# Approximation of Environmental legislation

# Role of Compliance Costing for Approximation of EU Environmental Legislation in Cyprus

Annexes
June 1999

:

# Table of Contents

# A. Water Quality

## A.1. Industrial Effluent

Historically, in most instances, industrial effluent is managed by the source industry and tends to be disposed of in absorption pits. However, it is expected that, with the recently commissioned central waste water treatment plant, and privately planned treatment plants, the majority of industrial sources will have suitable effluent treatment facilities within the next few years. Note: the central waste water treatment plant will also treat domestic septage. The cost implications of these developments are discussed below.

### A.1.1. Central Waste Water Treatment Plant[1]

**Background**

Due to the absence of a sewerage network in large areas of Nicosia and Larnaca, and in most of the villages of these districts, the domestic septage collected, from the overflowing septic tanks/absorption pits of residences, was taken by tanker and disposed to lagoons sited near the village of Potamia for Nicosia District, and near the village of Kelia for Larnaca District. In addition, a number of industries (about 100), either due to their location or due to their small size, have not been able to build their own waste water treatment plants and, as a result, these wastes have also been discharged to these lagoons.

The operation of the above lagoons has been causing serious environmental problems, e.g. pollution of watercourses and sub-strata.

In December 1993, the Government of the Republic of Cyprus, decided to proceed with the construction of a Central Waste Water Treatment Plant (CWWTP), where all the above wastes would be treated. In April 1994 a Consultancy Services Contract was awarded and soon thereafter a Environmental Impact Study was commenced in parallel with the preparation of draft Tender Documents for the construction of the Treatment Plant on a turnkey basis. The Contract was awarded in 1995 for the sums of approximately 14.0 million ECU for the construction and 2.4 million ECU for the five-year operation and maintenance of the Treatment Plant. Construction work commenced in February 1996 and the Substantial Completion and Take-Over Certificates were issued to the Contractor in February 1998.

**Treatment Plant Description**

All wastes that will be delivered to the Treatment Plant have been classified under one of six different categories. The design flows and loads for each category are shown in Table A.1. The capacity of the Treatment Plant is 2,200 $m^3$ per calendar day with an equivalent population of approximately 55,000 people. For each of the categories of waste, a different pre-treatment line has been constructed in order to accommodate the particular characteristics of that category. Following pre-treatment, all wastes are collected in the balancing tank and from there they are commonly processed through secondary and tertiary treatment. After tertiary treatment the recycled water will be collected and stored in the Treated Effluent Storage Reservoir, with a capacity of 284,000 $m^3$, from where it will be distributed via a pumped irrigation network to about 500 ha of land near Potamia and Geri.

1 This section provides a summary of key aspects of the Central Waste Water Treatment Plant (CWWTP) extracted from a promotional publication provided by the Environment Service: The Central Waste Water Treatment Plant at Vathia Gonia – Environmental Protection in Practice, Ministry of Agriculture, Natural Resources and Environment.

Table A.1 Design Specifications of CWWTP

| **Waste Category** | **Year 1994** | | | **Year 2004** | | |
|---|---|---|---|---|---|---|
| | **Flow ($m^3$/day)** | **$BOD_5$ load (kg/day)** | **SS load (kg/day)** | **Flow ($m^3$/day)** | **$BOD_5$ load (kg/day)** | **SS load (kg/day)** |
| Domestic Sewage | 1,263 | 904 | 2,100 | 1,683 | 1,207 | 2,804 |
| Dairy Wastes | 108 | 1,073 | 748 | 144 | 1,430 | 997 |
| Fats, Oils and Grease | 26 | 70 | 48 | 35 | 93 | 64 |
| Metal Wastes | 36 | - | 9 | 48 | - | 12 |
| Strong Organic Wastes | 56 | 310 | 192 | 75 | 413 | 256 |
| Weak Organic Wastes | 161 | 153 | 43 | 215 | 204 | 57 |
| Sludge | 80 | Not Known | Not Known | 108 | Not Known | Not Known |

**Note:** $BOD_5$ = Biochemical Oxygen Demand required in 5 days. SS = Suspended Solids.

For control as well as billing purposes a transponder has been fitted on each tanker which is licensed to discharge at the Treatment Plant. Through this transponder the tanker is automatically recognised upon its arrival at the Tanker Reception Building and this arrival is recorded on the computer at the reception area. Following this automatic recognition, the tanker driver then gives the operator at the reception a filled-in delivery docket on which the source and type of waste are indicated. By the operator entering the docket number in the computer the source and category of the waste are confirmed and the computer allocates a discharge bay to the tanker for discharge to the appropriate pre-treatment line.

The tanker driver then proceeds to the allocated bay, where his tanker is again automatically recognised and validated as being at the correct bay. If the tanker is in the correct bay, a green lamp is displayed and the electrically actuated discharge control valve commences opening, to enable discharge to take place. The valve opens on a time delayed basis so as to allow the tanker driver to connect to the system and to then prevent surge loading of the system when the tanker driver opens the valve on his tanker. If the tanker drives into an incorrect bay he will not get a green light, and must refer to the operators for further instructions.

The secondary treatment at the CWWTP comprises two parallel covered balancing and mixing tanks (total volume = 4,800 $m^3$) with integral pumping station feeding a completely mixed anoxic zone (volume = 650 $m^3$) followed by two aeration tanks also in parallel (total volume = 11,290 $m^3$). After the aeration tank, the mixed liquor overflows into two Final Settlement Tanks (FSTs) where the sludge (biomass) settles and is returned back to the aeration tanks after being mixed with the incoming waste in the anoxic zone. The dewatered sludge is carried by screw conveyor to a tipper trailer which is used to carry the sludge to the Sludge Storage Bays, for later removal and disposal onto fields as a soil conditioner. The secondary effluent from the Final Settlement Tanks overflows to the effluent pumping station and from there it is pumped into four continuously back-washed tertiary sand filters. After sand filtration the water is chlorinated in a contact tank prior to being discharged to the Treated Effluent Storage Reservoir, for irrigation use.

**Costs of CWWTP**

The capital cost (awarded price) of the plant was CY £$^{1995}$ 14.0 million ECU (exc. VAT and contract price adjustment). The final cost, including VAT and contract price adjustment, was approximately CY £$^{1995}$15.7 million ECU (1995).

In addition, the cost of providing the necessary infrastructure for the plant was 4.0 million ECU. The breakdown of the infrastructure costs is as follows:

| Cost Component | ECU (1995) |
|---|---|
| Acquisition of land | 117,950 |
| Access road | 1,095,250 |
| Electricity supply | 168,500 |
| Telephone communications | 40,440 |
| Treated storage lagoon | 808,800 |
| Irrigation network | 1,103,675 |
| Consulting engineering fees | 640,300 |
| Total infrastructure costs | 3,974,915 |

The recurring costs of the plant (awarded price) was 2.4 million ECU (1995) over five years, i.e. 471,800 per year (exc. VAT and contract price adjustment). At present, recurring costs are 576,720 ECU per annum. This figure will increase over the next five years as the CPA clause will increase the fees of the contractor, and as the flows to the plant increase; currently its working to 60% of its capacity.

The plan is to charge ‘full cost recovery’ prices to all users of the CWWTP. However, it has yet to decided what these prices should be; there is some concern that if ‘full cost recovery’ prices are charged to use the plant, then some industries may opt not to use it for economic reasons. Presently, the rates range from 2.40 ECU per $m^3$ (for domestic sewage) to 5.29 ECU per $m^3$ (for dairy effluent).

## A.1.2. Wineries

Four wineries in Limassol (SODAP Ltd, LEOL Ltd, ETKO Ltd, and KEO Ltd) currently discharge their effluent directly into the sea, adversely affecting the area between Limassol's two harbours. A study was recently completed by a Dutch consultant to investigate the potential of constructing a central waste water collection and treatment facility for these four wineries, which are located in close proximity to each other. The proposed central waste water treatment plant was designed to treat the effluent from the wineries to the discharge standards set by the Sewerage Board of Limassol Amathus; that is $BOD_5$ < 300 mg per litre, suspended solids < 350 mg per litre and pH between 5.5 and 9. The treated effluent from the plant could then be discharged into the collection system of the Sewerage Board. The estimated capital cost of the scheme was 1.1 million ECU (1996). The recurring costs of the scheme, comprising maintenance, chemicals, staff, energy, and disposal of solid waste, were estimated to be 56,350 ECU (1996) per annum.

The total annual cost of the central system, assuming that the capital is to be recovered over 10 years at an 8 per cent interest rate is about 215,050 ECU (1996). The Dutch consultants also estimated the total annual costs if an individual treatment plant where to be constructed at each winery. The total annual cost of an individual plant for each winery was estimated to be 320,400 ECU (1996).

However, one of the wineries, has recently opted to construct its own waste water treatment system. The average capital cost quoted by tenders for the project is 1.2 million ECU, of which 0.96 million ECU relates solely to the treatment plant. Effluent from the plant will be treated to the standards of the Sewerage Board of Limassol Amathus, and discharged into their sewer system. No further details of the system, including recurring costs, where available at this point in time. However, the capital costs of the above scheme are similar to those of the proposed central treatment facility, so it is not unreasonable to assume that the recurring costs will also be of a similar magnitude.

It is the opinion of representatives of the Government that a central system is no longer feasible. Therefore, it can be assumed that each of the other three wineries will follow suit and construct their own waste water treatment systems. Moreover, it is reasonable to assume that the capital costs will be the same for each winery, i.e. 1.2 million ECU.

All four wineries recently received a new discharge licence. Each of these licences requires the licence holder to comply with the stated emissions limits of the license within the next two years.

As mentioned above, the wineries have been discharging untreated effluent directly to sea for many decades. The costs of cleaning the sea bed in the vicinity of the sea outfalls is expected to be significant, although the magnitude of these costs is unknown at present.

### A.1.3. Animal Wastes

In 1997 about 150 intensive pig units were in operation in the Republic of Cyprus; comprising 414,000 pigs, of which 48,000 where sows. In total, these pig units generated just over 1.4 million $m^3$ of slurry. The disposal of slurry from these pig units is recognised by the Government as a serious problem; especially regarding the potential contamination of ground and surface waters.

Preliminary plans, which build on the experience of Member States of the EU, have been put forward for the appropriate collection, treatment and disposal of slurry. Details of these plans are presented in Table A.2 and Table A.3.

Table A.2 Summary of the Technical and Economic Data of the Plan for the Treatment and Utilisation of Pig Slurry in Cyprus (Aerobic Treatment)

| | Size of Pig Units (number of sows in 1994) | | | |
|---|---|---|---|---|
| | <50 | 50-124 | >124 | Total |
| Number of pig units | 42 | 46 | 87 | 175 |
| Number of sows | 1,135 | 4,056 | 32,280 | 37,471 |
| Volume of pig slurry ($m^3$) | 33,142 | 118,435 | 942,576 | 1,094,153 |
| Capital Costs (CY £[1997]): | | | | |
| Treatment system | - | 690,000 | 10,083,006 | 10,773,006 |
| Slurry tanks | 86,991 | 129,293 | 558,296 | 774,580 |
| Sub-total | 86,991 | 819,293 | 10,641,302 | **11,547,586** |
| Net recurring costs (CY £[1997]): | | | | |
| Operation & maintenance | - | 81,535 | 1,209,777 | 1,291,312 |
| Income: | | | | |
| Water | - | 5,448 | 43,358 | 48,806 |
| Manure | - | 28,424 | 226,218 | 254,642 |
| Cost of slurry disposal: | | | | |
| Irrigated land | - | 96,600 | 185,600 | 282,200 |
| Non-irrigated land | - | 47,009 | 374,122 | 421,131 |
| Mixed[1] | - | 46,635 | 347,229 | 393,864 |
| Cost of manure disposal | - | 18,885 | 150,058 | 168,943 |
| Sub-total | - | 256,792 | 1,997,210 | **2,254,002** |

**Note:**
1 Thirty per cent of the treated slurry is disposed in irrigated areas and seventy per cent is disposed in non-irrigated areas.

