sea, thus increasing the land requirements for the plant as there will be a need for the construction of a long-term storage reservoir.

The area is mainly agricultural and industrial land. No acquisition problems are expected as the site is within the sovereign base area.

No significant environmental impacts are anticipated although further assessments will be required to ensure this. The site, being next to the power plant and in an area already heavily developed, is of low landscape value, so there will be no significant landscape or visual impacts from sitting the plan in the area. Furthermore, no significant ecological impacts, with regards to land fauna and flora, are expected as the site is within an area with an industrial character and features thus not being an environmentally sensitive area.

6.2.2.5. ALTERNATIVE 5: NEAR LIOPETRI DAM

The site is near the Liopetri Dam, at a distance of about 1.8 km from the nearest houses, which ensures that there will be no noise or odour impacts on the resident population. The main advantage of this location is that the treated water can be stored in the Dam, thus reducing the land requirements for the plant.

The land around the Liopetri Dam is a forest area and a designated Z3 Protection Zone and a Protected Landscape area. Beyond this there is some agricultural land and the area is a designated Z1 Protection Zone which will increase the land requirements for the plant as a result of building restrictions regarding the land coverage percentage.

Sitting the plant near this site will potentially lead to significant landscape impacts due to the natural state and character of the area, as well as visual impacts as the plant will create an obstruction to views from and to the protected area. The designated site has a high landscape value, therefore such impacts will be significant and could potentially diminish such value. Additionally, its proximity to the Z3 protected area may potentially result in some ecological impacts, from the construction and operation of the treatment plant, possibly as a result of construction activity and noise.

6.3. EVALUATION OF ALTERNATIVE OPTIONS

6.3.1. FINAL SELECTION OF SITE ALTERNATIVES

Following the preliminary evaluation of the site alternatives and consultations with the relevant authorities, alternative sites 1(c) and 2(c) were selected for further evaluation.

6.3.2. EVALUATION OF FINAL ALTERNATIVES

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

A number of criteria have been used to determine the extent of each of the impacts, including the expected severity of the impact, its duration and the expected probability of occurrence. 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.

Table 6.4 below outlines the evaluation criteria used for the assessment of the weighted impact scores of the alternatives examined. The following tables which also conclude the chapter give the assessment results for the alternative schemes.

The preferred alternative obtains the highest score from the environmental evaluation which justifies the elimination of the alternative near Agios Georgios and the ‘no development option’ option. As for the alternative of having 10 STPs in comparison to having one, the following evaluation was performed.

Land Requirements and Availability: The land requirements for the construction of a separate treatment plant for each of the ten project communities, including the additional land that will be required in each case for landscaping, sludge storage, parking space, offices, etc, will be significantly higher as compared to the land requirements of a single STP that would service all the villages. This would lead to the acquisition of more private land and more pronounced impacts on land use.

Additionally, there would be land availability problems as it will be difficult to find suitable sites in each community that would satisfy land requirements of the STPs, while being at sufficient distances from housing areas, and where the construction of a plant would not results in significant environmental impacts. The risk of inappropriate site selection due to land availability restrictions could potentially result in more serious impacts on geology, soils, vegetation cover, etc, that would be more difficult to mitigate. Furthermore, there will be problem of acceptance of the project by all communities.

For instance, in communities like Ormideia and Xylofagou theconstruction of an STP would inevitably lead to the desctruction of prime agricultural land, as there are no suitable sites for locating the plants. Moreover, in many communities there are no suitable sites in terms of geomorphology for the construction of the storage reservoirs, which will lead to higher impacts on the geology and solids of the area, and higher construction costs.

Landscape Impacts: will be more pronounced from the construction of ten STPs while in many cases the plants will be visible from housing areas main roads and recreation and amenity areas, as it will be difficult to locate suitable sites in all communities that would minimize such impacts.

Construction Impacts: Although construction impacts of separate STPs for each of the ten communities will significantly minimize the impacts that would arise from the construction of the conveyance system, there will still be impacts from the construction of the ten plants at different locations throughout the project region, including soil impacts, noise, atmospheric pollution (dust, fumes, etc) and traffic impacts.

The preferred alternative was also the favourable option in the site evaluation.

TABLE 6.4: EVALUATION SYSTEM

IMPACT EXTENT

SEVERITY		DURATION		POSSIBILITY OF OCCURRENCE		TOTAL SCORE
Major Negative	-15	*Negative Impacts*		*Negative Impacts*		Severity + Duration + Possibility of Occurrence
Moderate Negative	-10	Permanent	-10	High Probability	-10	
Minor Negative	-5	Short Term	-5	Low Probability	-5	
No Impact	0	No Impact	0	No Impact	0	
Minor Positive	5	*Positive Impacts*		*Positive Impacts*		
Moderate Positive	10	Permanent	10	High Probability	10	
Major Positive	15	Short Term	5	Low Probability	5	

IMPACT SCORE

IMPACT EXTENT		IMPACT MITIGATION		IMPACT SCORE
Negative Impacts		*Negative Impacts*		Impact Extent x Impact Mitigation
	-35	Not Possible to Mitigate Impacts	2	
	-30	Impact Reduced	1	
	-25	Impact Prevented	0	
	-20	Impact Prevented and Positive Impacts Derived	-(2)	
	-15			
No Impact	0	No Impact	0	
Positive Impacts		*Positive Impact*	2	
	15			
	20			
	25			
	30			
	35			

TABLE 6.5 : EVALUATION OF ALTERNATIVES

ALTERNATE LOCATION 1(C). NEAR ACHNA DAM

	SEVERITY	DURATION	POSSIBILITY	TOTAL	

TABLE 6.5: EVALUATION OF ALTERNATIVE (CONT.)

TABLE 6.5: EVALUATION OF ALTERNATIVE (CONT.)

7. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

7.1. PURPOSE AND OBJECTIVES OF THE EMP

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 implementable. These mitigation measures are usually identified during the EIA stage and then set out in a practical and co-ordinated 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.

7.2. SUMMARY OF IMPACTS AND MITIGATION MEASURES

TABLE 7.1: ANTICIPATED IMPACTS AND PROPOSED MITIGATION MEASURES

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
Impacts Related to Project Location	
Permanent land acquisition Permanent acquisition of land for construction of the STP, the storage reservoir and the pumping stations	- Compensation for loss of land, agricultural trees and possible loss of income. - Compensation and relocation measures for acquisition of any houses.
Impacts on surface water hydrology	
Impacts on ecological values No destruction of habitats, but disturbance of wildlife, particularly birds during construction of the STP, due to proximity of site to the Achna Dam. Also, possible disturbance of wildlife during operation as a result of noise. Positive impacts through the creation of a new wetland habitat if an additional long term storage reservoir is created. If storage in Achna Dam additional permanent flow will enhance species diversity.	- Use of low noise equipment during operation and construction. Impacts during construction are only temporary, therefore no additional measures required other than those proposed for the construction phase.
Impacts Related to Project Design	
No significant impacts are anticipated - Treatment process is reliable and proven and effluent will meet the set performance standards.	

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
• Emergency storage will safeguard against problems in treatment process. • Sludge treatment to be chosen will be effective in achieving required standards.	
Impacts Related to Project 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.	• Compensation for the temporary use of land, loss of production, or inconvenience created. • Design to minimise construction land requirements. • Special obligation on contractor to minimise 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 STP, 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 should be carried out to clearly indicate the number of trees to be cleared. • An equivalent number of trees (natural 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 tyres 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.

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
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 minimise noise impacts and ensure compliance with noise control measures to be imposed on contractor. Construction operations must be carefully planned to minimise construction time.
Fumes: from vehicle movements and machinery.	Plan routes to minimise 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

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
	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.
Impacts Related to Project Operation	
Landscape impacts Minimum impacts	Planting on and off site, and retention of existing vegetation where possible
Noise impacts At STP and pumping stations. Impact at STP limited as site is at a considerable 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.
Odour impacts	↳ Application and adherence to proper process procedures. ↳ Covering of process areas and provisions for adequate air filtration. ↳ Regular monitoring of processes and conducting all appropriate chemical and biochemical analyses. ↳ Regular maintenance of the plant and pumping stations. ↳ Use of odour control systems in the STP design. ↳ Appropriate design of conveyance system to avoid formation of sulphides.
Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment	No measures required.
Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations	No measures required.
Risk of insufficient treatment of effluent	↳ Regular monitoring of effluent quality
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	

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
	⇩ 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 ⇨ Favour sludge ploughing down
	❑ Grassland:

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
⇨ Allow spreading before sowing and after each cut	
⇩ Control of the metal levels in foodstuffs	
❑ Analysis of the pollutant levels in animal products (especially in offal and milk)	
Human contamination	
⇩ Limit pollutant transfer in the food chain (see above)	
⇩ 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 STORAGE OF THE TREATED EFFLUENT IN THE ACHNA DAM	
Eutrophication	
⇩ Phosphorus and nitrogen removal	
Capacity considerations	
⇩ Feasibility Study to be carried out examining storage potential	
Odours from anoxic conditions in bottom layers, eutrophication	
⇩ Management study to be carried out, incorporating design adjustments ❑ Adjustable water intake ❑ Design of water outfall too create hydraulic circulation	
⇩ Regular monitoring of effluent quality and water quality	
MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENT IN IRRIGATION	
Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality	
⇩ Drafting of Reuse Management Plan, incorporating:	
❑ Appropriate site identification (for reuse in areas outside the Irrigation Scheme) ❑ 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	

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
⇩ Crop selection based on crop sensitivity to treated effluent constituents	
Adverse impacts on health	
⇩ Timing of irrigation prior to harvesting	
⇩ Correct irrigation practices	
⇩ Minimise 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	
⇩ Implements treated effluent quality monitoring programme to ensure compliance with the set standards	
⇩ Implement soil quality monitoring programme	
⇩ Monitoring of irrigation methods and practices	

7.3. MITIGATION MEASURES

7.3.1. CONTRACTUAL BACKGROUND FOR ENVIRONMENTAL MANAGEMENT

7.3.1.1. 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 bills of 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 displayed and prepared.

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.

7.3.1.2. PREPARATION OF TECHNICAL ENVIRONMENTAL SPECIFICATIONS

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

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

Each section will address the 2 following aspects :
Sub-Section 1: description of the Contractor's obligations with regards to those aspects covered by the section.
Sub-Section 2: description of indicators 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 : Labour Camps and Worker Health Management

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

- Maximisation of employment of locally based labour 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 C : 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 D : 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/near residential areas, Regulations about use of klaxons in villages.
Fumes, dust	Regulations on refuelling, 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 organised 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.

DESCRIPTION OF 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 "Labour 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 fulfil 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 fulfil 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.

7.3.2. COMPENSATION FOR LAND ACQUISITION AND RESETTLEMENT

Compensation must be paid for all permanent land acquisitions as well as temporary acquisitions. Possible resettlement plans should be considered in the case when the long term storage reservoir will be constructed and the house present on site will be acquired.

7.3.3. 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 minimise 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.

7.3.4. DECOMMISSIONING: RECLAMATION OF TEMPORARILY 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 fertilising and seeding, mulching and surface texturing. 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, fertilisation 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).

7.4. MONITORING PROGRAMS

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.

7.4.1. WATER QUALITY MONITORING DURING CONSTRUCTION

7.4.1.1. 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 organised: one, focussing 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.

7.4.1.2. 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.

7.4.1.3. 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.

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 characterisation 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.

Therefore, 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 labour 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.

- REPORTING AND DATA INTERPRETATION

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

7.4.1.4. ORGANIZATION

The Contractor will be requested to follow up on a *weekly basis* the pollution load from its installations, in imposed sampling sites and in accordance with sampling procedures determined. Samples have to be delivered to an agreed laboratory for analysis.

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

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.

For the monitoring of the larger receiving water bodies, sampling and analysis will be carried out once a month during the construction period (April to October) by the relevant authorities.

7.4.1.5. 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.

7.4.1.6. SCHEDULE OF ACTIVITIES

TABLE 7.2: SCHEDULE OF ACTIVITIES FOR WATER QUALITY MONITORING

PERIOD	ACTIVITIES	COMMENTS
PRE-CONSTRUCTION	Prepare Contractor specifications for water quality compliance monitoring	Defines number of sites, location, parameters to analyse, 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 representativeness of conditions prevailing in the area. If possible should rely on existing stations used for long term monitoring of the whole river system.
CONSTRUCTION	Sampling in selected sites on weekly basis, deliver samples to laboratory and provide weekly report on results	Weekly report submitted to relevant authority.
	Carry out monthly random 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.
OPERATION	Carry out monthly sampling of receiving water body	Regular monitoring of the receiving water quality of storage of the treated effluent in the Achna Dam or in case of groundwater recharge

7.4.2. WATER QUALITY MONITORING DURING OPERATION

During the operation of the STP, if the treated effluent is stored in the Achna 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

7.4.3. AIR AND NOISE MONITORING

7.4.3.1. OBJECTIVE OF MONITORING

Air quality is anticipated to be locally and temporally altered by the construction activities in 3 fields: Generation of exhaust fumes from trucks and heavy machinery, production of noise and emission of dust because of earthworks.

PRODUCTION OF 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 urbanised 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 minimised 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.

7.4.3.2. 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.

7.4.3.3. 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.

7.4.3.4. SCHEDULE OF ACTIVITIES

TABLE 7.3: SCHEDULE OF ACTIVITIES FOR AIR QUALITY MONITORING

PERIOD	ACTIVITIES	COMMENTS
PRE-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 urbanised areas
	Identify suitable sites in project area and carry out preliminary sampling & analysis	Sites must be selected for easy access and representativeness of conditions prevailing in the area.
CONSTRUCTION	Carry out public information about obligations of contractor regarding fumes, dust & noise Inform villagers on grievance procedure.	Open grievance boxes in villages concerned. Link with specifications on traffic control imposed to Contractor
	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 random 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	COMMENTS
OPERATION	No activity anticipated	

7.4.4. SLUDGE CONTROL MONITORING

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.

7.4.4.1. MONITORING OF SLUDGE QUALITY

The following parameters must be analysed in order to characterise 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 5.9.

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 7.4: 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 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-percentile of the samples within a twelve-month period are at or below the threshold value and if the 10-percentile of the samples exceed only one threshold value and by less than 50%.

TABLE 7.5: 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 minimise 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.

7.4.4.2. MONITORING OF SOIL QUALITY

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)

- MONITORING FOLLOWING SLUDGE APPLICATION

- 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 7.6: 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. 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 must contain samples that have been taken proportionally at 1 sample per hectare.

7.4.4.3. MONITORING OF 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.

TABLE 7.7: 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

7.4.4.4. MONITORING OF 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:

TABLE 7.8: 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 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

7.4.4.5. 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

7.4.5. MONITORING PROGRAMME FOR THE REUSE OF THE TREATED EFFLUENT

7.4.5.1. MONITORING OF TREATED EFFLUENT QUALITY

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 7.9: SUGGESTED DISCHARGE STANDARDS FOR THE TREATED EFFLUENT QUALITY

PARAMETER	LIMIT VALUES
BOD_5	10 mg/l
COD	< 125 mg/l
SS	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
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 7.10: HEAVY METAL CONCENTRATION LIMITS

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.

7.4.5.2. MONITORING OF SOIL QUALITY

Soil quality must be monitored to ensure that there are no adverse impacts on soil quality and productivity as a result of irrigation with treated effluents.

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.

7.4.5.3. 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 7.11: MONITORING OF 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

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

7.4.5.4. 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.

7.4.6. MONITORING OF CONSTRUCTION ACTIVITIES

7.4.6.1. IMPORTANCE 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.

7.4.6.2. CONTENT AND IMPLEMENTATION OF THE MONITORING

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, Labour 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 being the approval or not of payments for the concerned issues. For information purpose, some examples of SRS are provided in Appendix 2.

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.

7.4.6.3. SCHEDULE OF ACTIVITIES

TABLE 7.12: SCHEDULE OF ACTIVITIES FOR CONSTRUCTION ACTIVITIES MONITORING

PERIOD	ACTIVITIES	COMMENTS
PRE-CONSTRUCTION	Recruit personnel	
	Organise 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	Report based on monthly review plus weekly reports from
	Quarterly report on monitoring of construction activities	Report with conclusions to be submitted to authority
OPERATION	Follow up of sites rehabilitation the first 2-3 years after completion of construction	Reporting of problems to relevant authority

7.5. ENVIRONMENTAL MANAGEMENT ORGANIZATION

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.

7.6. COST ESTIMATE FOR THE EMP

ITEM		ANNUAL BUDGET (CYP)	5 YEAR BUDGET (CYP)	RESPONSIBILITY EXECUTION
Investments		(Year 1 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
	SUB-TOTAL	*1,870,000*	*1,870,000*	
Operational Expenses				
Environmental Manager (WDD)		20,000	100,000	WDD
Environmental Supervisor (CSE)		18,000	90,000	CSE
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 & Noise		2,000	10,000	WDD/Consultant
Operation Monitoring				
Water Quality		1,000	-	ES
Air Quality & Noise		1,000	-	ES
Sludge Quality		1,000		WDD/SB
Treated Effluent Quality		1,000		WDD/SB
	SUB-TOTAL	*176400*	*862,000*	
TOTAL COST		*2,046,400*	*2,732,000*	

8. PUBLIC CONSULTATION

Consultations were carried out with the relevant authorities, including:

- Water Development Department
- The Environment Service
- The Town and Country Planning Department

Consultations took place at the feasibility stage, when the STP site was to be selected. The recommendations made by the authorities were taken into consideration in the final decision over the proposed site. These recommendations are included in Appendix 13.

Consultations with the local authorities were also carried out. Representative of all community councils were present, with the exception of Avgorou and Sotira. The feasibility study was presented to members of the local councils, including the proposed schemes and alternative sites for the sewage treatment plant. The views of the communities were included in the evaluation of the alternative sites, whereby sites not accepted by the relevant communities were considered to be unacceptable as possible options. This led to the elimination of the Liopetri site, despite the fact that from a technical and economic perspective it was the preferred solution.

With regards to the preferred alternative near the Achna Dam, the site was accepted by the community council.

APPENDIX 14

SITE PICTURES

APPENDIX 10

ALTERNATIVE PROJECT SCHEMES

APPENDIX 11

ENVIRONMENTAL SCREENING OF ALTERNATIVES

APPENDIX 13

CONSULTATION LETTERS

APPENDIX 1

STANDARDS IN CYPRUS AND 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:

$$\frac{C_{M1}}{L_{M1}} + \frac{C_{M2}}{L_{M2}} + \text{- - - -} + \frac{C_{Mi}}{L_{Mi}} \leq 1$$

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.

- 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 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. (BAO_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 A1.6: 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]
<u>Acute Toxicity</u> Microtox: organism Photobacterium phosphorium (Vibrio fischeri) Algaltox 72 hours: organism Selenastrum capricornutum Daphtox: organism Daphnia magna Straus	Applicable	Applicable
<u>Gene Toxicity 1</u> Mutatox with and without activation with hepatic enzymes S9: organism Photobacterium phosphorium (Vibrio fischeri)	Not requested	Applicable
<u>Acceptable Limits</u> The results and the limits are expressed in Toxic 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: <u>Microtox</u>: TU50 ≤ 1 or/and TU20 ≤ 1.5 <u>Daphnia</u>: TU50 ≤ 1 <u>Algae</u>: 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: <u>Microtox</u>: TU50 ≤ 1 or/and TU20 ≤ 1.5 <u>Daphnia</u>: TU50 ≤ 1 <u>Algae</u>: TU50 ≤ 1 <u>Mutatox</u>: The treated waste must not be positive in the direct or

		following the activation with S9 Mutatox test

- 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.

* TU50, TU20: toxic 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.

- The following sludge treatment methods are acceptable:
  - Anaerobic digestion
  - Mesofile
  - Regular
  - Aerobic digestion
  - Heat 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 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.

- 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.

- For monitoring the use of sludge for agricultural purposes the following programme of analysis is defined:

  - Analyses of sludge: 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, phosphorus
    - cadmium, copper, nickel, lead, zinc, mercury and chromium (Table A1.3)

  - Soil analysis: 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 and chromium (Table A1.4)

    The maximum permissible heavy metal content of the soil is shown in Table 2 and the maximum permissible quantity that can be deposited every year on agricultural land is shown in Table A1.5.

- The following sampling methods are acceptable:
  - For the soil: 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.
  - For the sludge: The samples must be representative and sampling must be carried out after the treatment of the sludge and before its delivery to the user.

- Methods of analysis: 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)
  - Phosphorus (P)
  - Potassium (K)
  - Sodium (Na)
  - Calcium (Ca)
  - Manganese (Mg)

- ⇨ Iron (Fe)
- ⇨ Boron (B)

TABLE A1.3: MAXIMUM PERMISSIBLE HEAVY METAL CONTENT IN THE SLUDGE (MG/KG OF DRY MATTER)

PARAMETERS	MAXIMUM VALUE (MG/KG)
Cadmium (Cd)	40
Copper (Cu)	1750
Nickel (Ni)	400
Lead (Pb)	1200
Zinc (Zn)	4000
Mercury (Hg)	25
Chromium (Cr III)	1000

TABLE A1.4: MAXIMUM PERMISSIBLE HEAVY METAL CONTENT IN THE SOIL (MG/KG OF DRY MATTER)

PARAMETERS	MAXIMUM VALUE (MG/KG)
Cadmium (Cd)	3
Copper (Cu)	140
Nickel (Ni)	75
Lead (Pb)	300
Zinc (Zn)	300
Mercury (Hg)	1.5
Chromium (Cr III)	150

TABLE A1.5: 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	MAXIMUM VALUE (MG/KG)
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 A1.7: DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE

PARAMETER	VALUE
BOD_5	25 mg/l
COD	90 mg/l
SS	35 mg/l

For discharge to sensitive water bodies, the following additional limits shall apply:

TABLE A1.8: ADDITIONAL DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE FOR DISCHARGE TO SENSIBLE WATER BODIES

PARAMETER	VALUE
Total-N	15 mg/l N (10,000 to 100,000 PE) 10 mg/l N (> 100,000 PE)
Total-P	2 mg/l (10,000 to 100,000 PE) 1 mg/l (> 100000 PE)

In the case that the treated wastewater could not be reused, a possibility for discharge should be provided. The discharge point would in most cases be into a small, non permanent, water course in the vicinity of the treatment plant. Since these water courses most often are dry, they should be considered as sensible areas according to the EU directive and the additional standards in should apply.