Hence, the total capital cost of an 'aerobic' treatment plan and an 'anaerobic' treatment plan is 18.5 and 21.9 million ECU (1997), respectively. The corresponding recurring costs of each plan are 3.6 and 1.9 million ECU (1997).

A pilot scheme was developed for a large pig unit comprising 300 sows. This pilot scheme consists of an aerobic treatment plant, which has been in operation for three years. The objective of the pilot plant is to assist the Authorities in identifying the most efficient operating regime, as well as to provide an indication of the exact costs of operating such a system. The pilot scheme is due to finish this year, at which point the Government will assess the economic and technical viability of this option from the data collected over the last three years. The output of this assessment will then serve as an input to the development of a detailed implementation plan. Recurring costs for the pilot scheme for a typical year are 10,163 ECU (1997) (see below), which is equivalent to 34 ECU per sow. This is considerably less than the unit recurring costs given in Table A.2; possibly indicating the actual recurring costs of aerobic treatment may be less than those implied by Table A.2.

**Table A.3 Summary of the Technical and Economic Data of the Plan for the Treatment and Utilisation of Pig Slurry in Cyprus (Anaerobic Treatment)**

| | Size of Pig Units (number of sows in 1994) | | | |
|---|---|---|---|---|
| | <50 | 50-124 | >124 | Total |
| Number of pig units | 42 | 46 | 87 | 175 |
| Number of sows | 1,135 | 4,056 | 32,280 | 37,471 |
| Volume of pig slurry ($m^3$) | 33,142 | 118,435 | 942,576 | 1,094,153 |
| Capital Costs (CY £$^{1997}$): | | | | |
| Treatment system | - | 690,000 | 12,204,014 | 12,894,014 |
| Slurry tanks | 86,991 | 129,293 | 558,296 | 774,580 |
| Sub-total | 86,991 | 819,293 | 12,762,310 | **13,668,594** |
| Net recurring costs (CY £$^{1997}$): | | | | |
| Operation & maintenance | - | 81,535 | 610,201 | 691,736 |
| Income: | | | | |
| Biogas | - | | 516,661 | 516,661 |
| Water | - | 5,448 | 43,358 | 48,806 |
| Manure | - | 28,424 | 226,218 | 254,642 |
| Cost of slurry disposal: | | | | |
| Irrigated land | - | 96,600 | 185,600 | 282,200 |
| Non-irrigated land | - | 47,009 | 374,022 | 421,031 |
| Mixed[1] | - | 46,635 | 374,229 | 420,864 |
| Cost of manure disposal | - | 18,885 | 150,058 | 168,943 |
| Sub-total | - | 256,792 | 907,873 | **1,164,665** |

**Note:**
1 Thirty per cent of the treated slurry is disposed in irrigated areas and seventy per cent is disposed in non-irrigated areas.

Recurring costs of pilot scheme:

| **Cost Component** | **ECU (1997)** |
|---|---|
| Operation and maintenance costs: | |
| Separation | 1,288 |
| Aeration | 3,891 |
| Pumping | 1,780 |
| Sub-total | 6,959 |
| Monitoring costs | 3,204 |
| Total recurring costs | 10,163 |

Once a scheme to deal with the problem of pig slurry has been finalised, the Government plans to make cash grants to the pig units in order to subsidise the capital costs of the treatment facilities, and thereby encourage the penetration of the scheme. The proposed grant scheme is as follows:

- The Government will pay 66 per cent on capital costs under 192,240 ECU (1997);
- an additional 15 per cent on capital costs between 192,240 ECU (1997) and 400,500 ECU (1997); and
- an additional 2 per cent on any capital costs in excess of 400,500 ECU (1997).

## A.1.4. Other Industrial Sources

As noted in the Section on Air Pollution, the Factory Inspectorate of the Department of Labour identified industries where expenditures would be required in order to harmonise current operations with European environmental standards; this also included two industries which require waste water treatment plant. The two industries, and the required measures and the associated capital cost provided by the Factory Inspectorate, are reproduced in Table A.4. Again, this information was obtained directly from the listed industries. The estimated total capital cost of implementing the required environmental protection measures is 6.37 million ECU (1997). No data was available of the incremental recurring costs of the required measures.

As these measures are not strictly relevant to the environmental *acquis*, they are omitted from the cost analysis.

Table A.4 Costs of Water Treatment for Selected Industries

| Industry | Description of Measure | Total Cost (M ECU 1997) |
|---|---|---|
| Concrete mixing: 45 plants require | • Water recycling, settling and sludge separation plants at 120,150 per unit | 5.41 |
| Quarries: 30 quarries require | • Water recycling, settling and sludge separation plants at 32,040 per unit | 0.96 |
| **Total Capital Costs** | | **6.37** |

**Note:** The difference in unit costs reflects the fact that the equipment required at the quarries is much simpler than that required at the concrete mixing plants; finer dust.

In addition to the businesses listed in Table A.4, the Kofinou Central Slaughter House and the adjacent Comet Farm Rendering Plant also require a waste water treatment plant. At present the effluent from both plants is discharged into the same ponds system. The Factory Inspectorate was unable to provide any data on the estimated capital costs of the treatment plant that would be required at the site (assuming that a combined system is acceptable to both businesses). They were, however, able to provide some details of the effluent flows:

- slaughter house: 450 $m^3$ per day; $BOD_5$ 100 mg per litre; and
- rendering plant: 50 $m^3$ per day; $BOD_5$ 6,000 mg per litre.

It is therefore possible to derive an 'order of magnitude' estimate of the capital and recurring cost of a suitable wastewater treatment plant using standard unit costs. The capital cost of a waste water treatment plant for 2,000 P.E. ($BOD_5$ = 62.5 g per P.E. per day) ranges from US $\$^{1994}$ 1.88 per $m^3$ (mechanical) to US $\$^{1994}$ 3.135 per $m^3$ (biological – low load)2. Assuming that a treatment plant with a capacity of 600 $m^3$ per day is required, and the level of treatment provided is biological – low load, the estimated capital cost is US $\$^{1994}$ 686,600 (or 0.59 million ECU in 1997 prices) The recurring costs of the same plant are US $\$^{1994}$ 0.175 per $m^3$. Based on the above average flow parameters, the recurring costs of the plant are about US $\$^{1994}$ 31,900 per year (or 27,400 ECU (1997) per year).

While the above estimated capital and recurring costs are crude estimates, they are roughly in-line with the actually costs of the treatment works at the wineries (bearing in mind the differences in scale).

2 Somolyody, L. (1994) Municipal Waste Water Treatment in Central and Eastern Europe. World Bank.

In addition to all the above identified sources of industrial effluent, the Environment Service estimates that there are approximately 100 to 125 small factories, all of which will require some form of treatment plant. At present however, the treatment level and capacity required at each site is unknown. The Environment Service estimated that average flows at these factories ranged between 5 and 10 $m^3$ per day. Again, an ‘order of magnitude’ estimate of the capital and recurring cost of a suitable wastewater treatment plants can be formulated using standard unit costs. These are shown in Table A.5.

Table A.5 Estimated Costs of Wastewater Treatment Plants for Industries Not Covered by Other Plans

| Cost Component | Mechanical | Biological |
|---|---|---|
| Capital Costs (unit costs): | US $$^{1994}$ 1.880/$m^3$ | US $$^{1994}$ 3.135/$m^3$ |
| capacity 5 $m^3$ per day | US $$^{1994}$ 3,431 | US $$^{1994}$ 5,721 |
| capacity 10 $m^3$ per day | US $$^{1994}$ 6,862 | US $$^{1994}$ 11,442 |
| Recurring Costs (unit costs): | US $$^{1994}$ 0.108/$m^3$ | US $$^{1994}$ 0.175/$m^3$ |
| flow rate 5 $m^3$ per day | US $$^{1994}$ 197 | US $$^{1994}$ 319 |
| flow rate 10 $m^3$ per day | US $$^{1994}$ 394 | US $$^{1994}$ 639 |

Assuming that 110 treatment plants are required, the estimated capital cost ranges between the two end-points: US $$^{1994}$ 377,400 (or 324,000 ECU in 1997 prices) and US $$^{1994}$ 1,258,600 (or 1.1 million ECU in 1997 prices). Likewise, the estimated recurring costs ranges between the two end-points: US $$^{1994}$ 21,700 (or 18,600 ECU in 1997 prices) and US $$^{1994}$ 70,300 per year (or 60,200 ECU in 1997 prices).

Furthermore, about 20 of these factories will be required to install some form of monitoring equipment to measure ‘key’ parameters. These units are estimated to cost between 3,200 and 8,000 ECU (1997) each (i.e. a total capital cost of between 64,000 and 160,000 ECU).

It should be noted that a grant scheme exists to help industries cope with the capital costs of new effluent treatment plant. Once a treatment plant has been constructed, the investor must submit the technical and economic details of the plant for Governmental review, following which, an appropriate cash grant is awarded. The proposed grant scheme is as follows:

- the Government will pay 30 per cent on capital costs under 400,500 ECU (up to a maximum of 120,150 ECU); and
- an additional 15 per cent on any capital costs in excess of 400,500 ECU (with no maximum).

The award of any grants for plants costing in excess of 400,500 ECU (1997) requires special approval from the Government. The total budget for the whole scheme is 9.6 million ECU.

## A.2. Domestic Sources: Rural 3

### A.2.1. Introduction

In most cases, rural villages have piped water system, but no corresponding modern sewage collection and treatment system, although in recent years, some of the more problematic villages have been provided with central sewage systems. Sewage disposal in smaller villages in traditionally accomplished by draining sewage to an absorption pit; larger villages also tend to have septic tanks. “…In mountainous regions, such systems are often located in areas where rock is at or near the surface, or where impermeable soils and steep slopes are present. These conditions are unfavourable for the use of septic systems in general…”4. A

3 This section is based on the results of a study prepared for the Ministry of the Interior, the Department of Town Planning and the Department of Water Development, Fenco MacLaren Inc. in association with NV Consultants (1995) Rural Sanitation Study; and data provided by the Department of Water Development.
4 Fenco MacLaren study

study conducted by Mather and Kundu in 1984 found a very high incidence of absorption and soakaway pit failure. The same study noted the following major concerns as a consequence of these failures:

- health risks for the rural population;
- contamination of surface waters; and
- contamination of ground water supplies.

Moreover, many mountain villages (where the problems are more severe) are located within the catchment area of the dams-reservoirs from which drinking water is abstracted. There is therefore an urgent need to improve the rural waste water collection and treatment systems in order prevent the potential contamination of these sources of drinking water. This need is exaggerated by the fact that Cyprus can ill afford to lose any source of water (as noted below). In fact, it is possible that large rural areas, in particular the Troodos Mountain region, may be classified as a ‘sensitive area’, and therefore all villages located in these areas will require the construction of some form of central sewage collection systems and ‘appropriate’ treatment plant.

## A.2.2. Plans for Central Collection and Treatment Systems

In recognition of the need to improve rural sewage systems in the villages of the Republic of Cyprus, plans have been developed to provide central collection and treatment systems to some 359 villages. The estimated cost of these plans is discussed below.

**Cost of Rural Sewage Systems**

An ‘order of magnitude’ estimate of the costs of providing suitable sewage collection systems to rural villages is made here based on unit costs taken from a Fenco MacLaren study and population/village statistics provided by the Department of Water Development.

The unit costs developed by Fenco MacLaren were based on “…current (1993) prices in the Republic of Cyprus, and actual tendered prices or current supplier data. Unit rates were calculated from base information to reflect contemporary construction practices in the Republic. Per capita costs from current cost estimates for ongoing sewage projects in Nicosia and other communities were also used…”. The capital unit costs for a conventional sewage system (i.e. a standard gravity collection system with a short trunk sewer and a treatment plant offering secondary level treatment) are shown in Table A.6. Of all the systems considered by Fenco MacLaren, this system is most representative of those currently being constructed, and being considered for future implementation.

The capital costs include:

- engineering (preliminary and detailed design);
- capital works; and
- commissioning and start-up.

System component costs were estimated separately and then combined into a total system cost. Total system costs had to be calculated for each village before an overall costs per capita could be calculated. “…Private drains and other components for each household, collection systems, and septic systems were all based on an approximate geometric model of typical villages that related population, occupancy, and key system length and quantity assumptions to calculate quantities of capital goods required…”. “…Mountain and lowland villages were treated separately because differences in village geometry resulted in different material requirements…”. Hence, separate unit costs for each type of village. “…Unit prices were then applied to capital good requirements to arrive at total system costs for a particular type of village; these were then converted to per capita costs using appropriate population data…”.

Estimated recurring costs for the same 'conventional system' are shown in Table A.7. These costs include:

- collection system maintenance;
- treatment plant operating costs;
- daily inspection costs; and
- administrative costs.

Table A.6 Capital Cost Summary (CY £[1993] per capita): Conventional System

| | Mountain System | Lowland System |
|---|---|---|
| **Village Population:** | | |
| Up to 100 | 746 | 611 |
| 100 – 200 | 585 | 531 |
| 201 – 500 | 553 | 493 |
| 501 – 1,000 | 471 | 460 |
| 1,001 - 1,500 | 465 | 452 |
| 1,501 - 2,000 | 463 | 451 |
| More than 2,000 | - | 446 |

Table A.7 Recurring Cost Summary (CY £[1993] per capita): Conventional System

| | Mountain System | Lowland System |
|---|---|---|
| **Village Population:** | | |
| Up to 100 | 30 | 30 |
| 100 – 200 | 28 | 28 |
| 201 – 500 | 25 | 25 |
| 501 – 1,000 | 23 | 23 |
| 1,001 - 1,500 | 20 | 20 |
| 1,501 - 2,000 | 19 | 19 |
| More than 2,000 | 18 | 18 |

A breakdown of the number of villages, by population size and District, is given in Table A.8. Data on the exact number of residents in each village was also provided by the Department of Water Development; this is not shown. By multiplying the above unit costs by the corresponding number of residents in each 'size class' of village, and aggregating over all villages, the total capital and recurring costs of constructing suitable collection and treatment systems for all identified villages in rural areas of the Republic of Cyprus may be estimated. The estimated costs are presented in Table A.9.

Table A.8 Rural Villages (1996 estimate)

| | Number of Villages | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Nicosia** | | | **Limassol** | | | **Larnaca** | | | **Paphos** | | | **Famagusta** | | | **Republic of Cyprus** | | |
| | F | M | Total | F | M | Total | F | M | Total | F | M | Total | F | M | Total | F | M | Total |
| **Population Range:** | | | | | | | | | | | | | | | | | | |
| Up to 100 | 5 | 10 | 15 | 3 | 22 | 25 | 4 | 3 | 7 | 3 | 44 | 47 | - | - | - | 15 | 79 | 94 |
| 100 – 200 | 4 | 10 | 14 | 9 | 22 | 31 | 6 | 1 | 7 | 5 | 9 | 14 | - | - | - | 24 | 42 | 66 |
| 201 – 500 | 14 | 16 | 30 | 13 | 17 | 30 | 12 | 1 | 13 | - | 26 | 26 | - | - | - | 39 | 60 | 99 |
| 501 - 1,000 | 10 | 6 | 16 | 3 | 3 | 6 | 12 | 1 | 13 | 3 | 7 | 10 | - | - | - | 28 | 17 | 45 |
| 1,001 - 1,500 | 9 | 1 | 10 | 3 | 2 | 5 | 2 | - | 2 | 1 | 1 | 2 | - | - | - | 15 | 4 | 19 |
| 1,501 - 2,000 | 2 | - | 2 | - | - | - | 3 | - | 3 | - | 1 | 1 | 2 | - | 2 | 7 | 1 | 8 |
| More than 2,000 | 10 | - | 10 | 5 | - | 5 | 8 | - | 8 | - | - | - | 5 | - | 5 | 28 | - | 28 |
| | 53 | 43 | 97 | 36 | 66 | 102 | 47 | 6 | 53 | 12 | 88 | 100 | 7 | - | 7 | 156 | 203 | 359 |
| **Population (000)** | 59.7 | 11.8 | 71.5 | 30.1 | 13.9 | 44.0 | 55.0 | 1.6 | 56.6 | 4.1 | 18.8 | 22.9 | 21.3 | - | 21.3 | 170 | 46 | 216 |

**Note:** F = flat area; M = mountainous area.

Table A.9 Cost of Rural Waste Water Collection and Treatment System

| District | Capital Costs (CY £1993 million) | Recurring Costs (CY £1993 million) |
|---|---|---|
| **Nicosia:** | | |
| Lowland | 26.7 | 1.2 |
| Mountainous | 6.2 | 0.3 |
| Sub-total | 32.9 | 1.5 |
| **Limassol:** | | |
| Lowland | 13.6 | 0.6 |
| Mountainous | 7.6 | 0.3 |
| Sub-total | 21.2 | 0.9 |
| **Larnaca:** | | |
| Lowland | 24.6 | 1.1 |
| Mountainous | 0.8 | 0.1 |
| Sub-total | 25.4 | 1.2 |
| **Paphos:** | | |
| Lowland | 1.9 | 0.1 |
| Mountainous | 10.1 | 0.5 |
| Sub-total | 12.0 | 0.6 |
| **Famagusta:** | | |
| Lowland | 9.3 | 0.4 |
| Mountainous | - | - |
| Sub-total | 9.3 | 0.4 |
| **Republic of Cyprus:** | | |
| Lowland | 76.1 | 3.4 |
| Mountainous | 24.7 | 1.2 |
| Total | 100.8 | 4.6 |

As shown in Table A.9, the estimated total capital cost of constructing suitable sewage collection and treatment system for all identified rural villages with sewage problems in the Republic of Cyprus is about CY £1997 114.9 million (or 184.1 million ECU). The corresponding recurring costs are about CY £1997 5.24 million (or 8.4 million ECU).

Of the 370 identified villages 28 have populations in excess of 2,000; none of the villages have populations in excess of 10,000. The estimated total population of these 28 villages is 126,500. Furthermore, all of the villages are located in 'flat areas'. Hence, the estimated total capital cost of constructing suitable sewage collection and treatment system for rural villages with populations between 2,000 and 10,000 people is about CY £1997 49.9 million (or 79.9 million ECU). The corresponding recurring costs are about CY £1997 2.0 million (or 3.2 million ECU).

Note that collection systems and treatment plants have already been constructed for about 20 of the 359 identified villages, of which two systems are for villages with populations between 2,000 and 10,000. The total (actual) capital expenditure to date amounts to approximately CY £1997 15.4 million (or 24.7 million ECU). . The recurring costs associated with the systems currently in place are 1.1 million.

It must be stressed that the above figures will probably underestimate expected actual cost, in that

- the unit costs used only account for secondary level treatment whereas Government policy is to provide tertiary level treatment to allow for the recycling of treated effluent (The Department of Water Development estimate that about 80 per cent of all villages will receive tertiary treatment);
- following on from this, the unit costs do not account for the additional costs of re-use systems;
- the unit costs make no reference to actual site conditions; and
- the unit costs are based on resident populations, whereas capacity has to be provided for peak summer time populations (in some cases the population of villages will more than double).

In this sense, the above costs are minimum estimates. This conclusion is highlighted in cost data, on recently completed sewage projects in 'priority-problem' villages, provided by the Department of Water Development (part of the CY £$^{1997}$ 15.4 million). In some cases, the unit costs derived from this data were considerably higher than those estimated by Fenco MacLaren; by as much as an order of magnitude. Moreover, in no cases were the unit costs lower than those estimated by Fenco MacLaren.

The actual costs, however, may be reduced if it is possible for some villages, in close proximity to one another, to share some of the capital works. This fact has been recognised by the Department of Water Development.

As far as the financing of these new sewage systems is concerned, between 75 to 80 per cent of the capital costs are funded by the Government; essentially because the relatively low incomes of village residents makes full cost recovery unfeasible.

# A.3. Domestic Sources : Urban

## A.3.1. Introduction

Collection and treatment of domestic sewage in the main urban centres and developed tourist areas of Cyprus is the responsibility of non-profit making, publicly operated Sewerage Boards. An individual Sewerage Board serves the following main municipalities: Nicosia, Limassol, Larnaca, Ayia Napa/Paralimni and Paphos. A central sewerage collection system and sewage treatment plants programme is currently underway, and it is expected that each urban area will be served by such systems by shortly after the year 2000.

A brief description of the investment programme currently underway, or planned for the future, the purpose of which is to provide sewerage services to the service area for which each Sewerage Board is responsible, is provided below. An estimate of the recurring and non-recurring costs of this investment programme is also provided. All information was obtained from the individual Sewerage Boards.

## A.3.2. Sewerage Board of Nicosia

At present Nicosia is served by a central collection system and treatment plant which has been operational for more than 18 years; the STP is situated in the area north east of Nicosia which is not under Government control. In 1996 the population of the service area was about 200,000 inhabitants, of which about 100,000 were served by the system. Plans currently exist to connect the remainder of the resident population, and to provide adequate capacity for growth in the population of the service area. It is anticipated that by 2010 the population of the service area will be about 240,000 inhabitants, all of which will be served by the system.

The proposed investment programme includes (note: these are estimates as the design has not been finalised):

- 800 km of main sewers, force mains, laterals, etc. (ranging in diameter from 200 mm to 600 mm);
- 12,000 manholes;
- between 10 and 15 pumping stations, depending on the final design; and
- two STPs offering secondary activated sludge treatment, with a total capacity of 37,000 $m^3$ per day5.

The capital cost of this investment programme comprises:

| Cost Component | CY £$^{1997}$ million |
|---|---|
| Acquisition of land | 1.20 |
| Collection system | 42.70 |
| Forcemains | 2.34 |
| STPs | 24.4 |
| Pumping stations | 6.16 |
| Design and supervision | 5.20 |
| Total capital costs | 82.00 |

An additional CY £$^{1997}$ 8-10 million would be required for tertiary level treatment to be installed, and to re-use the water for irrigation an additional CY £$^{1997}$ 1 million would be required for the necessary piping infrastructure. Hence, the estimated total cost of providing suitable sewage collection and treatment facilities to those residents of Nicosia currently unconnected ranges from 131.4 to 150.0 million ECU, depending on the level of treatment installed.

5 This estimate was based on a forecast consumption per capita rate that may not be realised due to shortages of potable water supply, the required capacity of the STPs may therefore be less than this figure.

Presently, there is no indication as to whether the additional costs of the tertiary treatment would be subsidised by Government (which is the case with the other Sewerage Boards - see below).

It is anticipated that about 25-30 per cent of the proposed investment programme will be operational by 2003; the entire programme should be operational by 2010.

The recurring costs of the investment programme comprise (all figures are quoted in CY $£^{1997}$):

| Cost Component | 2003 | 2010 |
|---|---|---|
| Energy | 400,000 | 1,400,000 |
| Labour | 215,000 | 700,000 |
| Other | 85,000 | 200,000 |
| Total recurring cost | 700,000 | 2,300,000 |

This is equivalent to between 1.1 and 3.7 million ECU. The variation in operating costs between 2003 and 2010 mainly reflects the time phasing of the investment, as well as growth in population, water consumption per capita, etc.