APPENDIX 4

PROJECT IMPLEMENTATION PROGRAMME

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 middle load)
C	Mixed sludge (A and B2 types)
D	Digested sludge

TABLE A8.2: PHYSICOCHEMICAL CHARACTERISTICS OF SEWAGE SLUDGES

PARAMETER		ANAEROBIC SLUDGE		AEROBIC SLUDGE	
		MEAN	STD	MEAN	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	
		MEAN	STD	MEAN	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
Total 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
Date	1995 – 1999
Dry Matter (%)	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	4.3×10^4/100g
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
O.M. %	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
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 DM	$N - NH_4$ % OF N TOTAL	P % OF DM
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 DM)	$N\text{-}NH_4^+$ (% 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 (%)
Aerobic digested sludge	24 – 61 %
Anaerobic 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 DM)	P (% of DM)
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 microorganisms, livestock and human health, and accumulate in the environment. The average content of 7 heavy metals in the member states is given below.

TABLE B10: AVERAGE CONTENT IN SEWAGE SLUDGE OF 7 HEAVY METALS IN THE MEMBER STATES

	DIRECTIVE 86/278/EEC mg/kg DM	RANGE IN THE MEMBER STATES mg/kg DM
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 microorganisms 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 15

REFERENCES

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6. Agricultural Statistics 2001, Statistical Service
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APPENDIX 12

DRAWINGS

APPENDIX 2

WATER PRODUCTION

APPENDIX 16

OPINION OF THE PUBLIC AUTHORITY

APPENDIX 3

PUMPING STATIONS

TABLE A3.1: PUMPING STATIONS

LOCATION		HEAD (m)	FLOW (l/s)	INSTALLED POWER (kW)	ANNUAL ENERGY CONSUMPTION (kWh)
	URBAN/RURAL/ GOVERNMENTAL				
Avgorou – Achna STP	U	15	150.0	33.75	211 179
Acnha – Achna STP	U	27	38.0	15.39	96 297
Deryneia - Frenaros	U	15	38.4	8.64	54 062
Sotira – Frenaros	U	28.8	19.2	8.29	51 899
Ormideia – Achna	U	90	15.0	20.25	126 707
Xylotymbou – Achna	G	45	15.0	10.13	63 354
Sotira TA – Liopetri	U	90	15.0	20.25	126 707
A.G. Acheritou – Achna STP 1	U	45.9	9.3	6.40	40 065
A.G. Acheritou – Achna STP 2	R	60	9.3	8.37	52 372
Liopetri – Avgorou	U	21.3	35.0	11.18	69 971
Xylofagou – Avgorou	U	22	18.0	5.94	37 167
Frenaros - Avgorou	U	21.3	70.0	22.37	139 941

TABLE A3.2: GRAVITY CONVEYORS

LOCATION		PIPE	QUANTITY (m)
	URBAN/RURAL/ GOVERNMENTAL	DIAMETER (mm)	
Xylotymbou – Achna	U	200	0
Ormideia – Achna	U	200	80
Achna – Achna STP	U	300	580
Achna – Achna STP	U	700	1 988
Xylofagou – Avgorou	U	250	161
Avgorou – Achna STP	U	600	628
A.G. Acheritou – Achna STP	U	200	206
A.G. Acheritou – Achna STP	U	200	1 060
Liopetri – Avgorou	U	300	21
Sotira – Frenaros	U	200	20
Sotira TA – Liopetri	U	200	67
Deryneia – Frenaros	U	400	132
Frenaros - Avgorou	U	400	2 591
		TOTAL	7 533

TABLE A3.3: PUMPING MAINS

LOCATION		PIPE DIAMETER (mm)	QUANTITY (m)
	URBAN/RURAL/ GOVERNMENTAL		
Xylotymbou – Achna	U	140	2 697
Ormideia – Achna	U	160	3 954
Achna – Achna STP	U	250	5 442
Xylofagou – Avgorou	U	180	3 583
Avgorou – Achna STP	U	400	1 145
A.G. Acheritou – Achna STP	U	125	1 520
A.G. Acheritou – Achna STP	U	140	2 854
Liopetri – Avgorou	U	250	3 371
Sotira – Frenaros	U	180	2 791
Sotira TA – Liopetri	U	160	4 219
Deryneia – Frenaros	U	250	1 650
Frenaros – Avgorou	U	315	3 953
		TOTAL	37 178

APPENDIX 5

CLIMATIC DATA

TABLE A5.1: CLIMATOLOGICAL DATA 1981 – 1990: ACHNA STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	19,1	19,8	23,6	30,8	35,3	35,9	37,7	38	36,9	32,1	26,6	21,8	29,7
Mean Monthly Minimum Temperature (C)	1,1	1,2	2,4	5,7	8,3	13,9	17,9	17,7	15,8	11,3	6,3	3	8,6
Mean Monthly Temperature (C)	10,1	10,5	13	18,25	21,8	24,9	27,8	27,85	26,35	21,7	16,45	12,4	19,15
Extreme Monthly Maximum Temperature	20.3	20.8	25.5	36.5	39.8	37.6	41.8	39.0	38.5	34.5	29.5	25.0	–
Extreme Monthly Minimum Temperature	-1.7	-1.0	0.4	5.0	7.0	12.5	18.0	17.1	15.2	7.3	2.7	0.2	–
PRECIPITATION													
Normal Precipitation (mm) (1961-1990)	59	54	39	17	8	3	0	0	1	20	44	84	329
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	80	80	77	65	56	56	59	58	60	63	74	79	67
Mean RH at 13:00 hrs LST (%)	60	58	58	52	49	50	52	50	48	46	53	58	52

TABLE A5.2: CLIMATOLOGICAL DATA 1991 – 2000: ACHNA STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	20,1	20,5	23,7	30,8	34,6	36,6	38,2	38,2	36,7	34,1	28,2	21,5	30,3
Mean Monthly Minimum Temperature (C)	1,3	1,4	2,7	5,4	9,9	14,7	18,7	19,4	15,9	12,5	6,6	4	9,4
Mean Monthly Temperature (C)	10,7	10,95	13,2	18,1	22,25	25,65	28,45	28,8	26,3	23,3	17,4	12,75	19,85

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Extreme Monthly Maximum Temperature (C)	22.5	23.3	27.0	35.9	40.5	41.7	41.2	42.5	41.0	36.5	31.2	24.5	–
Extreme Monthly Minimum Temperature (C)	-2.0	-1.0	1.0	2.5	7.5	12.5	17	17.7	13.6	9.5	2	0.6	–
PRECIPITATION													
Mean Monthly Precipitation (mm)	53,1	37,4	27,7	24,8	10,1	1	0,4	0	3,1	25,4	52,2	77,1	312,1
Normal Precipitation (mm)(1961-1990)	59,3	53,7	38,6	17,1	8,4	3,5	0,1	0	1,4	20	43,6	83,8	329,5
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	81	78	73	67	60	59	62	65	60	61	73	82	68
EVAPORATION													
Mean Daily Evaporation (mm)	1,2	1,9	3	4,4	6,3	8,1	8,5	7,8	6,5	4,4	2,2	1,1	4,6
WINDRUN													
Mean Daily Windrun at 2m (km)	98	108	122	117	110	111	115	107	110	102	101	90	108

TABLE A5.3: MONTHLY AND ANNUAL PRECIPITATION (MM), 1961 – 1990

VILLAGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUALLY
Xylotymvou	59	53	35	18	9	4	1	0	1	19	41	83	323
Achna	59	54	39	17	8	3	0	0	1	20	44	84	329
Xylofagou	62	55	31	17	9	2	0	0	0	22	40	80	318
Vrysoulles	62	59	35	14	10	3	1	0	1	22	44	84	335
Frenaros	61	58	34	13	11	3	1	0	1	22	43	84	331
Sotira	63	58	35	15	9	3	1	0	1	23	43	84	335
Paralimni	70	62	35	15	7	3	1	0	1	25	45	87	351
Deryneia	69	63	36	15	9	3	1	0	1	24	46	88	355

TABLE A5.4.: AVERAGE MONTHLY WIND SPEED, M/S (1982 – 1992)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUALLY
Anemograph, Height: 7m	2,8	3	3,1	3,1	3,2	3,3	3,4	3,3	3,1	2,8	2,7	2,7	3
Anemometre, Height: 2m	1,4	1,4	1,5	1,4	1,5	1,5	1,5	1,5	1,4	1,3	1,3	1,3	1,4

TABLE A5.5: PERCENTAGE OF OCCURRENCE OF THE MEAN HOURLY WIND SPEED, 1982 – 1992: ACHNA STATION

WIND DIRECTION	FREQUENCY %	WIND SPEED (M/S)													
		<1	2	3	4	5	6	7	8	9	11	13	15	17	>17
0	8,5	0,23	3,16	2,71	1,42	0,57	0,25	0,09	0,03	0,02	0,01	0	0	0	0
30	5,9	0,19	1,52	1,08	1,09	0,95	0,6	0,32	0,11	0,04	0,02	0	0,01	0,01	0
60	5,2	0,13	0,97	0,98	1,06	0,96	0,64	0,33	0,08	0,03	0,01	0	0,04	0,19	0,01
90	1,8	0,14	0,77	0,44	0,31	0,1	0,04	0,01	0	0	0	0	0,01	0,02	0
120	1,4	0,18	0,64	0,25	0,2	0,08	0,03	0,01	0	0	0	0	0	0	0
150	2	0,15	0,6	0,45	0,37	0,24	0,14	0,03	0,01	0,01	0	0	0	0	0
180	17	0,29	1,8	2,13	3,15	4	3,23	1,58	0,54	0,19	0,09	0,02	0	0	0
210	13,7	0,22	2,64	2,53	1,93	1,89	1,73	1,38	0,74	0,37	0,22	0,03	0,07	0,12	0
240	4,8	0,16	2,24	1,41	0,5	0,22	0,13	0,08	0,03	0,02	0	0	0,08	0,13	0
270	6,6	0,31	3,5	1,72	0,59	0,26	0,11	0,07	0,04	0,01	0,01	0	0,07	0,12	0
300	16,8	0,29	4,62	6,47	3,19	1,38	0,57	0,18	0,08	0,02	0	0	0,02	0,03	0
330	16,5	0,26	5,31	7,08	2,66	0,76	0,25	0,1	0,05	0,02	0	0	0	0	0
TOTAL		**2,55**	**27,77**	**27,25**	**16,47**	**11,41**	**7,72**	**4,18**	**1,71**	**0,73**	**0,36**	**0,05**	**0,3**	**0,62**	**0,01**

TABLE A5.6: MEAN HOURLY WIND SPEED, 1982 – 1992: ACHNA STATION

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01.00	2,4	2,5	2,5	2,3	2,3	2,1	2,2	2,1	2,4	2,3	2,4	2,5
02.00	2,4	2,5	2,5	2,3	2,2	2	2,1	2,2	2,3	2,4	2,4	2,5
03.00	2,4	2,5	2,6	2,2	2,1	1,8	2	2,1	2,2	2,3	2,4	2,5
04.00	2,4	2,6	2,5	2,2	2	1,8	1,9	1,9	2,1	2,3	2,4	2,5
05.00	2,4	2,5	2,4	2,2	2	1,7	1,8	1,8	2	2,3	2,4	2,5
06.00	2,4	2,5	2,4	2,1	2	1,7	1,8	1,7	1,9	2,2	2,4	2,4
07.00	2,4	2,5	2,4	2,3	2,4	2,2	2,1	1,9	2	2,2	2,4	2,3
08.00	2,4	2,6	2,6	2,8	2,8	2,6	2,5	2,3	2,3	2,5	2,4	2,3
09.00	2,6	2,8	3	3,2	3,2	3,1	3	2,7	2,6	2,8	2,7	2,5
10.00	3,1	3,4	3,5	3,6	3,9	3,9	3,8	3,3	3	3,2	3,1	2,9
11.00	3,5	3,9	3,8	4,1	4,7	4,7	4,6	4,3	3,8	3,6	3,4	3,3
12.00	3,7	4,1	4,2	4,6	5,2	5,3	5,3	5,1	4,6	4	3,7	3,6
13.00	3,8	4,4	4,5	4,8	5,4	5,7	5,7	5,5	5,1	4,4	3,9	3,7
14.00	3,9	4,4	4,7	5	5,4	5,8	5,9	5,8	5,3	4,4	4	3,9
15.00	3,9	4,3	4,6	5	5,3	5,6	5,9	5,9	5,3	4,4	4	3,8
16.00	3,5	4,2	4,4	4,6	4,9	5,4	5,7	5,8	5,1	4,1	3,7	3,4
17.00	2,9	3,6	3,8	4	4,4	4,9	5,4	5,4	4,5	3,3	3	2,7
18.00	2,5	2,8	2,9	3,2	3,6	4,2	4,7	4,6	3,4	2,3	2,4	2,4
19.00	2,3	2,4	2,4	2,5	2,7	3,3	3,7	3,5	2,6	2	2,1	2,3
20.00	2,3	2,4	2,2	2,3	2,2	2,6	2,8	2,7	2,3	2	2,1	2,3
21.00	2,3	2,3	2,3	2,2	2,2	2,4	2,4	2,4	2,4	2,1	2,2	2,4
22.00	2,3	2,4	2,4	2,3	2,2	2,3	2,2	2,3	2,5	2,3	2,2	2,4
23.00	2,3	2,4	2,4	2,3	2,3	2,3	2,3	2,3	2,5	2,3	2,3	2,4
24.00	2,4	2,5	2,4	2,3	2,2	2,2	2,3	2,3	2,5	2,3	2,4	2,4
MEAN MONTHLY WIND SPEED	**2,77**	**3,02**	**3,06**	**3,10**	**3,23**	**3,32**	**3,42**	**3,33**	**3,11**	**2,83**	**2,77**	**2,75**

TABLE A5.7: WIND DIRECTION, 1982 – 1992: ACHNA STATION

WIND DIRECTION	0	30	60	90	120	150	180	210	240	270	300	330
MONTH	PERCENTAGE OF OCCURRENCE											
January	13,6	8,6	6,2	2,1	1,3	1,2	3,8	10,8	5,2	8	15,3	23,9
February	9,7	9,3	7,5	2,2	1,3	2	5,9	12,4	6,1	7,7	14,5	21,4
March	9,9	9	7,5	1,2	1,1	1,7	8,2	11,3	5,9	7,8	15,9	20,5
April	8,4	6	7,7	1,8	1,8	3,4	14,7	14,2	4,7	6,4	15,7	15,2
May	6,1	5	4,9	2,2	1,8	2,8	23,7	16,1	4,2	5,8	15,4	12
June	5	3,5	3	1,4	1,9	2,1	35,2	15	4,4	5,8	12,4	10,4
July	5	2,3	2,6	0,9	1,1	2,3	32,1	21,2	4	5,9	12,2	10,4
August	4,6	2,6	2,1	1,4	0,9	2	30,9	19,2	4,2	6,5	15,4	10,3
September	4,2	3,6	2,3	1,5	0,7	1,7	23,6	15,5	4,8	6,5	24,4	11,3
October	8,3	5,6	4,6	1,8	1,4	1,7	13,2	10,6	4,7	5,8	24,6	17,7
November	13,1	7,9	7,6	2	1,5	1,4	6,9	8,2	4,7	5,3	18,8	22,7
December	13,6	8	6,3	2,9	1,7	1,5	5,2	9,6	5,3	7,4	16,4	22
AVERAGE	**8,46**	**5,95**	**5,19**	**1,78**	**1,38**	**1,98**	**16,95**	**13,68**	**4,85**	**6,58**	**16,75**	**16,48**

APPENDIX 6

DESCRIPTION OF COMMUNITIES

XYLOTYMVOU

GENERAL DESCRIPTION

Xylotymvou lies west of Xylofagou. It is an inland village, but located not far from the tourism development areas of southern Famagusta and Larnaca Town. Potato crop agriculture is the main source of income. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Xylotymvou, like the rest of the villages in the area, is endowed with rich agricultural land. Tourism-related employment provides supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Xylotymvou has grown from 3,139 in 1992 to 3,438 in 2001, corresponding to an absolute growth of only 9.5% (or 0.9% per annum). This rate of growth is much lower that of the Famagusta District average (excluding Paralimni and Ayia Napa). It has only a limited population growth in contrast with the other villages in the area. This is attributed to the absence of local tourism development.

There appear to be two alternative scenarios which lead roughly to the same estimate of future housing needs: Projection of future household increase based on the current trend and one based on the population capacity of the presently allocated housing land for the future growth. Both show the future (2030) number of household to be approximately 1,330-1,370.

TABLE A6.1: POPULATION FORECAST FOR XYLOTYMVOU

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 0.9% p.a. population growth scenario	1,030	1,130	1,250	1,370
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period)	1,030	1,130	1,230	1,330
Probable future growth scenario (continuation of the current rate of population growth)	1,030	1,130	1,230-1,250	1,330-1370

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Xylotymvou is its location near Larnaca and Southern Famagusta, both major tourism employment centres. Agriculture has been for many years an important growth factor explaining the community's population growth. Its growth of approximately 0.9% p.a. is likely to continue in the next 30 years. Agriculture will probably decline but tourism employment will continue to be the major source of economic and population growth.

Tourism development (apartments and hotels) is unlikely to be attracted in any significant scale.

The possibility of the future opening of Famagusta will provide some new employment compensating for the decline of agricultural income. The land stock already zoned for housing development is estimated to be sufficient for the 30-year period.

As a conclusion, a population of approximately 4500 inhabitants (1370 households) with an average growth of 0.9% is projected at the horizon 2030.

DENSIFICATION OF THE POPULATION

The spatial development pattern of Xylotymvou 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 mainly towards Ormideia village (west). The area of the village housing development zone is about 165 ha of which only about 100 is built up. The remaining area of about 65 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 40). The densification of the population in the residential area is estimated to be approximately 30 inhabitants/ha.

ACHNA

GENERAL DESCRIPTION

Achna is a Refugee Housing Estate of 561 housing units established by the Government under the Refugee Housing Programme, located at the north-western edge of the part of Famagusta District under the control of the Cyprus Government. It fronts directly on the 'buffer zone'. The village of Achna itself is in the occupied area. Building development in the Estate is managed by the Refugee Housing Management Programme of the Ministry of Interior (Dept. of Town Planning & Housing). The site of the Estate is legally Forest Land used for housing to provide temporary housing for refugees mainly of Achna village. The surrounding land is mostly rich agricultural land. Tourism-related employment provides supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of the Achna Housing Estate has remained roughly constant. New housing development of about 110 houses around the Estate accounts for population increase from 1,763 in 1992 to 1,952 in 2001, corresponding to an absolute growth of only 10.7% (or 1.0% per annum). This rate of growth is just lower that of the Famagusta District average (excluding Paralimni and Ayia Napa). It has only a limited population growth because of the 'abnormal' character and position of the settlement constraining the availability of land for housing expansion and the economic opportunities for growth.

There appear to be two alternative scenarios for the future growth of Achna. One under the existing conditions of constrained growth, and one with the 'Solution of the Cyprus Problem'. The first is based on the current low population growth and the other (rather speculative scenario) based on Achna village regaining its growth potential as a 'suburb' of Famagusta also with rich agricultural land for potato production. Under the second scenario it could be expected that population growth will be close to the urban/peri-urban average of 1.75% p.a., like the one assumed for Avgorou under the 'Solution of the Cyprus Problem' scenario.

TABLE A6.2: POPULATION FORECAST FOR ACHNA

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 1.0% p.a. population growth scenario	631	700	770	850
With 'Solution of the Cyprus Probable' scenario (growth rate of 1.75% p.a). It is assumed that about 80% of the Estate population (416) will move to the village increasing at 1.75% p.a).		500	600	700

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The continuation of the existing situation will mean limited growth of the Achna population within the framework of the Refugee Estate. Growth will be confined to the available land north and south-east of the Estate.

The Solution of the Cyprus Problem will shift and increase population growth in and around Achna village due to opening up of the village and its proximity to Famagusta town. Most part of the reconstruction and reactivation of Famagusta will probably take about 2-3 years.

From the point of view of wastewater infrastructure planning the existing Refugee Housing will probably be used for low-income housing thus requiring service provision. This will be necessary for household service delivery and for the protection of the Achna Dam from uncontrolled effluent disposal. It may be assumed that about half of the estate houses will be rehabilitated to accommodate regional low-income population

As a conclusion, a population of approximately 3200 inhabitants is projected at the horizon 2030.

DENSIFICATION OF THE OPULATION

The spatial development of Achna Estate is planned according to the Government Master Plan. There is no designated housing development zone and building development around the Estate is regulated according to the old Streets and Buildings Regulation Law Cap. 96. To the north of the Estate lies the Achna Dam which is Protected Area where no building development is allowed except in special cases approved by the Planning Authority. New housing is mostly located north of the Estate and south east of the Achna Dam Protected Area.

The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha**.**

ORMIDEIA

GENERAL DESCRIPTION

Ormideia lies to the south of Xylotymvou. It is an inland village, but located not far from the tourism development areas of southern Famagusta and Larnaca Town. Potato crop agriculture is the main source of income. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Ormideia (like Xylotymvou and Xylofagou) is endowed with rich agricultural land. Tourism-related employment provides supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Ormideia has grown from 3,682 in 1992 to 3,960 in 2001, corresponding to an absolute growth of only 7.5% (or 0.7% per annum). This rate of growth is much lower that of the Famagusta District average (excluding Paralimni and Ayia Napa). It has only a limited population growth in contrast with the other villages in the Famagusta District area. This is attributed to the absence of local tourism development.

There appear to be two alternative scenarios which lead roughly to the same estimate of future housing needs: Projection of future household increase based on the current trend and one based on the population capacity of the presently allocated housing land for the future growth. Both show the future (2030) number of household to be approximately 1,500.

TABLE A6.3: POPULATION FORECAST FOR ORMIDEIA

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 0.7% p.a. population growth scenario	1,200	1,300	1,400	1,500
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period.)	1,200	1,130	1,230	1,500
Probable future growth scenario (continuation of the current rate of population growth)	1,200	1,300	1,400	1,500

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Ormideia (like in Xylofagou and Xylotymvou) is its location near Larnaca and Southern Famagusta, both major tourism employment centres. Agriculture has been for many years an important growth factor explaining the community's population growth. Its growth of approximately 0.7% p.a. is likely to continue in the next 30 years. Agriculture will probably decline but tourism employment will continue to be the major source of economic and population growth.