Current user charges consist of two components: a fixed charge based on the value of the property to which the laterals are provided; and a service charge based on the measured volume of potable water delivered. The former recover the capital costs of providing the collection system and the STP, whereas the latter recover the recurring costs of providing services to those properties that are connected and actually using the system. At present, a uniform charge is imposed on all users of the system.

The service charge is collected directly by the Water Board of Nicosia, on behalf of the Sewerage Board of Nicosia, on a payment of 5 per cent. The fixed charge is paid directly to the Sewerage Board of Nicosia.

## A.3.3. Sewerage Board of Limassol Amathus

Limassol, the second largest city in Cyprus and situated on the south west coast, is partially served by a central sewerage system at present. Plans are currently underway to expand this system to serve the entire Limassol metropolitan area.

Phase A of the central collection and treatment plant system was completed in 1995; it currently serves about 60,000 people (this represents about 40 per cent of the current estimated population of 148,700 people), and collected and treated approximately 3.3 million $m^3$ of effluent in 1997, equivalent to about 9,000 $m^3$ per day. In addition to the collection system, Phase A comprises a STP providing secondary level treatment and a STP providing tertiary level treatment. The capacity of each plant, which are located at the same site, is 22,000 $m^3$ of effluent per day. It is anticipated that by the completion of Phase B of the investment programme in 2010, the system will serve between 150,000 and 170,000 people.

Expansion of the current system, i.e. Phase B of the investment programme, requires:

- 130-140 km of laterals and main sewers;
- 3-5 km of main collectors and force mains;
- manholes (assuming that manholes are required about every 65m);
- 3-6 pumping stations; and
- an increase in the capacity of the STPs to 48,000 $m^3$ per day
- 12,000 house connections.

The capital cost of this the whole investment programme comprises (note: the costs for Phase A are actual in that they have already been incurred; whereas the costs for Phase B are estimates that depend on the final design, and have yet to be incurred):

| Cost Component | Phase A | Phase B | |
|---|---|---|---|
| | 1995<br>CY £1995 mn. | 1996-2005<br>CY £1995 mn. | 2005-2010<br>CY £1995 mn. |
| Sewers: | | | |
| Drainage | 3.00 | 10.65 | 26.33 |
| Laterals/main sewers | 10.50 | 29.16 | 44.33 |
| Collector/force mains | 10.35 | 1.55 | 3.30 |
| Sub-total | 23.85 | 41.36 | 73.96 |
| Pumping stations | 5.50 | 0.75 | 0.92 |
| STP: | | | |
| Secondary treatment | 8.00 | 6.37 | - |
| Tertiary treatment | 1.85 | - | - |
| Sub-total | 9.85 | 6.37 | - |
| Disposal facilities | 0.70 | - | - |
| Tunnel | 2.10 | - | - |
| Contractor claims | 3.00 | - | - |
| Total capital costs | 45.00 | 48.48 | 74.88 |

Therefore, about CY £1997 123.36 million (or 197.63 million ECU) still needs to be spent to provide suitable sewage collection and treatment facilities to those residents of Limassol currently unconnected (i.e. to complete Phase B).

In addition, Phase B of the investment programme includes storm drainage systems for three major roads in the area, at a total costs of CY £1995 5 million. One third of the cost of this drainage system is funded through a Government grant.

For the year ended the 31st of December 1997, the recurring costs of the Sewerage Board of Limassol Amathus amounted to:

| Cost Component | CY £1997 |
|---|---|
| Operation and maintenance costs: | |
| Labour | 153,600 |
| Energy | 200,820 |
| Materials | 154,828 |
| Other | 251,189 |
| Sub-total | 760,437 |
| Administrative costs | 533,710 |
| Total recurring costs | 1,294,147 |

Given that the system collected and treated 3.3 million $m^3$ of effluent in 1997, the total recurring costs reported above equates to about CY £0.40 per $m^3$. Moreover, the 3.3 million $m^3$ of effluent treated in 1997 was collected from 60,000 people; this equates to about 55 $m^3$ per person per year. Once Phase B of the investment programme is operational in 2010, it is anticipated that the whole system will serve approximately 160,000 people (the mid-point between 150,000 and 170,000). Estimated total recurring costs by 2010 are therefore likely to be in the order of CY £1997 3.52 million per year; of which just under 60 per cent relate to operation and maintenance costs and just over 40 per cent relate to administrative costs. The additional recurring costs associated with connecting the remainder of the population of Limassol are therefore just under CY £1997 2.23 million per year (or 3.57 million ECU per year).

The charging system is identical to that used by the Sewerage Board of Nicosia; except that discriminatory pricing is practised by the Sewerage Board of Limassol Amathus. For example, hotels pay unit charges up to 4 times more than individual households for similar services. Different unit charges are also applied to industrial dischargers connected to the system.

The capital and recurring costs of the tertiary STP is financed by the Government. The treated effluent is used for irrigation. It is the intention of the Government to sell the treated water ( and accrue the receipts from any sales), however, rates have not yet been established. The treated water is currently provided to farmers, hotels, etc. free of charge. However, draft regulations have been prepared by the Water Development Department for charging for treated water.

Two industrial estates are located within the service area of the Sewerage Board of Limassol Amathus. The intention is to connect both of these estates to the central sewerage and treatment system. The capital cost of providing the necessary collection infrastructure is estimated to be around CY $£^{1997}$ 500,000 (or 0.8 million ECU). Note: it is the standard policy of Sewerage Boards to require industries to treat their waste water to the standards of domestic effluent before they will be granted permission to connect to the central system.

## A.3.4. Larnaca Sewerage and Drainage Board

Larnaca, situated on the south coast of the Island, currently has a population of about 66,400. A central sewerage system and drainage system is currently under construction within the municipal borders of Larnaca. The system is to be constructed in two phases. Work is currently underway on Phase A. The objective is to have the entire system operational by 2010, at which point it will serve just under 73,000 people.

Phase A of the proposed investment programme includes:

- 140 km of main sewers, force mains, laterals, etc.;
- 9.62 km of storm drains;
- 2,300 manholes (assuming that manholes are required about every 65m);
- 17 pumping stations;
- one STPs offering tertiary level treatment, with a total capacity of 8,500 $m^3$ per day; and
- one re-use scheme.

The total investment scheme comprises (i.e. the total objective):

- 460 km of main sewers, force mains, laterals, etc.;
- 50 km of storm drains;
- 7,900 manholes (assuming that manholes are required about every 65m);
- 25 pumping stations;
- one STPs offering tertiary level treatment, with a total capacity of 25,000 $m^3$ per day; and
- one re-use scheme.

The capital cost of this investment programme comprises (all figures are quoted in CY $£^{1997}$ million):

| Cost Component | Phase A | Total |
|---|---|---|
| Land | 0.68 | 1.15 |
| Sewerage network | 10.11 | 38.84 |
| Pumping stations | 1.84 | 3.60 |
| Secondary STP | 4.94 | 15.63 |
| Tertiary STP and re-use scheme | 5.27 | 21.00 |
| Drainage system | 4.14 | 33.74 |
| Engineering and design | 1.66 | 6.50 |
| Technical assistance | 0.37 | 1.50 |
| Total capital costs | 29.01 | 121.96 |

The recurring costs of the investment programme comprise (all figures are quoted in CY £[1997]):

| Cost Component | Phase A | Total |
|---|---|---|
| Labour | 233,000 | 550,000 |
| Energy | 112,000 | 210,000 |
| Consumables | 26,000 | 55,000 |
| Maintenance | 98,000 | 230,000 |
| Administration | 121,000 | 200,000 |
| Total recurring costs | 590,000 | 1,245,000 |

It is not possible to ascertain what percentage of the current population is currently connected, and therefore identify which of the above quoted costs best represent the additional costs of compliance. If additional compliance costs are restricted to those costs not yet incurred, then the capital and recurring costs of providing suitable collection and treatment facilities to the population of Larnaca are CY £[1997] 93.0 million (or 148.9 million ECU) and CY £[1997] 0.66 million (or 1.0 million ECU) respectively. These costs would increase to 195.4 million ECU and 2.0 million ECU if Phase A were to be included.

The charging system is similar to that of the Sewerage Board of Limassol.

## A.3.5. Sewerage Board of Ayia Napa and Paralimni

The area served by the Sewerage Board of Ayia Napa and Paralimni, situated on the south east coast, currently does not have a central sewerage system. However, the construction of such a system is underway. It is scheduled to be operational by the middle of 2000. At present, households utilise a combination of absorption pits and septic tanks; hotels have their own (secondary) STP, which they are required to install by law. Once the central system becomes operational however, all hotels will be required to connect to this system. The resident population of the service area is about 2,000 people. There are also over 25,000 tourist beds in the area. The system to be constructed must therefore have the capacity to collect and treat the effluent from nearly 30,000 people during the peak of summer.

The proposed investment programme includes (note: these are estimates as the design has not been finalised):

- 55 km of main sewers, force mains, laterals, etc. (ranging in diameter from 160 mm to 500 mm);
- 42 km of irrigation pipelines;
- 850 manholes (assuming that manholes are required about every 65m);
- 10 pumping stations, depending on the final design; and
- one STP offering tertiary level treatment, with a total capacity of 12,000 $m^3$ per day.

It was not possible to obtain a dissaggregated cost estimate for the system. The whole system is estimated to cost about CY £[1997] 10 million (or 16.02 million ECU). The Sewage Treatment Plant (STP) is to be operated by the private sector. The CY £[1997] 10 million represents the initial capital costs and the operating and maintenance costs the operator expects to incur over the first five years of operation.

Of the estimated total costs of CY £[1997] 10 million, the Government will provide about CY £[1997] 3 million to cover the additional costs of providing tertiary level treatment and the infrastructure for the irrigation system. The treated water from the plant is to be used mainly for the irrigation of playgrounds, of which there are approximately 16, in the Ayia Napa and Paralimni area.

A similar charging system to that of the Sewerage Board of Limassol is to be employed.

### A.3.6. Sewerage Board of Paphos

The area served by the Sewerage Board of Paphos also does not have a central sewerage system at present. Paphos is situated on the west coast of the Island and has a population of around 36,300. Tenders are about to be requested to construct a central sewerage system beginning in the Spring of 1999. It is scheduled to be partially operational by the middle of 2002.

As is the case in the Ayia Napa and Paralimni area, households currently utilise a combination of absorption pits and septic tanks and hotels have their own (secondary) STP. Again, once the central system becomes operational, all hotels will be required to connect to this system.

The planned system is to be constructed in two phases; Phase A will serve only the existing municipal boundaries. Phase B will cover the remainder of the Sewerage Board's service area.

Phase A of the proposed investment programme includes the following:
(note: these are estimates as the design has not been finalised):

- 145 km of main sewers, force mains, laterals, etc. (ranging in diameter from 200 mm to 900 mm);
- 25 km of storm drainage (2 m in diameter);
- 2,600 manholes (assuming that manholes are required about every 65m);
- 3 pumping stations; and
- one STP offering tertiary level treatment, with a total capacity of 8,000 $m^3$ per day.

Again, it was not possible to obtain a dissaggregated cost estimate for the system. The total capital costs of Phase A is estimated to be around CY £$^{1997}$ 41 million (or 65.7 million ECU), of which about CY £$^{1997}$ 10 million relates to the storm drainage system. The Government will provide about CY £$^{1997}$ 4.5 million to cover the additional costs of providing tertiary level treatment. The treated water from the plant is to be used for aquifer recharge by the Department of Water Development.

Phase B is estimated to cost a further CY £$^{1997}$ 40 million (or 64.01 million ECU). The total capacity of the central sewerage system, when both phases are operational, will be 20,000 $m^3$ per day.