Tourism development (apartments and hotels) is unlikely to be attracted in any significant scale.

The possibility of the future opening of Famagusta will provide some new employment compensating for the decline of agricultural income.

The land stock already zoned for housing development is estimated to be sufficient for the 30-year period.

As a conclusion, a population of approximately 4900 inhabitants (1500 households) with an average growth of 0.7% is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Ormideia is typical of most villages. It has an old village core with old houses and shops, around which new shops and some offices are concentrated, and a spread out new housing development area mainly towards Xylotymvou village (north). The area of the village housing development zone is about 185 ha of which about 120-125 is built up. The remaining area of about 60-65 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 20).

Housing development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones were recently designated 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. The housing development zones (village core and surrounding area) of 185 ha corresponds to a population capacity of about 7,500, while the presently vacant land stock (about 35% of the area) could accommodate an additional amount of about 250-270 housing units.

The densification of the population in the residential area is estimated to be approximately 30 inhabitants/ha**.**

AVGOROU

GENERAL DESCRIPTION

Avgorou lies to the east of Liopetri and borders on Achna (refugee housing estate) close to the 'buffer zone'. It is an inland village with potato crop agriculture being the main source of growth combined with tourism employment as a source of supplementary income. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Avgorou, like the rest of the villages in the area, is endowed with rich agricultural land.

POPULATION TRENDS

The population of Avgorou has grown from 3,581 in 1992 to 4,002 in 2001, corresponding to an absolute growth of nearly 11.8% (or 1.1% per annum). This rate of growth is equal to the Famagusta District average (excluding Paralimni and Ayia Napa) and well below the District average including these two prime settlements. It has the fourth highest growth rate among the settlements included in the Study villages, after Sotira, Deryneia and Liopetri.

A range of projections appear to exist of future population growth with several intermediate ones. Two are considered here. One projection is base on the current population growth of 1.1%, and one based on the population capacity of the designated housing zone area, which give different population estimates. A third scenario is considered following the Solution of the Cyprus Problem that will transform Avgorou into a 'suburb' of Famagusta.

TABLE A6.4: POPULATION FORECAST FOR AVGOROU

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 1.1% p.a. population growth scenario	1,111	1,240	1,380	1,540
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period	1,111	1,320	1,530	1,750
Probable future growth scenario (with and without Solution of the Cyprus Problem)				
-Without Solution (Population growth rate is unlikely to increase above the current rate. Agricultural development will decline due to foreign competition in the European potato market and falling export prices).	1,111	1.240	1,380	1,540
-With the Solution of the Cyprus Problem (Its close proximity to Famagusta will transform Avgorou as a 'suburb' of Famagusta, with a consequent increase in population growth probably similar to the national urban average of between 1.5 – 2.0%, say 1.75%).	1,111	1,320	1,570	1,870

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

Without the Solution of the Cyprus problem, Avgorou will remain an agricultural village with supplementary tourism employment income. But, with the Solution of the Cyprus problem being a highly probable scenario, it will assume a new role as a peri-urban village of Famagusta offering opportunities for new housing and population development triggered by the Famagusta urban and tourist economy. The assumed growth rate of 1.75% p.a. seems justified being close to that in areas under urbanization pressures.

Avgorou may also attract seasonal holiday houses in locations close to the main Avgorou-Famagusta road.

The possibility of the future opening of Famagusta will provide new employment compensating for the decline of agricultural income.

The land stock already zoned for housing development is estimated to be sufficient for a large proportion of the demand for up to 2020 but the reactivation of Famagusta will call for a new land use plan for Avgorou.

As a conclusion, a population of approximately 6700 inhabitants (1870 households) with an average growth of 1.8% is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Avgorou 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. The area of the village housing development zone is about 435 ha of which only about 222 is built up. The remaining area of about 213 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 35). Development sprawls in all areas but mainly towards Liopetri and Achna.

Housing development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones were recently designated 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. Part of the designated housing zones takes into account future holiday housing demand. The housing development zones (village core and surrounding area) of 435 ha corresponds to a population capacity of about 18,000, while the presently vacant land stock (about 50% of the area) could accommodate an additional amount of about 640 housing units.

The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha**.**

XYLOFAGOU

GENERAL DESCRIPTION

Xylofagou lies to the west of Liopetri. It is no coastal building development area and thus without any tourism development, but location very close to the tourism development areas of Sotira, Paralimni and Ayia Napa. Potato crop agriculture is the main source of income. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Xylofagou, like the rest of the villages in the area, is endowed with rich agricultural land. Tourism-related employment provides supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Xylofagou has grown from 4,517 in 1992 to 4,957 in 2001, corresponding to an absolute growth of only 9.7%. This rate of growth is much lower that of the Famagusta District average (excluding Paralimni and Ayia Napa). It has only a limited population growth in contrast with the other villages in the area. This is attributed to the absence of local tourism development.

There appear to be two alternative scenarios which lead roughly to the same estimate of future housing needs: Projection of future household increase based on the current trend and one based on the population capacity of the presently allocated housing land for the future growth. Both show the future (2030) number of household to be approximately 1,900.

TABLE A6.5: POPULATION FORECAST FOR XYLOFAGOU

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
10-year average of 9.7 % population growth scenario	1,464	1,600	1,750	1,900
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period	1,464	1,600	1,750	1,900
Probable future growth scenario (continuation of the current rate of population growth	1,464	1,600	1,750	1,900

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Xylofagou is its location near a major tourist centre of Paralimni and Ayia Napa. Agriculture has been for many years an important parallel and contributory growth factor, both explaining the community's population growth despite its 'rural' character. Its low population growth is likely to continue in the next 30 years. Agriculture will probably decline but tourism employment will continue to be the main source of economic and population growth as at present.

Tourism development (apartments and hotels) is unlikely to be attracted in any significant scale in the coastal area as most of the coastal area is in the Sovereign British Military Area.

The possibility of the future opening of Famagusta will provide some new employment compensating for the decline of agricultural income.

The land stock already zoned for housing development is estimated to be sufficient for the 30-year period.

As a conclusion, a population of approximately 6400 inhabitants (1900 households) with an average growth of 0.9% is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Xylofagou 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 towards Liopetri (northeast and east) and Ayia Napa. The area of the village housing development zone is about 278 ha of which only about 200 is built up. The remaining area of about 80 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 30).

Housing and tourism development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones were recently designated 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. Part of the designated housing zones takes into account future holiday housing demand. The housing development zones (village core and surrounding area) of 278 ha corresponds to a population capacity of about 11,500, while the presently vacant land stock (about 30% of the area) could accommodate an additional amount of about 450 housing units.

The densification of the population in the residential area is estimated to be approximately 25 inhabitants/ha**.**

AGIOS GEORGIOS ACHERITOU

GENERAL DESCRIPTION

Agios Georgios Acheritou is a refugee housing estate of 500 housing units established by the Government under the Refugee Housing Programme, located at the northern upper corner of the part of Famagusta District under the control of the Cyprus Government. It fronts directly on the 'buffer zone' and the road to Famagusta controlled by the Sovereign British Base Area. The village of Agios Georgios Acheritou itself is in the occupied area. Building development in the Estate is managed by the Refugee Housing Management Programme of the Ministry of Interior (Dept. of Town Planning & Housing). The surrounding land is mostly rich agricultural land. Tourism-related employment provides some supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Agios Georgios Acheritou Housing Estate has actually declined from 1,765 in 1992 to 1,646 in 2001. There is a tendency for refugee families to move to other areas mostly in the Famagusta District nearer the tourist areas. New housing development of about 31 houses around the Estate within the designated housing development zone.

There appear to be two alternative scenarios for the future growth of Agios Georgios, like for Achna. One under the existing conditions of declining, or at best constant population, and one with the 'Solution of the Cyprus Problem'. The first is based on the current constant population level and the other (rather speculative scenario) based on Agios Georgios Acheritou village regaining its growth potential as a 'suburb' of Famagusta also with rich agricultural land for potato production. Under the second scenario it could be expected that population growth will be close to the urban/peri-urban average of 1.75% p.a., like the one assumed for Achna and Avgorou under the 'Solution of the Cyprus Problem' scenario.

TABLE A6.6: POPULATION FORECAST FOR AGIOS GEORGIOS ACHERITOU

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Constant 2002 population scenario	531	531	531	531
With 'Solution of the Cyprus Probable' scenario (growth rate of 1.75% p.a). It is assumed that about 80% of the Estate population will move to the village increasing at 1.75% p.a).		505	600	720

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The continuation of the existing situation will mean at best constant population growth within the framework of the Refugee Estate.

The Solution of the Cyprus Problem will stimulate a shift of population growth in and around Agios Georgios Acheritou village (a few km. north of the Estate) due to opening up of the village and its proximity to Famagusta town. Most part of the reconstruction and reactivation of Famagusta will probably take about 2-3 years.

From the point of view of wastewater infrastructure planning the existing Refugee Housing will probably be used for low-income housing thus requiring service provision. It may be assumed that about half of the estate houses will be rehabilitated to accommodate regional low-income population.

As a conclusion, a population of approximately 3200 inhabitants is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development of Agios Georgios Acheritou Estate is planned according to the Government Master Plan. There is a designated housing development zone of 80 ha and building development around the Estate is regulated according to the Policy for the Countryside. An area of about 70 ha is mostly empty with capacity to accommodate about 260 additional housing units. This area is highly unlikely to be developed as there is no demand for housing land due to the areas political constraints and location disadvantage at some distance from the tourism employment areas.

Future growth of any notable scale cannot be anticipated unless under the scenario of the Solution of the Cyprus problem when the village of Acheritou will become accessible to its inhabitants. Most of the Estate inhabitants (elderly couples) are from this village.

The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha**.**

LIOPETRI

GENERAL DESCRIPTION

Liopetri lies to the south east of Sotira. It is a coastal village with a small coastal area most of it taken up by the Protected Area of Potamos Liopetriou (an estuary). It has limited tourism potential, although its location close to the tourism development areas of Paralimni, Ayia Napa and Sotira constitutes a main source of growth together with potato crop agriculture. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Liopetri, like the rest of the villages in the area, is endowed with rich agricultural land with potato crops representing the second most important source of income after tourism-related employment. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Liopetri has grown from 3,321 in 1992 to 3,837 in 2001, corresponding to an absolute growth of nearly 15.5% (or 1.4% per annum). This rate of growth is higher than that of the Famagusta District average (excluding Paralimni and Ayia Napa) and well below the District average including these two prime settlements. It has the third highest growth rate among the settlements included in the Study villages, after Sotira and Deryneia.

A range of projections appear to exist of future population growth with several intermediate ones. One projection is base on the current population growth, and one based on the population capacity of the designated housing zone area, which roughly corresponds to the housing needs up to the year 2030 if the presently high population growth rate of 1.4 per annum continues over the whole period.

TABLE A6.7: POPULATION FORECAST FOR LIOPETRI

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 1.4% p.a. population growth scenario	1,085	1,250	1,430	1,650
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period	1,085	1,250	1,400	1,600
Probable future growth scenario (the same at present) Population growth is unlikely to increase above the current rate. Agricultural development will decline due to foreign competition in the European potato market and falling export prices. With the Solution of the Cyprus Problem tourism development will most probably shift towards Deryneia and Famagusta reducing local tourism-related development. But, Liopetri being close to Famagusta will be part of the regional tourism labour pool as at present.	1,085	1,250	1,400	1,600

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Liopetri is its location near a major tourist centre of Paralimni and Ayia Napa. Agriculture has been for many years an important parallel and contributory growth factor, both explaining the community's population growth despite its 'rural' character. Its growth of 1.4% p.a. is unlikely to continue in the next 30 years, if Famagusta remains in the occupied area. Agriculture will probably decline but tourism employment in near proximity will continue to be the major source of economic and population growth.

Tourism development (apartments and hotels) is unlikely to be attracted in any significant scale in the coastal area as most of the coastal area is a Protected Area (Potamos Liopetriou).

The possibility of the future opening of Famagusta will provide new employment compensating for the decline of agricultural income.

The land stock already zoned for housing development is estimated to be sufficient for the 30-year period.

As a conclusion, a population of approximately 5700 inhabitants (1650 households) with an average growth of 1.3% is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Liopetri 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. The area of the village housing development zone is about 426 ha of which only about 260 is built up. The remaining area of about 166 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 30). Development sprawls in all areas but mainly towards Sotira and Xylofagou, and also in the countryside zone along the road to the coastal area of 'Potamos'.

Housing and tourism development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones were recently designated 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. Part of the designated housing zones takes into account future holiday housing demand. The housing development zones (village core and surrounding area) of 426 ha corresponds to a population capacity of about 17,500, while the presently vacant land stock (about 40% of the area) could accommodate an additional amount of about 500 housing units.

The densification of the population in the residential area is estimated to be approximately 15 inhabitants/ha**.**

FRENAROS

GENERAL DESCRIPTION

Frenaros lies to the west of Sotira. It is an inland village without any tourism development. Its location close to the tourism development areas of Paralimni, Ayia Napa and Sotira constitutes an advantage which does not materialize into population growth. Potato crop agriculture is the main source of income. Building development sprawl, comprising residential and some commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Frenaros, like the rest of the villages in the area, is endowed with rich agricultural land. Tourism-related employment provides supplementary income. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Frenaros has grown from 3,123 in 1992 to 3,305 in 2001, corresponding to an absolute growth of only 5.8% (or 0.5% per annum). This rate of growth is much lower that of the Famagusta District average (excluding Paralimni and Ayia Napa). It has only a limited population growth in contrast with the other villages in the area.

A range of projections appear to exist of future population growth with several intermediate ones. One projection is base on the current population growth trend and one based on the population capacity of the designated housing zone area. Land capacity scenario over-estimates future population growth up to the year 2030.

TABLE A6.8: POPULATION FORECAST FOR FRENAROS

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 0.5% p.a. population growth scenario	994	1,050	1,100	1,155
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period)	994	1,210	1,430	1,650
Probable future growth scenario (the same at present)	994	1,050	1,100	1,155

Population growth is unlikely to increase above the current rate. Agricultural development will decline due to foreign competition in the European potato market and falling export prices. The Solution of the Cyprus Problem will not in any foreseeable way stimulate new growth in the village.				

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Frenaros is agriculture and only marginally tourism employment. Its growth of 0.5% p.a. is likely to continue in the next 30 years. Agriculture will probably decline and tourism employment will not continue to a major source of new economic and population growth.

The possibility of the future opening of Famagusta will be unlikely to stimulate new housing development above the needs of the local population.

The land stock already zoned for housing development is estimated to be more than sufficient for the 30-year period.

As a conclusion, a population of approximately 3800 inhabitants (1155 households) with an average growth of 0.5 % is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Frenaros 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. The area of the village housing development zone is about 333 ha of which only about 200 is built up. The remaining area of about 130 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 30). Development sprawls in all areas but mainly towards Sotira and Deryneia.

Housing and tourism development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones were recently designated 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. Part of the designated housing zones takes into account future holiday housing demand. The housing development zones (village core and surrounding area) of 333 ha corresponds to a population capacity of about 13,500, while the presently vacant land stock (about 40% of the area) could accommodate an additional amount of about 650 housing units.

The densification of the population in the residential area is estimated to be approximately 15 inhabitants/ha**.**

SOTIRA

GENERAL DESCRIPTION

Sotira is the fastest growing village among the group of villages included in this Study. Its coastal location and physical proximity to Ayia Napa (that together with Paralimni account for about 40% of the total tourism accommodation capacity in Cyprus) are the prime factors determining population growth. Building development sprawl, comprising residential and holiday-homes, typically follows the same pattern common in almost all settlements in Cyprus. Sotira, like the rest of the villages, are endowed with rich agricultural land with potato crops being the second most important source of income after tourism employment. As tourism and potato crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Sotira has grown from 3,556 in 1992 to 4,258 in 2001, corresponding to an absolute growth of nearly 20% (or 1.8% per annum). This rate of growth is higher than that of the Famagusta District average (excluding Paralimni and Ayia Napa) and only just below the District average including these two prime settlements.

A range of projections appear to exist of future population growth with several intermediate ones. One projection is base on the population capacity of the designated housing zone area, which roughly corresponds to the housing needs up to the year 2030 if the presently high population growth rate of 1.8 per annum continues over the whole period.

TABLE A6.9: POPULATION FORECAST FOR SOTIRA

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 1.8% p.a. population growth scenario	1,167	1,395	1,668	1,995
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period	1,167	1,400	1,640	1,900
Plus: a proportion of the vacant coastal tourist housing land (say 30% or 60 ha) taken up by the local population, with the remaining accommodating seasonal population from other areas.	70	210	350	500
Total local population growth	1,237	1,610	1,990	2,400
Plus: seasonal coastal zone housing for visitors (70% or 140 ha)	156	500	830	1,156
Total housing development (land stock scenario)	1,393	2,110	2,820	3,556
Probable scenario (declining local population growth rate combined with seasonal housing development roughly equal to coastal land stock capacity)				
Local population growth: Based on the assumption that the population growth rate will be reduced to about 1.5% for the period 2002-2030 due to reduced agricultural development and potato export prices.	1,167	1,355	1,570	1,820
Plus: coastal housing development (80% of the land zone, the rest taken up by hotel accommodation) accommodating seasonal holiday houses including possible European Union citizens.	226	680	1,130	1,350
Total estimated housing development	1,393	2,035	2,700	3,170

JUSTIFICATION FOR THE PROBABLY GROWTH SCENARIO

The main source of population growth in Sotira is its coastal location near a major tourist area in Cyprus. Agriculture has been for many years an important parallel and contributory growth factor, both explaining the community's high population growth considering its "rural" character. Its growth of 1.8% p.a. is unlikely to continue in the next 30 years, as this reflects the major post 1974 tourist boom in the wider southern Famagusta District that transformed the whole area from rural to tourist resort and offered new opportunities for combined tourism and agricultural employment and income. A similar boom is unlikely. Potato crop agriculture is recently facing serious threats from declining potato export prices and gradual abolition of various subsidies in view of Cyprus EU accession.

On the other hand, population growth will continue to increase but at a lower rate as agriculture is likely to decline. Tourism is also likely to decline if, following the solution of the Cyprus Problem, Famagusta town and its tourism sector is revitalized taking some of the demand from the southern Famagusta area.

However, as Sotira and its coastal area still retain much of the traditional rural landscape, it is likely to evolve as an attract holiday housing market for Cypriots and possibly EU citizens. It is only 1 hour travel distance from Nicosia and Limassol and shortly a marina for about 500 boats will be developed at Ayia Thekla bay. It is therefore reasonable to assume that Sotira will continue to benefit economically from both tourism and agriculture and thus population and housing development will remain major growth sources. The predicted decline in the local population growth will probably be counterbalanced by a boost in the holiday housing market thus overall growth will not deviate significantly from that indicated by the present land stock capacity.

As a conclusion, a population of approximately 6600 inhabitants (1820 households) with an average growth of 1.5 % is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Sotira 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. The area of the village housing development zone is about 365 ha of which only about 200 is built up. The remaining area of about 165 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 50). In the coastal tourism development area (218 ha) there are about 226 holiday houses mostly spread out in grouped apartment complexes and individual housing units.

Housing and tourism development is at present controlled by the Policy for the Countryside, which provides for specific land use zones and density standards. These zones have been designated 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 their population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zones (village core and surrounding area) of 365 ha corresponds to a population capacity of about 15,000, while the presently vacant land stock (about half of the area) could accommodate an additional amount of about 750 housing units. The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha**.**

DERYNEIA

GENERAL DESCRIPTION

Deryneia lies to the north of Sotira and fronts on the 'buffer zone' which separates the Municipality of Deryneia from Famagusta town. Its coastal area is currently inaccessible and the settlement grown towards Paralimni and Sotira, mostly along the main roads linking Deryneia to these two growth areas. Thus, Deryneia has very limited tourism accommodation development within its own territory although its economy mainly depends on tourism employment in Paralimni and Ayia Napa (that together account for about 40% of the total tourism accommodation capacity in Cyprus). Building development sprawl, comprising residential and commercial development, typically follows the same pattern common in almost all settlements in Cyprus. Deryneia, like the rest of the villages in the area, is endowed with rich agricultural land with fruit crops representing the second most important source of income after tourism-related employment. As tourism and crop agriculture tend to be seasons activities, employment in both is combined.

POPULATION TRENDS

The population of Deryneia has grown from 4,163 in 1992 to 4,954 in 2001, corresponding to an absolute growth of nearly 19.0% (or 1.7% per annum). This rate of growth is higher than that of the Famagusta District average (excluding Paralimni and Ayia Napa) and only just below the District average including these two prime settlements. It has the second highest growth rate among the settlements included in the Study villages, after Sotira.

A range of projections appear to exist of future population growth with several intermediate ones. One projection is base on the population capacity of the designated housing zone area, which roughly corresponds to the housing needs up to the year 2030 if the presently high population growth rate of 1.8 per annum continues over the whole period. Another projection is based on the possibility of the Solution of the Cyprus Problem that gives a higher estimate of future population.

TABLE A6.10: POPULATION FORECAST FOR DERYNEIA

SCENARIOS	POPULATION (HOUSEHOLDS)			
	2001	2010	2020	2030
Average 1.7% p.a. population growth scenario	1,570	1,860	2,200	2,600
Housing land stock scenario (The additional estimated housing development capacity of vacant land stock in the village housing zone apportioned evenly over the 30-year period) As the coastal area is currently inaccessible and Deryneia is a coastal settlement the housing development zone provides for both new housing for the local population and holiday houses. It is not possible to separate these two types of housing development.	1,570	1,900	2,230	2,600
Probable future growth scenario: -Without Solution of the Cyprus Problem (the current population growth rate will continue).		1,900	2,230	2,600
-With Solution of the Cyprus Problem (the coastal area will become accessible for development and tourism growth will increase as out-growth of Famagusta, population growth will probably increase to about 2.0% p.a).		1,920	2,340	2,860

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Deryneia at present is its location near a major tourist centre of Paralimni and close to Ayia Napa. Agriculture has been for many years an important parallel and contributory growth factor, both explaining the community's high population growth despite its 'buffer zone' constraint. Its growth of 1.7% p.a. may continue in the next 30 years due to tourism growth in Paralimni. Agriculture is recently facing serious threats from competition in the European markets and declining export prices, and the gradual removal of various subsidies in view of Cyprus EU accession.