As far as recurring costs are concerned, operation and maintenance expenditures in 1997 amounted to CY £$^{1997}$ 77,976. By 2002, when Phase A of the central sewerage system is scheduled to be operational, recurring costs are estimated to be CY £$^{1997}$ 646,272, rising to CY £$^{1997}$ 752,634 by 2010. The additional recurring cost associated with the collection system and treatment plant, when fully operational, is therefore approximately CY £$^{1997}$ 674,658 (or 1.1 million ECU).

## A.4. Water Supply Programme [6]

### A.4.1. Introduction

Two major types of water demand (i.e. user categories) are distinguished: municipal demand and agricultural demand. Water demand by industry and commercial users (including tourism) is classified under municipal demand. In 1993, about 54 million cubic metres of water, abstracted from -reservoirs and aquifers, was used to supply drinking water to cities and villages for municipal, industrial and commercial use (M & I water demand). A breakdown of M & I water demand is provided in Table A.10.

6 This section is based on data provided by the Department of Water Development.

Table A.10 Water for Municipal, Industrial and Commercial Purposes (1993)

| | Nicosia District | Limassol District | Larnaca District | Paphos District | Famagusta District |
|---|---|---|---|---|---|
| Population (000) | 254.7 | 182.0 | 106.2 | 54.9 | 32.0 |
| Gross water (M $m^3$) | 17.22 | 17.63 | 7.89 | 5.60 | 4.86 |
| Supply to TRNC. (M $m^3$) | 2.24 | - | - | - | 0.87 |
| Total sales (M $m^3$) | 11.94 | 12.74 | 5.72 | 4.38 | 3.32 |
| Losses (%) | 20.3 | 27.8 | 27.5 | 21.8 | 16.8 |
| Domestic (M $m^3$) | 10.98 | 9.85 | 4.92 | 3.69 | 1.96 |
| Commerce/industry (M $m^3$) | 0.45 | 0.90 | 0.28 | 0.50 | 0.32 |
| Hotels (M $m^3$) | 0.51 | 1.99 | 0.48 | 0.19 | 1.04 |
| Other (M $m^3$) | - | - | 0.04 | - | - |

## A.4.2. Water Supply and Demand Balance

A thorough assessment of the present and future hydrological balance has not been undertaken to date (a study will be commissioned shortly to address this gap in knowledge). Nevertheless, the Department of Water Development was able to provide conservative estimates of future demand for drinking water. These estimates are shown in Table A.11. As the table indicates, gross M & I demand is anticipated to increase from 57 million $m^3$ in 1995 to 64 million $m^3$ by 2000, 78 million $m^3$ by 2010, and 95 million $m^3$ by 2020.

Table A.11 Projected Population and Gross M & I Water Demand

| | Year | | | | |
|---|---|---|---|---|---|
| | 1993 | 1995 | 2000 | 2010 | 2020 |
| Population (000) | 630 | 644 | 679 | 743 | 800 |
| Annual increase (%) | 1.13 | 1.07 | 0.90 | 0.75 | |
| Gross demand per capita: Annual increase (%) | 2.10 | 1.20 | 1.10 | 1.30 | |
| Gross water demand (M $m^3$) | 53 | 57 | 64 | 78 | 95 |
| Annual increase (%) | 3.30 | 2.30 | 2.00 | 2.00 | |

Historically, the balance between supply and demand for water has been maintained. However, the supply of water varies from year to year due to varying climatic conditions; so while 1993 was not a drought year and the supply of water from dam-reservoirs and aquifers was adequate to meet demand, this has not been the case since. The recent persistent drought has brought into question the ability of Cyprus's current water supply sources to meet both current and future demand, even without an increase of demand if current levels of use were maintained.

## A.4.3. Water Development Programme

In recognition of this imbalance between supply and demand, a programme has been initiated, comprising the following measures:

- secure additional sources of supply;
- manage water demand;
- modify the current irrigation water allocation matrix;
- built up strategic water reserves; and
- institute changes in the existing legal and institutional framework.

**Secure Additional Sources of Supply**

It is envisaged that an additional 12 large dams will be constructed, with a total capacity of 85 million cubic metres. It is hoped that the reliable yields of the resulting reservoirs will be about 25 million cubic metres per year. Most of the rivers to be dammed (e.g. Karyiotis, Limnitis, Xeros, Marathasa) however, flow to the north. The co-operation of the Turkish Cypriots is therefore required before these resources can be developed.

A programme of desalination plants is planned, in order to meet domestic needs (see Table A.12). The current policy is to offer the private sector a fixed term contract to supply a set quantity of suitable water for an agreed price per cubic metre. The Department of Water Development is then obliged to purchase the water at this price for the term of the contract. However, at any point, the Department of Water Development has the right to buy out the plant operator. The unit costs given in Table A.12 recover the capital and recurring costs of the plant, plus a return to the investor, over the term of the contract. They may therefore be looked at as levelised costs (i.e. total annual costs divided by output). Assuming that the plants operate at full capacity (as is the case with the existing plant), and the unit cost of the other three units is around CY $£^{1997}$ 0.56 per $m^3$, then the estimated total annual cost of the entire desalination plant programme is about CY $£^{1997}$ 22.2 million (or 35.6 million ECU). It is not possible to distinguish capital costs from recurring costs.

The plant at Dhekelia is already operational, therefore additional future expenditures amount to CY $£^{1997}$ 14.3 million (or 22.3 million ECU).

Table A.12 Desalination Plant Programme

| Location | Capacity ($m^3$ per day) | Year of Operation | Operating Life | Unit Cost (CY £ per $m^3$) | Remarks |
|---|---|---|---|---|---|
| Dhekelia | 40,000 | 1997 | 10 | 0.54 | BOOT Type |
| West Larnaca | 40,000 | 2000 | 10 | 0.44 - 0.67 | BOOT Type |
| Limassol Port | 15,000 | 1999 | 2 or 10 | ? | Mobile Unit |
| Ayios Thoodhoros | 15,000 | 1999 | 2 or 10 | ? | Mobile Unit |

It is Government policy to treat effluent to a sufficient standard (typically tertiary level) in order that it can be reused. Presently, about 3 million cubic metres of treated effluent is recycled. As noted in the development plans regarding waste water treatment (discussed elsewhere in this study), the tertiary treatment capacity in the Republic of Cyprus is forecast to substantially increase over the next 20 years. It therefore follows that the amount of effluent recycled will also increase over this period. In fact, it is estimated that by 2020 over 25 million cubic metres of treated effluent will be reused. Between 50 and 60 per cent of this total will be used for amenity purposes, e.g. urban parks, sports fields; the remainder will be used for irrigation.

**Water Demand Management**

The Department of Water Development plans to reduce agricultural demand by increasing the price of water. If the unit cost of water used for irrigation is increased from 34 per cent to 38 per cent of the average cost, savings of around 3 to 4 million cubic metres per year are expected. Of course, there are direct and indirect welfare costs associated with such a policy, however, these are not quantifiable within the scope of this study.

The Department of Water Development also expects to save between 6 and 8 million cubic metres per year through the use of advanced technological distribution and application systems (i.e. reduce system losses). Furthermore, plans exist to increase 'public awareness' with the aim of reducing per capita domestic consumption. It is also proposed that subsidies be introduced to encourage households to utilise 'grey water' for toilet flushing, garden watering, etc. The combination of these measures is expected to reduce household consumption by 3 to 5 million cubic metres per year. Again, there are direct and indirect welfare costs associated with these proposals, which are not quantifiable within the scope of this study.

**Other Strategies**

The Department of Water Development would like to see a move away from current cropping patterns, which tends to favour water intensive crops, e.g. bananas, citrus fruit, towards less water intensive winter crops. Also, with respect to agricultural use, a programme for the horizontal limitation of irrigated agriculture is been considered.

Plans also exist to build so-called 'strategic' reservoirs; these reservoirs would be available for use only in emergencies.

Finally, it is the opinion of the Department of Water Development that harmonising existing legislation with that of the EU and the subsequent formation of a 'Water Entity', with the responsibility for all matters pertaining to water management, will help the Government generate a more efficient response to the Republic of Cyprus's current water problems.

**The Cost of Meeting Water Demand**

The capital costs of both on-going and proposed works, designed to address the water demand and supply imbalance in Cyprus, are shown in Table A.13 and Table A.14, respectively. The estimated capital cost of all projects is CY $£^{1997}$ 223.3 million (or 357.73 million ECU); of which 53.7 per cent (or 192 million ECU) relates to continued works and 46.3 per cent (31.2 million ECU) relates to proposed works.

Estimates of the recurring costs of the projects listed in Table A.13 and Table A.14 are unavailable at present. Based on experience gained during the Southern Conveyor Project and the Vasilikos Pendaskinos Project, the Department of Water Development found that recurring costs are approximately 2 per cent of the initial investment costs per year. Hence, the recurring costs of the investment programme are CY $£^{1997}$ 4.46 million per year (or 7.1 million ECU).

Table A.13 Capital Costs: Continued Works (Annual Investment in CY £[1996] million)

| | Year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **Total** |
| **Southern Con. Project** | 5.72 | 8.49 | 8.07 | 2.45 | 1.35 | | | | | | | | | | | | | 26.07 |
| **Karyotis Project** | | | 2.42 | 3.30 | 5.29 | 7.74 | 8.48 | 2.81 | 0.30 | | | | | | | | | 30.34 |
| **Paphos Project** | 1.88 | 1.00 | 7.30 | 13.14 | 12.65 | 10.35 | 8.60 | 5.00 | | | | | | | | | | 59.92 |
| **Total** | 7.60 | 9.49 | 17.79 | 18.89 | 19.29 | 18.09 | 17.08 | 7.81 | 0.30 | | | | | | | | | 116.3 |

Table A.14 Capital Costs: Planned Works (Annual Investment in CY £[1996] million)

| | Year | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **Total** |
| **West Mesaoria Project** | | | | 0.50 | 4.30 | 5.90 | 6.20 | 2.60 | | | | | | | | | | 19.50 |
| **Northern Conveyor Project** | | | | | | | | | | 5.50 | 8.25 | 8.25 | 8.25 | 8.25 | 8.25 | 5.50 | 2.75 | 55.00 |
| **Ha Potami Project** | | | 0.15 | 1.15 | 1.08 | 2.75 | 3.40 | 2.15 | 1.30 | 0.95 | | | | | | | | 12.93 |
| **Sewerage Reuse Projects** | 2.00 | 1.00 | 4.00 | 2.00 | 2.00 | 0.20 | 0.20 | 0.30 | 0.50 | 0.30 | 0.30 | 0.20 | | | | | | 13.00 |
| **Total** | 2.00 | 1.00 | 4.15 | 3.65 | 7.38 | 8.85 | 9.80 | 5.05 | 1.80 | 6.75 | 8.55 | 8.45 | 8.25 | 8.25 | 8.25 | 5.50 | 2.75 | 100.4 |

# B. Management of Municipal Solid Waste [7]

## B.1. The Existing Situation In the Republic of Cyprus [8]

### B.1.1. The Collection of Waste

The present situation involves the municipalities taking responsibility for the collection of waste in their own areas. As part of this system, they also own and maintain the collection equipment. The waste is collected from the kerbside between two and six times per week (depending on the time of year). The waste has to be collected frequently due to the lack of bulk storage containers.

Municipal waste is generally not segregated prior to collection, and recycling activities are few. There is some recycling of aluminum cans (about 1,500 tonnes per annum), paper and cardboard (about 4,000 tonnes per annum), all of which is baled and exported, except for paper/cardboard waste products from printing works which are recycled domestically. Glass beverage bottles of local origin are recycled through a deposit system, other glass containers are not recycled.

At present, there are no manufacturers which operate using only recycled materials. However that is not to say that there is no capacity for recycling. For example, in Limassol, a company currently uses about 1000 – 1500 tonnes of paper / cardboard per annum which is baled and exported. Also, it is possible that plastics manufacturers could use post consumer products after grading and pelleting. It is highly likely that such plants already recycle production waste internally.