On the other hand:

Population growth will continue to increase due to the availability of tourism employment at close proximity.

Tourism development (apartments and hotels) is likely to be attracted in the coastal area when Famagusta becomes accessible following the solution of the Cyprus Problem.

The possibility of future merging of the Deryneia coastal area with that of southern Famagusta is likely to stimulate the holiday housing market for Cypriots and possibly EU citizens.

The land stock already zoned for housing development although sufficient for long-term needs will probably be expanded in future revisions of the Deryneia Local Plan to cover the coastal area towards Famagusta.

As a conclusion, a population of approximately 9500 inhabitants is projected at the horizon 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Deryneia 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. The area of the village housing development zone is about 650 ha of which only about 200 is built up. The remaining area of about 400 ha is predominantly empty with scattered houses and semi developed road network. There are also scattered houses outside the designed housing development zone (about 40). Development sprawls in all areas but mainly towards Paralimni, with which it is physically merged, towards the coastal area and towards Sotira. In the east and south-east, closer to the coast, most of the seasonal holiday houses are concentrated (about 280 houses and apartments).

Housing and tourism development is at present controlled by the Deryneia Local Plan, which provides for specific land use zones and density standards. This Plan has been in place since the year 2000. 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 their population capacity in term of the land stock it includes is far greater that the realistic residential housing needs for the foreseeable future. Part of the designated housing zones take into account future holiday housing demand. The housing development zones (village core and surrounding area) of 650 ha corresponds to a population capacity of about 33,000, while the presently vacant land stock (about half of the area) could accommodate an additional amount of about 1,000 housing units.

The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha**.**

APPENDIX 7

AGRICULTURAL LAND IN THE REGION

AGRICULTURAL LAND IN THE KOKKINOCHORIA REGION

TABLE A7.1: LAND USE IN THE KOKKINOCHORIA REGION (1994)

	IRRIGABLE AREA (DONUMS)	NOT IRRIGABLE AREA (DONUMS)
Temporary crops	44 456	32 941
Permanent crops	4 642	140
Fallow land	1 344	529
Grazing land	–	90
Forest land	–	474
Uncultivated land	636	1 867
Scrub land	–	909
Total	51 080	36 952
TOTAL AGRICULTURAL LAND		**88 032**

TABLE A7.2: IRRIGATED LAND BY SOURCE OF WATER IN THE KOKKINOCHORIA REGION (1994)

SOURCE OF WATER	IRRIGATED AREA (DONUMS)
Borehole / Well	22 177
Dam	28 899
River	3
Spring	0
TOTAL	**51 080**

TABLE A7.3: AREA OF TEMPORARY CROPS IN THE KOKKINOCHORIA REGION (1994)

TEMPORARY CROPS	IRRIGATED AREA (DONUMS)	NOT IRRIGATED AREA (DONUMS)
Cereals	291	40 517
Pulses	575	8
Industrial crops	150	0
Aromatic plants	1	0
Fodder crops for grain	0	2
Green fodder for grazing	53	2 982
Green fodder for hay	106	2 951
TOTAL	**1 177**	**46 461**

TABLE A7.4: AREA OF VEGETABLES AND FLOWERS IN THE KOKKINOCHORIA REGION (1994)

	VEGETABLES (DONUMS)	FLOWERS (DONUMS)
Open field	35 361	2
Greenhouses	127	2
Tunnels	150	–
TOTAL	**35 639**	**4**

TABLE A7.5: AREA AND CROPS PLANTED IN NURSERIES IN THE KOKKINOCHORIA REGION (1994)

PLANTS	AREA, m^2
Ornamental plants	1 658
Vegetable plants	3 300
Seedlings	–
Forest plants	–
Mushrooms	3 000
TOTAL	**7 958**

TABLE A7.5: AREA OF PERMANENT CROPS IN THE KOKKINOCHORIA REGION (1994)

CROPS	IRRIGATED AREA (DONUMS)	NOT IRRIGATED AREA (DONUMS)
Table grapes	17	1
Wine grapes	–	–
Citrus	3 449	10
Dry nuts	32	8
Fruits	505	13
Olives	594	84
Carobs	17	49
TOTAL	**4 614**	**165**

TABLE A7.6: TOTAL NUMBER OF TREES IN THE KOKKINOCHORIA REGION (1994)

TREES	TOTAL NUMBER
Citrus	150 170
Dry nuts	1 779
Fruits	28 089
Olives	24 830
Carobs	1 811
TOTAL	**206 679**

AGRICULTURAL LAND BY VILLAGE

TABLE A7.7: AGRICULTURAL LAND BY VILLAGE (1994)

VILLAGE	TOTAL AREA (DONUMS)		
	Irrigated	Not Irrigated	Total
Achna	3 975	3 685	7 660
Avgorou	8 730	5 944	14 674
Agios Georgios	1 190	2 280	3 470
Deryneia	2 321	3 688	6 009
Liopetri	6 861	2 099	8 960
Sotira	7 241	2 730	9 971
Frenaros	5 898	4 028	9 926
Xylotymvou	1 602	7 760	9 362
Xylofagou	10 879	4 809	15 688
Ormideia	6 687	2 443	9 130
TOTAL	**55 384**	**39 466**	**94 850**

TABLE A7.8: AGRICULTURAL LAND USE BY VILLAGE (1994)

VILLAGE	TEMPORARY CROPS (DONUMS)	PERMANENT CROPS (DONUMS)	FALLOW LAND (DONUMS)	UNCULTIVATED FOREST AND SCRUB LAND (DONUMS)
Achna	6 956	493	39	172
Avgorou	12 965	1 057	229	424
Agios Georgios	2 600	710	9	152
Deryneia	5 126	458	75	351
Liopetri	7 166	364	294	1 137
Sotira	8 580	236	405	753
Frenaros	8 146	942	351	487
Xylotymvou	8 896	247	63	157
Xylofagou	14 213	299	156	1 019
Ormideia	6 758	1 027	610	733

TABLE A7.9: AREA OF TEMPORARY CROPS BY VILLAGE (1994)

VILLAGE	CEREALS (DONUMS)	PULSES (DONUMS)	INDUSTRIAL (DONUMS)	FODDERS (DONUMS)	POTATOES (DONUMS)	VEGETABLES (DONUMS)
Achna	4 530	4	752	2 129	106	3
Avgorou	7 193	115	736	6 535	205	1

VILLAGE	CEREALS (DONUMS)	PULSES (DONUMS)	INDUSTRIAL (DONUMS)	FODDERS (DONUMS)	POTATOES (DONUMS)	VEGETABLES (DONUMS)
Agios Georgios	1 939	–	451	95	80	6
Deryneia	3 840	137	329	359	714	1
Liopetri	2 716	54	364	4 399	780	–
Sotira	2 925	271	198	4 866	853	2
Frenaros	5 173	42	650	2 772	183	4
Xylotymvou	7 333	4	–	791	573	62
Xylofagou	5 225	28	–	1 347	7 820	640
Ormideia	2 738	38	–	560	3 417	540

TABLE A7.10: PERMANENT CROPS BY VILLAGE (1994) (NUMBER OF TREES)

VILLAGE	VINES	CITRUS	FRUITS	NUTS	OLIVES	CAROBS
Achna	14 370	2 237	200	1 234	312	–
Avgorou	34 484	3 890	530	4 720	1	–
Agios Georgios	26 747	1 216	179	1 267	2	–
Deryneia	19 907	1 633	138	1 436	6	–
Liopetri	10 350	2 722	178	2 530	54	–
Sotira	4 202	5 171	129	5 164	174	–
Frenaros	39 290	2 161	254	1 760	17	–
Xylotymvou	–	5 496	1 024	82	1 201	615
Xylofagou	1	4 478	4 227	134	3 649	17
Ormideia	2	33 176	6 220	212	3 038	218

THE KOKKINOCHORIA IRRIGATION SCHEME AND AREAS OUTSIDE THE SCHEME

Part of the project region is covered by the Kokkinochoria Government Irrigation Scheme. For the irrigated areas outside the Scheme, water demand is satisfied, to a large extent, by groundwater. Detailed information on the area of irrigated land and water demand for areas within the Kokkinochoria scheme, as well as on the irrigated areas which are outside the scheme is provided in the following tables.

TABLE A7.11: AREAS WITHIN THE KOKKINOCHORIA IRRIGATION SCHEME AND WATER DEMAND (2001)

CROP	AREA (DECARS)	UNIT IRRIGATION DEMAND (m^3)	TOTAL WATER DEMAND (m^3)	%
Permanent Crops				
Citrus	5 330	750	3 997 500	
Deciduous	222	750	166 500	

CROP	AREA (DECARS)	UNIT IRRIGATION DEMAND (m³)	TOTAL WATER DEMAND (m³)	%
Permanent Crops				
Olives	3 645	450	1 640 250	
Table grapes	0			
Bananas	0			
Sub-total	*9 197*		*5 804 250*	*30*
Greenhouses				
Sub-total	386	860	331 960	2
Open Field Vegetables				
Potatoes	35 457	295	10 459 815	54
Other vegetables	3 500	736	2 576 000	13
Sub-total	38 957		13 035 815	
Fodders				
Sub-total	150	1 150	172 500	1
TOTAL	**48 690**		**19 344 525**	**100**

TABLE A7.12: IRRIGATED AREAS FOR MAJOR WATERSHEDS (EXCL. GOVERNMENT WATER SCHEME AREAS, 2001)

CROP	ACHNA – FAMAGUSTA AREA		ORMIDEIA – PARALIMNI AREA (DECARS)	
	Irrigated Area (decars)	Irrigation Water Demand (1000 m³)	Irrigated Area (decars)	Irrigation Water Demand (1000 m³)
Citrus	656	459	12	8
Deciduous	23	15	–	
Olives	267	107	–	
Vines	–		–	
Bananas	–		–	
Fodders	–		76	88
Potatoes	23	5	39	12
Greenhouses	–		–	
Vegetables	–		–	
TOTAL	968	585	127	108

TABLE A7.13: AREA AND WATER DEMAND FOR OPEN FIELD VEGETABLES IN THE KOKKINOCHORIA IRRIGATION SCHEME (2001)

	AREA (DECARS)	%	WATER DEMAND (m³/DECAR)	AVERAGE DEMAND (m³/DECAR)
Open Field Vegetables				
Tomatoes	1 000	17.8	600	107
Watermelon	1 700	30.2	450	136
Kolokasse	800	14.2	2 040	290

	AREA (DECARS)	%	WATER DEMAND (m^3/DECAR)	AVERAGE DEMAND (m^3/DECAR)
Open Field Vegetables				
Beans	500	8.9	550	49
Squash	400	7.1	350	25
Leafy vegetables	400	7.1	700	50
Cucumbers	300	5.3	550	29
Carrots	300	5.3	440	23
Eggplants / Peppers	130	2.3	600	14
Strawberries	50	0.9	650	6
Flowers	40	0.7	950	7
TOTAL	**5 620**	**100.0**		**736**
Potatoes				
Potatoes spring	21 000	70.0	250	175
Potatoes autumn	9 000	30.0	400	120
TOTAL	**30 000**	**100.0**		**295**

TABLE A7.14: UNIT CROP IRRIGATION WATER DEMAND BY VILLAGE (m^3/DECAR/YEAR, 2001)

CROPS	ACHNA	AVGOROU	AGIOS GEORGIOS	SOTIRA	LIOPETRI	XYLOFAGOU
Permanent Crops						
Citrus	750	700	700	800	700	750
Deciduous	800	700	650	800	700	750
Olives	470	400	400	470	400	450
Table grapes	265	230	250	250	270	230
Bananas	0	0	0	0	0	0
Fodders	1 200	1 150	1 050	1 100	1 100	1 150
Almonds	550	450	400	550	450	500
Annual Crops						
Tomatoes GH[1]	900	850	750	800	800	850
Cucumbers GH	900	850	750	800	800	850
Beans GH	650	600	500	550	550	600
Peppers GH	900	850	750	800	800	850
Melons GH	650	600	500	550	550	600
Strawberries GH	750	700	600	650	650	700
Flowers GH	1 000	950	850	900	900	950
Potatoes	350	300	200	250	250	300
Tomatoes OF[2]	650	600	500	550	550	600

CROPS	ACHNA	AVGOROU	AGIOS GEORGIOS	SOTIRA	LIOPETRI	XYLOFAGOU
Cucumber OF	650	600	500	550	550	600
Beans OF	650	600	500	550	550	600
Squash	400	350	250	300	300	350
Onions	500	450	350	400	400	450
Peppers OF	650	600	500	550	550	600
Groundnuts	600	550	450	500	500	550
Cabbage	500	450	350	400	400	450
Parsley	800	750	650	700	700	750
Carnation	950	900	800	850	850	900
Artichoke	750	700	600	650	650	700
Kolokasse	2 100	2 040	1 920	1 980	1 980	2 040
Tobacco	0	0	0	0	0	0
Spices	400	350	250	300	300	350
Carrots	480	440	360	400	400	440
Beets	300	250	150	200	200	250
Watermelon	500	450	350	400	400	450
Broad beans	150	100	0	50	50	100
1. Greenhouse, 2. Open Field						

TABLE A7.15: AREAS AND WATER DEMAND FOR IRRIGATED AREAS OUTSIDE THE KOKKINOCHORIA IRRIGATION SCHEME (2001)

CROP	AGIOS GEORGIOS		ORMIDEIA	
	Area (decars)	Water Demand (m³)	Area (decars)	Water Demand (m³)
Citrus	656	459 032	25	16 075
Deciduous	23	14 788	11	6 873
Olives	267	106 618	373	145 097
Grapes	–			
Bananas				
Fodders				
Greenhouses				
Potatoes	23	4 600	3	750
Vegetables			20	11 000

APPENDIX 9

IRRIGATION LAND REQUIREMENTS

TABLE A9.1: UNIT WATER DEMAND

CROPS	ACHNA m³/donum/year	AVGOROU m³/donum/year	AGIOS GEORGIOS m³/donum/year	SOTIRA m³/donum/year	LIOPETRI m³/donum/year	XYLOFAGOU m³/donum/year
Permanent Crops						
Citrus	1003	936	936	1070	936	1003
Deciduous	1070	936	870	1070	936	1003
Olives	629	535	535	629	535	602
Table grapes	355	308	334	334	361	308
Fodders	1605	1538	1405	1472	1472	1538
Almonds	736	602	535	736	602	669
Annual Crops						
Tomatoes GH[1]	1204	1137	1003	1070	1070	1137
Cucumbers GH	1204	1137	1003	1070	1070	1137
Beans GH	870	803	669	736	736	803
Peppers GH	1204	1137	1003	1070	1070	1137
Melons GH	870	803	669	736	736	803
Strawberries GH	1003	936	803	870	870	936
Flowers GH	1338	1271	1137	1204	1204	1271
Potatoes	468	401	268	334	334	401
Tomatoes OF[2]	870	803	669	736	736	803
Cucumber OF	870	803	669	736	736	803
Beans OF	870	803	669	736	736	803
Squash	535	468	334	401	401	468
Onions	669	602	468	535	535	602
Peppers OF	870	803	669	736	736	803
Groundnuts	803	736	602	669	669	736
Cabbage	669	602	468	535	535	602
Parsley	1070	1003	870	936	936	1003
Carnation	1271	1204	1070	1137	1137	1204
Artichoke	1003	936	803	870	870	936
Kolokasse	2809	2729	2569	2649	2649	2729
Spices	535	468	334	401	401	468
Carrots	642	589	482	535	535	589
Beets	401	334	201	268	268	334
Watermelon	669	602	468	535	535	602
Broad beans	201	134	0	67	67	134

The expected wastewater flows for the years 2005, 2015 and 2030 have been used to calculate the cultivated area that would be required for each crop for each of the six villages so as to provide an indication as to the land requirements for the reuse of the treated effluent.

TABLE A9.2: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2005 (DONUMS)

CROPS	ACHNA	AVGOROU	AGIOS GEORGIOS	SOTIRA	LIOPETRI	XYLOFAGOU
Permanent Crops						
Citrus	1914	2050	2050	1794	2050	1914
Deciduous	1794	2050	2208	1794	2050	1914
Olives	3054	3588	3588	3054	3588	3190
Table grapes	5416	6240	5741	5741	5316	6240
Fodders	1196	1248	1367	1305	1305	1248
Almonds	2610	3190	3588	2610	3190	2871
Annual Crops						
Tomatoes GH[1]	1595	1689	1914	1794	1794	1689
Cucumbers GH	1595	1689	1914	1794	1794	1689
Beans GH	2208	2392	2871	2610	2610	2392
Peppers GH	1595	1689	1914	1794	1794	1689
Melons GH	2208	2392	2871	2610	2610	2392
Strawberries GH	1914	2050	2392	2208	2208	2050
Flowers GH	1435	1511	1689	1595	1595	1511
Potatoes	4101	4784	7177	5741	5741	4784
Tomatoes OF[2]	2208	2392	2871	2610	2610	2392
Cucumber OF	2208	2392	2871	2610	2610	2392
Beans OF	2208	2392	2871	2610	2610	2392
Squash	3588	4101	5741	4784	4784	4101
Onions	2871	3190	4101	3588	3588	3190
Peppers OF	2208	2392	2871	2610	2610	2392
Groundnuts	2392	2610	3190	2871	2871	2610
Cabbage	2871	3190	4101	3588	3588	3190
Parsley	1794	1914	2208	2050	2050	1914
Carnation	1511	1595	1794	1689	1689	1595
Artichoke	1914	2050	2392	2208	2208	2050
Kolokasse	683	704	748	725	725	704
Spices	3588	4101	5741	4784	4784	4101
Carrots	2990	3262	3987	3588	3588	3262
Beets	4784	5741	9569	7177	7177	5741
Watermelon	2871	3190	4101	3588	3588	3190
Broad beans	9569	14353	0	28706	28706	14353

TABLE A9.3: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2015 (DONUMS)

CROPS	ACHNA	AVGOROU	AGIOS GEORGIOS	SOTIRA	LIOPETRI	XYLOFAGOU
Permanent Crops						
Citrus	2254	2415	2415	2113	2415	2254
Deciduous	2113	2415	2601	2113	2415	2254
Olives	3597	4226	4226	3597	4226	3757
Table grapes	6379	7350	6762	6762	6261	7350
Fodders	1409	1470	1610	1537	1537	1470
Almonds	3074	3757	4226	3074	3757	3381
Annual Crops						
Tomatoes GH[1]	1878	1989	2254	2113	2113	1989
Cucumbers GH	1878	1989	2254	2113	2113	1989
Beans GH	2601	2817	3381	3074	3074	2817
Peppers GH	1878	1989	2254	2113	2113	1989
Melons GH	2601	2817	3381	3074	3074	2817
Strawberries GH	2254	2415	2817	2601	2601	2415
Flowers GH	1690	1779	1989	1878	1878	1779
Potatoes	4830	5635	8452	6762	6762	5635
Tomatoes OF[2]	2601	2817	3381	3074	3074	2817
Cucumber OF	2601	2817	3381	3074	3074	2817
Beans OF	2601	2817	3381	3074	3074	2817
Squash	4226	4830	6762	5635	5635	4830
Onions	3381	3757	4830	4226	4226	3757
Peppers OF	2601	2817	3381	3074	3074	2817
Groundnuts	2817	3074	3757	3381	3381	3074
Cabbage	3381	3757	4830	4226	4226	3757
Parsley	2113	2254	2601	2415	2415	2254
Carnation	1779	1878	2113	1989	1989	1878
Artichoke	2254	2415	2817	2601	2601	2415
Kolokasse	805	829	880	854	854	829
Spices	4226	4830	6762	5635	5635	4830
Carrots	3522	3842	4696	4226	4226	3842
Beets	5635	6762	11270	8452	8452	6762
Watermelon	3381	3757	4830	4226	4226	3757
Broad beans	11270	16904	0	33809	33809	16904

TABLE A9.4: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2030 (DONUMS)

CROPS	ACHNA	AVGOROU	AGIOS GEORGIOS	SOTIRA	LIOPETRI	XYLOFAGOU
Permanent Crops						
Citrus	2925	3134	3134	2742	3134	2925
Deciduous	2742	3134	3375	2742	3134	2925
Olives	4667	5484	5484	4667	5484	4875
Table grapes	8278	9538	8775	8775	8125	9538
Fodders	1828	1908	2089	1994	1994	1908
Almonds	3989	4875	5484	3989	4875	4387
Annual Crops						
Tomatoes GH[1]	2437	2581	2925	2742	2742	2581
Cucumbers GH	2437	2581	2925	2742	2742	2581
Beans GH	3375	3656	4387	3989	3989	3656
Peppers GH	2437	2581	2925	2742	2742	2581
Melons GH	3375	3656	4387	3989	3989	3656
Strawberries GH	2925	3134	3656	3375	3375	3134
Flowers GH	2194	2309	2581	2437	2437	2309
Potatoes	6268	7312	10969	8775	8775	7312
Tomatoes OF[2]	3375	3656	4387	3989	3989	3656
Cucumber OF	3375	3656	4387	3989	3989	3656
Beans OF	3375	3656	4387	3989	3989	3656
Squash	5484	6268	8775	7312	7312	6268
Onions	4387	4875	6268	5484	5484	4875
Peppers OF	3375	3656	4387	3989	3989	3656
Groundnuts	3656	3989	4875	4387	4387	3989
Cabbage	4387	4875	6268	5484	5484	4875
Parsley	2742	2925	3375	3134	3134	2925
Carnation	2309	2437	2742	2581	2581	2437
Artichoke	2925	3134	3656	3375	3375	3134
Kolokasse	1045	1075	1143	1108	1108	1075
Spices	5484	6268	8775	7312	7312	6268
Carrots	4570	4986	6094	5484	5484	4986
Beets	7312	8775	14625	10969	10969	8775
Watermelon	4387	4875	6268	5484	5484	4875
Broad beans	14625	21937	0	43874	43874	21937