### B.1.2. The Disposal of Municipal Waste

Most municipal waste is disposed of via landfill. There are five landfill sites operating at present. No other treatment facilities exist. In the rural areas, waste is often disposed of locally.

The landfills are owned, run and maintained by the municipalities. However they serve more than the local area, with 75% of the population of the Government controlled area being served by the five landfills. The landfills have no system for control or registration, and no registration of the waste hauliers and other producers of waste. This means that there is no data on waste quantities and composition. The landfills are also not constructed according to present good standards, for example they have no measures to prevent the escape of leachate.

The charges for waste services are paid directly to the municipality by all the premises in the area from households to industrial premises. The level of charges relate to the type of property. The municipalities can set the charges which tend to be set to recover more than the costs of services provided (to supplement municipal budgets). As a result of this system, equivalent households, in the same and different areas, can pay different charges for the same service. In other words, user charges to not reflect the costs of waste management practices, and thus do not send the correct price signals to users of these services.

### B.1.3. Current Waste Arisings

Surveys carried out in 1993, and subsequent supplementary surveys and comments, produced the following estimates of current waste arisings (more recent data is not available at present). Three Districts were included in the survey, and analysis included quantity, composition, and density of the waste. Two further District municipalities provided information which was used directly in the surveys.

An estimate is shown in Table B.1.

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7 Municipal solid waste includes domestic waste from households as well as waste from shops, supermarkets, offices, institutions, canteens, restaurants and hotels. It includes ordinary refuse, metal cans, plastics, paper and cardboard, glass, garden waste.

8 This Annex is based on a report by Carl Bro Environmental in association with NV Consultants (1994) Recycling of Municipal Solid Waste in the Main Urban and Tourist Centres of Cyprus prepared for the Ministry of the Interior.

Table B.1 Estimate of Waste Arisings in Cyprus in 1993

| | **Residential areas** (tons/years) | | **Tourists areas** (tons/years) | | **Others areas** (tons/years) | | **Total** (tons/years) | |
|---|---|---|---|---|---|---|---|---|
| | 1993 | 2007 | 1993 | 2007 | 1993 | 2007 | 1993 | 2007 |
| Nicosia | 118,300 | 139,400 | 600 | 1,200 | 26,200 | 47,200 | 145,500 | 187,800 |
| Limassol | 74,900 | 94,300 | 6,300 | 14,200 | 14,600 | 26,300 | 95,800 | 134,800 |
| Larnaca | 49,600 | 54,900 | 3,000 | 6,400 | 11,100 | 20,000 | 63,700 | 81,300 |
| Paphos | 25,000 | 30,300 | 5,900 | 22,400 | 5,500 | 9,900 | 36,400 | 62,600 |
| Famagusta | 13,200 | 17,800 | 10,200 | 38,700 | 4,000 | 7,200 | 27,400 | 63,700 |
| Total | 281,400 | 336,700 | 26,000 | 82,900 | 61,400 | 110,600 | 368,800 | 530,200 |

**Source:** Carl Bro Environment (1994) Recycling of MSW in the Main Urban and Tourist Centres of Cyprus.

The main tourist influx occurs between May and September, which has implications for municipal waste production. There is not as clear a link as might be expected, however, as Table B.1 shows. Residential areas produce 68% of the waste, while only 7% is produced in tourist areas. The Carl Bro study found that the average per capita production is approximately 470 kg/year for residential areas, and approximately 670 kg/'Tourist Year' for tourist areas.9

The quantities identified above are quite high in relation to the EU average of 327 kg/year (Carl Bro, 1994). Note, however, that some of this variation might be due to differences in the definition of municipal waste.

Table B.2 shows the composition of municipal waste.

Table B.2 The Composition of Municipal Waste

| | **1993** | **2007** |
|---|---|---|
| Organic | 24% | *It is assumed. that the Cyprus composition of the waste will not change considerably by 2007* |
| Paper | 17% | |
| Plastic | 13% | |
| Garden waste | 11% | |
| Combustible Refuse | 11% | |
| Non combustible Refuse | 9% | |
| Cardboard | 8% | |
| Metal | 4% | |
| Glass | 3% | |
| TOTAL | **368,900 tons** | **530,200 tons** |

**Source:** Carl Bro Environment (1994)

The Table shows organic matter to be the single most important component of municipal waste. It accounts for one fifth of the total waste. Together with garden waste, 'digestible' waste constitutes more than one third of the total waste arising. Paper and cardboard constitute another quarter.

## B.1.4. The Forecast for 2007

The content and quantity of municipal waste is affected by a number of factors. The more important are:

- Population growth. Based on the rate of growth in the period 1982 to 1992, Cyprus will have a population of 719,500 in 2007. Waste arisings from residential areas have been projected according to this growth rate.

9 In addition to household waste, these figures include waste from commercial premises, hotels and restaurants.

- Growth in tourism. It has been estimated that the number of bed nights will increase from 14 million in 1992 to 50 million in 2007.
- Patterns of consumption. This is influenced by prices, world trade, consumer preference etc. Generally, it is expected that there will be a higher level of plastics and packaging materials, but it is very difficult to predict, thus it is assumed the composition will not change considerably until 2007 (Carl Bro, 1994).

Based on the assumptions above, a forecast has been made for municipal waste production in the year 2007, this was also given in Table B.2 above.

## B.1.5. Goals for Municipal Waste Management

EU member states have acceded to the following ranking of the preferred waste management strategies:

- Prevention (minimisation).
- Material recovery (re-use, recycling, reclamation of materials).
- Energy recycling (anaerobic digestion, incineration with energy utilisation).
- Composting or incineration without energy utilisation.
- Landfill of waste.

The following principles should also be embodied into any waste management strategy: the 'polluter pays' principle; segregation of waste at source; co-operation within the waste sector; BATNEEC; and of course, the relevant Directives and standards of the EU environmental *acquis*.10

Goals for municipal waste management in Cyprus will reflect 'special conditions', including the fact that Cyprus is an island of limited size and population, the impact of the tourist industry, and the limited economic resources.

For sustainability to be achieved in waste management, the Carl Bro study identified the following general objectives which need to be attained:

- "... Conservation of natural resources and the reduction of the environmentally damaging effects of waste handling and management.
- Reduction of quantities of waste through recycling and waste minimisation.
- Improvement of waste collection systems in terms of the service provided to waste producers.
- Improvement of the working and occupational health conditions relevant to waste management.
- Improved cost effectiveness and better utilisation of resources (human, technical and fiscal)..."

These objectives should be supported by measures relating to: institutional strengthening - new regulations and rate systems, increased public awareness; collection - improved systems, wider coverage, separation of different types of waste; recycling - development of systems and creation of markets; treatment and disposal - implementation of a registration system, modern treatment and disposal facilities, and closure of unacceptable dump sites.

## B.1.6. Future Management of Municipal Waste in Cyprus

**Management Scenarios**

Three new scenarios have been developed by Carl Bro which differ in approach and strategy, but comply with the overall goals as presented above (including relevant EU legislation). The main difference between the scenarios is the degree and method of waste treatment and the level of recycling. The scenarios concern household waste only (i.e. they exclude industrial waste, hospital waste, etc., but include commercial waste), and reflect the situation in the year 2007. That is, the three scenarios only differ in their treatment of household waste from residential and tourist areas. A complete future waste management plan, however, should also take account of the excluded waste streams.

10 The Carl Bro study explicitly recognises Cyprus's application for membership to the EU in its scenario development.

"... A prerequisite of all three scenarios is that the producers of the waste sort their waste into various categories. This is not considered a burden if sufficient collection equipment is available ..." The three scenarios are compared against the reference scenario; Scenario I, which reflects the present waste management situation, in Table B.3.

Table B.3 Comparison of the Waste Management Scenarios (additional treatment facilities)

| | **I Reference** | **II Low recycling – Landfilling** | **1.1.6.1.1III Low recycling - Incineration** | **IV High Recycling – Agricultural based Biogas** |
|---|---|---|---|---|
| Recycling activities | - | Low (Recycling Banks and Centres) | Low[1] (Recycling Banks and Centres) | High[2] (Blue Boxes, Recycling Banks and Centres) |
| Incinerators | - | - | 3 | - |
| Biogas | - | - | - | 3 |
| Landfills | only waste disposal | 3-5 | 3 | 3-5 |

**Source:** Carl Bro Environment (1994)

**Notes:**

[1] A high recycling activity includes facilities for recycling of tyres and wrecked cars, a Blue Box System applied in residential areas of major urban areas, Recycling Centres and Banks in minor urban areas and tourist areas.

[2] A low recycling activity includes facilities for recycling of tyres and wrecked cars, and a Bring System (Recycling Centres and Banks) in all urban areas and tourist areas.

The total quantities of waste disposed of and treated in 2007 under the various scenarios is shown in Table B.4.

Table B.4 Total Quantities of Waste for Disposal and Treatment in 2007 Under the Different Scenarios

| | I | II | III | IV |
|---|---|---|---|---|
| **Recycling** | - | 20,467 tons (4%) | 20,467 tons (4%) | 45,872 tons (9%) |
| **Incineration** | - | - | 360,000 tons (68%)<br>111,60 tons (31%) in landfill | - |
| **Biogas** | - | - | - | 78,000 tons (15%) |
| **Landfill** | 530,200 tons | 509,733 tons (96%) | 149,733 tons (28%) | 406,328 tons (76%) |
| **TOTAL** | 530,200 tons | 530,200 tons | 530,200 tons | 530,200 tons |

**Source:** Carl Bro Environment (1994)

**Financial Evaluation**

This section summarises the capital costs, and operational costs and revenues (net recurring costs) related to each of the scenarios, as estimated by Carl Bro Environment. Where Cyprus prices were not available, prices were based on European experience, approximated for Cyprus conditions.

Revenues from the sale of energy and recyclable materials were based on prices obtained from Cyprus. However, in many cases those prices seem high compared to European levels, if an international market exists.

"... The net cost for each collection system and treatment plant are stated as costs for the first year of operation ...". Also, "... new collection costs include capital costs for investments in new equipment (e.g. containers, vehicles) and operation costs (e.g. wages, maintenance) ...". The cost of new treatment facilities is included, i.e. the cost of new sanitary landfills, incinerators etc (in compliance with EU standards). "... The cost of incinerators, biogas plant, and new landfills are calculated as the 'per ton tipping fee', using a great number of basic assumptions concerning energy prices etc ...". Estimated investments are shown in Table B.5, while estimated annual net costs are shown in Table B.6.

It should be noted that representatives of the Environment Service, and the Ministry of Interior expressed some reservations over the direct applicability of the above scenarios to Cyprus. These reservations mainly relate to: the age of the data set, the simplified nature of the forecasts; the completeness of the waste strategies; and the feasibility of actually implementing the measures described. There is thus some uncertainty as to whether the estimated costs are truly representative of those required to provide a suitable waste management strategy. However, the figures cited in Table B.5 and Table B.6 should provide a reasonable approximation – the right order of magnitude – of the costs involved. Recently, a representative of Carl Bro has visited Cyprus in order to complete the study with regards to data analysis, waste strategies and costs. The study is now expected to be completed in June 1999.

Table B.5 Capital Costs for Scenarios I to IV in 2007

| | I | II | III | IV |
|---|---|---|---|---|
| Recycling Banks | - | 693 | 693 | 168 |
| Recycling Centres | - | 910 | 910 | 910 |
| Blue Box System | - | - | - | 1,500 |
| Source Segregation | - | - | - | 6,400 |
| Refuse Collection | 4,650 | 4,650 | 4,650 | - |
| Paper Processing | - | 285 | 285 | 285 |
| Glass Processing | - | 2,450 | 2,450 | 2,450 |
| Can Processing | - | 300 | 300 | 300 |
| Tyre Processing | - | 2,155 | 2,155 | 2,155 |
| Incinerators | - | - | 59,550 | - |
| Biogas Plants | - | - | - | 9,960 |
| Landfills | 78 | 15,840 | 11,880 | 15,840 |
| TOTAL | CY $£^{1994}$ 4.7 mn | CY $£^{1994}$ 27.8 mn | CY $£^{1994}$ 82.9 mn | CY $£^{1994}$ 40.0 mn |
| | CY $£^{1997}$ 5.1 mn | CY $£^{1997}$ 30.3 mn | CY $£^{1997}$ 90.4 mn | CY $£^{1997}$ 43.6 mn |
| | 8.2 million ECU | 48.5 million ECU | 144.8 million ECU | 69.8 million ECU |

**Source:** Carl Bro Environment (1994)

Table B.6 Annual Net Costs for Scenarios I to IV in 2007

| | I | II | III | IV |
|---|---|---|---|---|
| Recycling Banks | - | 406 | 406 | 98 |
| Recycling Centres | - | 399 | 399 | 399 |
| Blue Box System | - | - | - | 760 |
| Source Segregation | - | - | - | 3,100 |
| Refuse Collection | 2,300 | 2,300 | 2,300 | - |
| Paper Processing | - | 120 | 120 | 275 |
| Glass Processing | - | 197 | 197 | 449 |
| Can Processing | - | 667 | 667 | 1,306 |
| Tyre Processing | - | 720 | 720 | 720 |
| Incinerators | - | - | 5,400 | - |
| Biogas Plants | - | - | - | 250 |
| Landfills | 387 | 3,568 | 1,829 | 2,844 |
| TOTAL | CY $£^{1994}$2.7 mn | CY $£^{1994}$6.4 mn | CY $£^{1994}$10.1 mn | CY $£^{1994}$6.1 mn |
| | CY $£^{1997}$2.9 mn | CY $£^{1997}$6.8 mn | CY $£^{1997}$10.8 mn | CY $£^{1997}$6.5 mn |
| | 4.6 million ECU | 10.9 million ECU | 17.3 million ECU | 10.4 million ECU |

**Source:** Carl Bro Environment (1994)

# C. Industrial Pollution Control and Risk Management

## C.1. The Electricity Authority of Cyprus [11]

Electricity generation and transmission in Cyprus is the responsibility of the Electricity Authority of Cyprus (EAC).

### C.1.1. Existing System

At present the EAC operates two thermal power stations with a total installed capacity of 690 MW (see Table C.1). The (new) Dhekelia power station is located on the south east coast of Cyprus. It is situated adjacent to the (old) Dhekelia power station, which was built in 1952 and has since been decommissioned. Dhekelia consists of 6 x 60 MW heavy fuel oil fired steam units; the first unit was commissioned in 1982 and the last unit in 1993. Moni power station, also located on the south coast of the island, consists of 6 x 30 MW heavy fuel oil fired steam units. The first unit was commissioned in 1966 and the last one in 1976. Four gas turbines are also sited at the Moni power station. These units are recent additions, the first two were installed in 1992 and the other two in 1995, and they are mainly used to meet peak loads, or as stand-by plant for the heavy fuel oil units. However, it is the intention of the EAC to gradually retire the old and inefficient units at Moni.

Table C.1 EAC Existing Generating Capacity

| Power Station | Generating Units | Capacity |
|---|---|---|
| Dhekelia | 6 x 60 MW oil/steam | 360 MW |
| Moni | 6 x 30 MW oil/steam | 180 MW |
| Moni | 4 x 37.5 MW gas turbines | 150 MW |
| Total | | 690 MW |

### C.1.2. Future Development

In order to meet continuously increasing demand for electricity, the EAC plans to establish a new power station at a site near Vasilikos on the south coast of Cyprus. While the EAC has opted for an oil fired station, it has been designed in such a way that, should the availability or use of fuel oil become problematic in the future, the power station could switch to coal.

The Vasilikos power station will be built in three phases (see Table C.2). The first phase, expected to be operational in the year 2000, consists of 2 x 130 MW heavy fuel oil fired units. Two further phases, comprising 2 x 120 MW units, will bring the total installed capacity to 740 MW by the end of 2008.

Table C.2 EAC Future Development at Vasilikos

| Phase | Generating Units | Capacity | Approximate Year of Operation |
|---|---|---|---|
| 1 | 2 x 130 MW | 260 MW | 2000 |
| 2 | 2 x 120 MW | 240 MW | 2004 |
| 3 | 2 x 120 MW | 240 MW | 2008 |
| | | 740 MW | |

11 This section is based on information provided by, and discussions held with Mr. M. Antoniou, Senior Assistant Generation Manager, and Dr. A. Poullikkas, mechanical engineer, Electricity Authority of Cyprus.

## C.1.3. Expenditure on 'Environmental' Projects

The Generation Department of the EAC provided information on numerous 'environmental' projects (i.e. projects required to meet environmental regulations/standards) which have been undertaken over last five years at each of their existing power stations. A list of 'environmental' projects and their associated costs was also provided for the proposed power station at Vasilikos.

Continuous emission monitoring equipment was installed at Dhekelia power station: units 1 and 2 are continuously monitored for $NO_x$ and CO; units 3 and 4 are continuously monitored for $NO_x$, CO and $CO_2$; and units 4 and 5 are continuously monitored for $NO_x$, CO, $CO_2$ and $SO_2$. A portable flue gas analyser is used to measure particulate emissions. Continuous emission monitoring equipment will also be installed at Vasilikos. There is no continuous emission monitoring scheme at the Moni power station, although a portable flue gas analyser was purchased in 1997 to measure emissions of $SO_2$, $NO_x$ and CO. The total cost of the emission monitoring units for all three power stations is CY £$^{1997}$ 221,100.

Two mobile ambient air quality monitoring units were purchased in 1994 for each of the Moni and Dhekelia power stations. These units measure ground level concentrations of $SO_2$, $NO_x$, $PM_{10}$ and CO. Two mobile units are also required for the Valilikos power station. The total cost for all six mobile monitoring units is CY £$^{1997}$ 694,700.

A water treatment plant was installed at the Dhekelia power station in 1995. The purpose of this plant, which cost CY £$^{1997}$ 669,000 and has annual operating costs of CY £$^{1997}$ 72,000, is to treat the effluent generated during the washing of boilers and other cleaning/maintenance operations. The plant at Dhekelia will also treat the effluent from the power station at Vasilikos, which will be transferred to Dhekelia via road tankers. Additional treatment plant is required at Vasilikos, in order to neutralise the acid boiler wash prior to its transport to Dhekelia.

A separate sewage treatment plant was constructed at Dhekelia in 1996. A similar small treatment plant will be constructed at Vasilikos to deal with domestic sewage. Each plant costs CY £$^{1997}$ 51,400. All treated water, both sewage and boiler wash, is used for irrigation. As the boiler wash from Vasilikos is transferred to Dhekelia, the intention is to construct a rainwater collection and retaining system to provide additional water for site irrigation. Normally water for irrigation is abstracted from boreholes. The rainwater retaining system thereby preserves groundwater supplies. The system, including the irrigation piping, is estimated to cost CY £$^{1997}$ 208,900.

In 1995 the EAC were required by the Ministry of Labour and Social Insurance to raise the height of the stack on units 1 and 2 at Dhekelia power station. The stack was initially constructed to a height of 60 m and needed to be increased to 100 m; the stacks on the other 2 phases at Dhekelia were originally constructed to the required height of 100 m. The cost of raising the stack height was CY £$^{1997}$ 617,600.

Based on an evaluation by ERM (Environmental Resource Management), a stack height of 125 m is required at Vasilikos power station in order to ensure that ground level concentrations do not exceed either the Cyprus standards or the relevant EU limit values. The required 125 m stack is estimated to cost CY £$^{1997}$ 2.26 million.

To comply with 88/609/EEC, abatement equipment is to be installed at Vasilikos power station; multi-cyclones are required to reduce particulate emissions and low $NO_x$ burners and recycling fans are to be installed to reduce emissions of $NO_x$. The corresponding costs are CY £$^{1997}$ 165,700 and CY £$^{1997}$ 1.75 million respectively; equivalent to CY £$^{1997}$ 637 per MW and CY £$^{1997}$ 6,730 per MW. ). Recurring costs are assumed to be between 4 and 6 per cent of the investment costs12.

If fuel oil of sufficiently low sulphur content cannot be found, flue gas desulphurisation (FGD) units will be required in order to meet EU limit values for $SO_2$13. The EAC were unable to provide estimates of the cost of FGD installations. The cost of FGD installations has thus been estimated using

12 AEA Technology (1997) Emission Inventories of GHGs and Ozone Precursors. Second year report for DG XI.

13 The EAC estimate that in order to meet the required emission standards, in the absence of FGD, they would need to burn a fuel oil with a sulphur content of 0.8 per cent. To use oil with 1 per cent sulphur content as opposed to oil with 3.5 per cent sulphur content costs the EAC an additional US $$^{1998}$ 6.0 million per year.

data from the UK14. Capital and recurring cost data for two types of FGD process are given in Table C.3. An order of magnitude estimate of the cost of installing FGD units at Vasilikos is found by multiplying the unit costs in Table C.3 by the declared capacity of the power station. The resulting cost estimates are reported in Table C.4. The capital cost of an FGD installation for Phase 1 at Vasilikos ranges between CY £$^{1997}$ 32.57 and CY £$^{1997}$ 49.57 million; the recurring costs range between CY £$^{1997}$ 4.82 million and CY £$^{1997}$ 6.23 million.

Table C.3 Unit Cost of FGD Installations15

| Cost Component | Limestone or Lime Slurry Scrubbing UK £$^{1990}$ per $kW_e$ | Lime Slurry Scrubbing/Spray Drying UK £$^{1990}$ per $kW_e$ |
|---|---|---|
| Capital Cost | 175 | 115 |
| Recurring Cost: | | |
| Energy | 5 | 3 |
| Non-energy | 12 | 19 |

Table C.4 Total Cost of Installing FGD at Vasilikos Power Station

| Cost Component | Limestone or Lime Slurry Scrubbing UK £$^{1990}$ million | Lime Slurry Scrubbing/Spray Drying UK £$^{1990}$ million |
|---|---|---|
| Capital Cost: | | |
| Phase 1 (260 MW) | 45.5 | 29.9 |
| Phase 2 (240 MW) | 42.0 | 27.6 |
| Phase 3(240 MW) | 42.0 | 27.6 |
| Total Capital Cost | 129.5 | 85.1 |
| Recurring Cost: | | |
| Phase 1 (260 MW) | 4.42 | 5.72 |
| Phase 2 (240 MW) | 4.08 | 5.28 |
| Phase 3 (240 MW) | 4.08 | 5.28 |
| Total Recurring Cost | 12.58 | 16.28 |

Sulphur abatement measures will also be required at Dhekelia and Moni power stations in order to comply with 88/609/EEC. The estimated total cost of installing FGD units at Dhekelia is shown in Table C.5. (The cost of FGD units for the Moni power station has not been estimated, as the power station is due to be gradually retired over the next ten years.) The capital cost of an FGD installation for Dhekelia ranges between CY £$^{1997}$ 45.10 and CY £$^{1997}$ 68.63 million; the recurring costs range between CY £$^{1997}$ 6.67 million and CY £$^{1997}$ 8.63 million.

In addition, abatement measures will need to be implemented at Dhekelia to reduce $NO_x$ emissions from all units, and particulate emissions from the last unit (which was commissioned after 1987). Assuming that the unit costs of the measures to be installed at Vasilikos will be the same order of magnitude as the cost of applying the same measures to Dhekelia, the estimated total cost is:

- CY £$^{1997}$ 2.43 million for $NO_x$ abatement, i.e. 360 MW times CY £$^{1997}$ 6,730 per MW; and
- CY £$^{1997}$ 76,400 for particulate abatement, i.e. 120 MW times CY £$^{1997}$ 637 per MW.

14 FGD cost data was obtained from Abbott, J. A. (1996) "Sulphur Dioxide Ambient Air Quality Study", a report prepared for the UK DETR.

15 To place these unit costs in perspective, Ifo Institute (1994) "Environmental Standards and Legislation in Western and Eastern Europe Towards Harmonisation: the economic costs and benefits of harmonisation", estimates the capital cost of FGD plant in the range of £80 to £220 per kW, depending on whether the plant is 'new' or 'retrofit'.

Note: retrofitting as opposed to installing 'new' plant, can increase costs from between 50 to 200 per cent16. Therefore, reducing emissions from Dhekelia is more likely to cost between CY £1997 3.65 and CY £1997 7.29 million for $NO_x$ and CY £1997 0.11 and CY £1997 0.23 million for particles. Again, recurring costs are assumed to be between 4 and 6 per cent of the investment costs.

Table C.5 Total Cost of Installing FGD at Dhekelia Power Station (360 MW)

| **Cost Component** | **Limestone or Lime Slurry Scrubbing** UK £1990 million | **Lime Slurry Scrubbing/Spray Drying** UK £1990 million |
|---|---|---|
| Capital Cost | 63.0 | 41.4 |
| Recurring Cost | 6.12 | 7.92 |

In summary, the following capital expenditures have been made on 'environmental' projects at the Moni power station since 1994:

| **Cost Component** | **CY £1997** | **Year** |
|---|---|---|
| Noise abatement equipment | 51,400 | 1994 |
| Mobile air monitoring units | 205,800 | 1994 |
| Atomising steam burners | 514,700 | 1996 |
| Emission monitoring unit | 10,200 | 1997 |
| | 782,100 | |

Likewise, the following capital expenditures have been made on 'environmental' projects at the Dhekelia power station since 1994:

| **Cost Component** | **CY £1997** | **Year** |
|---|---|---|
| Mobile air monitoring units | 257,300 | 1994 |
| Effluent treatment plant | 669,000 | 1995 |
| Raising stack heights | 617,600 | 1995 |
| Sewage treatment plant | 51,400 | 1996 |
| Continuous emission monitoring units | 25,700 | 1997 |
| | 1,621,000 | |

Planned capital expenditures for 'environmental' projects at the Vasilikos power station include:

| **Cost Component** | **CY £1997** |
|---|---|
| Sewerage treatment plant | 51,400 |
| Continuous emission monitoring units | 185,200 |
| Mobile air monitoring units | 231,600 |
| Multi-cyclones for dust collection | 165,700 |
| Low $NO_x$ burners | 1,544,000 |
| Recycling fans for $NO_x$ reduction | 205,800 |
| Acid neutralisation plant | 596,000 |
| Rainwater retaining system | 180,100 |
| Irrigation system | 28,800 |
| 125 m Stack | 2,264,700 |
| | 5,453,300 |

Note: the total of CY £1997 5.45 million refers only to Phase 1 of the Vasilikos power station. If FGD units using the lime slurry scrubbing process were to be installed on Phase 1 at Vasilikos, total capital expenditures would increase to CY £1997 38.02 million.

The EAC also spends approximately CY £1997 82,300 per year on general environmental management.

16 EDC/EPE (1997) Compliance Costing for Approximation of EU Environmental Legislation in the CEEC. Final report for EU DGXI.

# D. Staff and Training Needs

## D.1. Introduction

In general, the Government bodies involved in ‘environmental management and protection’ are under strain from the proliferation of laws and programmes. Not only is there a lack of legal empowerment, but there is a shortage of personnel in strategic/co-ordinating, executive or supportive Government Departments. In order to address these issues, and facilitate harmonisation with the EU environmental *acquis*, additional suitably trained staff are required in key agencies, and the knowledge of existing staff needs to be expanded. Of course, the provision of appropriate training and creation of new posts will incur costs. The estimated magnitude of these costs is explored below.

## D.2. Additional Staff

At various junctures in Chapters 3 through 7, the need for institutional strengthening to comply with the environmental *acquis* (in the form of additional Government staff) was highlighted. An estimate of the cost of additional staff required by three Government Departments affected by the demands of the *acquis* is provided below. At this stage it is not possible to say with certainty whether these additional staff estimates are sufficient to ensure compliance with the *acquis*; they represent a best possible first assessment of the costs involved17. Given that the full implications of the IPPC Directive and the proposed Water Framework Directive are not fully understood at present (or accounted for below), it is likely that the actual outturn compliance costs in this area will be higher than those provided here.

### D.2.1. Department of Labour

At present the Factory Inspectorate of the Department of Labour employs 11 well qualified engineers at the central office in Nicosia; five of whom deal solely with pollution. In order to meet the demands of the EU environmental *acquis*, it is estimated that one additional ‘professional’ level staff member will be required for the head office in Nicosia. Also, an additional 6 inspectors will be required.

The total salary payable to a ‘new’ Government employee in 1999 is given in Table D.1. Using the mid-point of the ‘technical’ scale (i.e. A4 CY £$^{1997}$ 5,802), and allowing for general overheads of 30 per cent, the recurring cost of four additional inspectors is about CY £$^{1997}$ 30,200 per annum. Likewise, based the mid-point of the ‘professional’ scale (i.e. A10 CY £$^{1997}$ 13,133), the recurring cost of four additional head office staff is about CY £$^{1997}$ 68,300 per annum. The estimated total recurring cost of all eight new posts is CY £$^{1997}$ 98,500 per annum (or 157,800 ECU per annum).

### D.2.2. Department of Water Development

There is a foreseen shortage of human resources in the Department of Water Development in order to meet the additional requirements of the EU environmental *acquis*. An estimated 5 to 6 additional ‘technical’ level staff will be required to undertake water quality monitoring duties. Using the mid-point of the ‘technical’ scale (i.e. A4 CY £$^{1997}$ 5,802), and allowing for general overheads of 30 per cent, the recurring cost of six additional inspectors is about CY £$^{1997}$ 45,300 per annum (72,600 ECU per annum).

The requirements of the ‘Framework Directive’, in particular the establishment of river basin management plans, might require the creation of additional posts in a number of agencies. However, estimates of the exact number could not be made at present. Due to the geography of Cyprus a wide ranging number of plans may be required, depending on how a river basin is defined; staffing implications for preparing and maintaining these plans is therefore indeterminable at present. Staffing requirements in this sector need to be investigated further.

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17 Estimates were provided by the relevant Departments, based on a needs assessment. These estimates, in turn, were validated by the consultants, as best as possible.

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### D.2.3. The Environment Service

The Environment Service within the Ministry of Agriculture, Natural Resources and Environment was strengthened in 1997 with the creation of 6 new posts; essentially doubling current capacity. Four of these new posts are at the 'professional' level (i.e. scale point A8 with an annual salary of CY £$^{1997}$ 9,384). The other two posts are at the 'technical' level (each with an annual salary of CY £$^{1997}$ 5,802, taking the mid-point of the 'technical' scale). The total recurring cost of all six new posts within the Environment Services, allowing for general overheads of 30 per cent, is thus CY £$^{1997}$ 63,882 per annum (or 102,300 ECU per annum).

However, in order to meet perceived future needs (mainly to meet the additional demands of the environment *acquis* in the waste management, horizontal, and nature protection sectors), it is estimated that the following new posts will be required:

- one (senior management) post at A14 (total salary CY £$^{1997}$ 21,865);
- two (senior management) posts at A13 (total salary CY £$^{1997}$ 20,400);
- four ('professional' level) posts at A11 (total salary CY £$^{1997}$ 15,524); and
- thirteen ('technical' level) posts at A9 (total salary CY £$^{1997}$ 11,651);

Therefore, the total recurring cost of all posts required to meet the future needs of the Environment Services, again allowing for general overheads of 30 per cent, is estimated at about CY £$^{1997}$ 359,091 per annum (or 575,300 ECU per annum).

Table D.1 Cost of a New Government Post in 1999

| Salary Scale Points | Total Salary (CY £$^{1997}$) |
|---|---|
| Technical/Clerical Level Staff: | |
| Entry Scale Point A1 | 5,576 |
| A2 | 5,608 |
| A3 | 5,730 |
| A4 | 5,802 |
| A5 | 6,077 |
| A6 | 7,682 |
| A7 | 8,673 |
| Professional Level Staff: | |
| Entry Scale Point A8 | 9,384 |
| A9 | 11,651 |
| A10 | 13,133 |
| A11 | 15,524 |
| A12 | 17,226 |
| Senior (Management) Staff: | |
| Entry Scale Point A13 | 20,400 |
| A14 | 21,865 |
| A15 | 24,792 |
| A16 | 27,205 |

## D.3. Training Needs

In March 1998, the Ministry of Agriculture, Natural Resources and Environment (MANRE) produced a report titled "Issues of interest to Cyprus for assistance from TAIEX on environmental legislation and policy". This document essentially outlines the perceived training needs of the Government as regards 'environmental management and protection'.

A summary of the training needs, as estimated by MANRE and reported in the cited report, are presented in Table D.3. The needs are expressed in terms of man-days, and are dissaggregated by environmental theme. Also, as the cost of external experts/consultants attending the suggested training sessions is likely to differ from the cost of Government employees, a further distinction is made between ‘external experts’ and ‘public servants’. The cost of the latter is assumed to be represented by the opportunity cost of their attendance, in terms of forgone productivity, as measured by their salary.

Table D.1 presented data on the costs to the Government of new posts, for a variety of salary scale points. This data is summarised in Table D.2. Also, the approximate cost of a man-day is included in the table, assuming a 260 day working year.

**Table D.2 Cost for Public Servants (CY £$^{1997}$)**

| | Annual Total Salary | Daily Cost |
|---|---|---|
| Technical Staff (A4) | 5,802 | 22 |
| Professional Staff (A | 13.133 | 51 |
| Senior Staff (A14) | 21,865 | 84 |

For the purpose of this exercise, the day cost of a public servant is assumed to be CY £$^{1997}$ 51 per day (or 81 ECU per day), although a range of public servants, encompassing all scale points, are likely to be involved in the proposed training programme. External experts are assumed to cost CY £$^{1997}$ 400 per day (or 640 ECU per day).

The total cost of the proposed training programme is about CY £$^{1997}$ 145,900 (or 233,700 ECU). Note: this is very approximate, e.g. it does not include any administration costs; travel costs, accommodation, etc. As a result of the omission of these factors, the true cost of the training programme is likely to be considerably higher than 233,700 ECU.

**Table D.3 Estimated ‘Environmental’ Training Needs of Government**

| Theme | Total Man-days Needed | | Estimated costs (CY £$^{1997}$) | |
|---|---|---|---|---|
| | Public Servant | External Expert | Public Servant | External Expert |
| Sustainable development[1] | 170 | 78 | 8,670 | 31,200 |
| Horizontal Legislation | 268 | - | 13,668 | - |
| Water Quality | 91 | 18 | 4,641 | 7,200 |
| Nature Protection | 91 | 18 | 4,641 | 7,200 |
| Waste Management | 91 | 12 | 4,641 | 4,800 |
| Nuclear | 91 | 18 | 4,641 | 7,200 |
| Air Quality | 91 | 18 | 4,641 | 7,200 |
| Chemicals | 91 | 18 | 4,641 | 7,200 |
| Noise | 91 | 18 | 4,641 | 7,200 |
| Industrial Risks | 91 | 18 | 4,641 | 7,200 |
| **Total** | **1,166** | **216** | **59,466** | **86,400** |

**Notes:**

1 Assistance sought relates to: Resolution 75/725 (02); Resolution 87/328; Resolution 93/138; Regulation 92/2078; and Directive 93/76.