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A Comparison for the Sewerage System of Main Municipalities in Northern Cyprus

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Raed Bashitialshaaer: A Comparison for the Sewerage System of Main Municipalities in Northern Cyprus

Approval of the Graduate School of Applied and Social Sciences

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To My Family

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ABSTRACT

A Comparison for the Sewerage System of Main Municipalities in Northern Cyprus

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In this M.Sc. Thesis of a comparison for sewerage system of the three main municipalities of Turkish Republic of Northern Cyprus (T R N C) has been studied and discussed. The study covers the future population calculations for three municipalities, Nicosia, Famagusta and Kyrenia, by means of Turkish and European standards. The comparisons for sewerage system of the three municipalities are compared to search for the urgent investment required among the municipalities. This has been done through the Prioritisation Method and the effects of Agriculture, Residential and Industrial areas are considered. There are some important notices has been taken in consideration for each industry, because of changing in Biological Oxygen Demand (BOD) and Oxygen Demand (OD) reading from each industry.

Keywords: Population, Prioritisation, Municipalities, BOD

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INTRODUCTION

1.1 General

Cyprus is situated at the far eastern corner of Mediterranean Sea, with Turkey to the north, Syria to the east, Egypt to the south and Greece to the west. Due to its strategic geographical position it has become a central point between east and west, north and south. It covers an area of 9251 km^2, and is the third largest island in the Mediterranean Sea after Sicily and Sardinia as shown in (Figure 1.1). Its maximum length is 225 km, while its greatest width is 97 km. Its coastline is of 700 km.

The Turkish Republic of Northern Cyprus comprises 38% of the island with an area of 3355 km^2, covering the Northern part of the island sum of 200 km, of the coastline. The three corresponding cities and their surroundings are by far the most populated area of Northern Cyprus, and the population for the whole of the three cities Nicosia, Famagusta and Kyrenia are estimated to be around 153,885 out of total 200,587 in 1996 and the location of the three cities are shown in (Figure 1.2). This constitutes approximately 76.7 %, of Northern Cyprus population.

The island of Cyprus knows to be a place of magic fully deserving the title of "Pearly of the Mediterranean". It is a rich and colorful tapestry of unspoilt natural beauty, ranging from sparkling crystal clear waters and golden beaches to fields carpeted by wide flowers in the spring and the pine clad heights. [1]

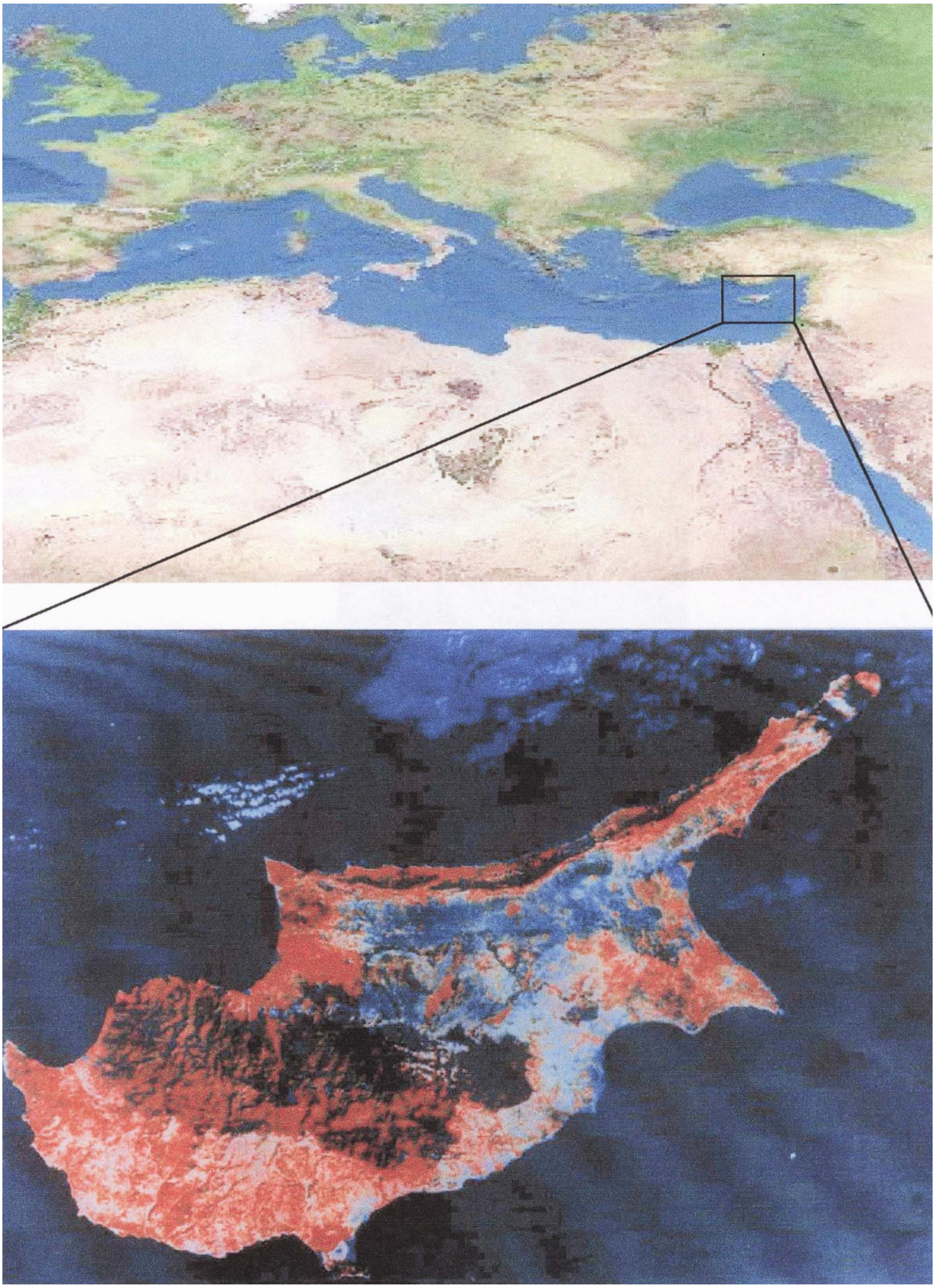


Figure 1.1 Cyprus Island Location Map

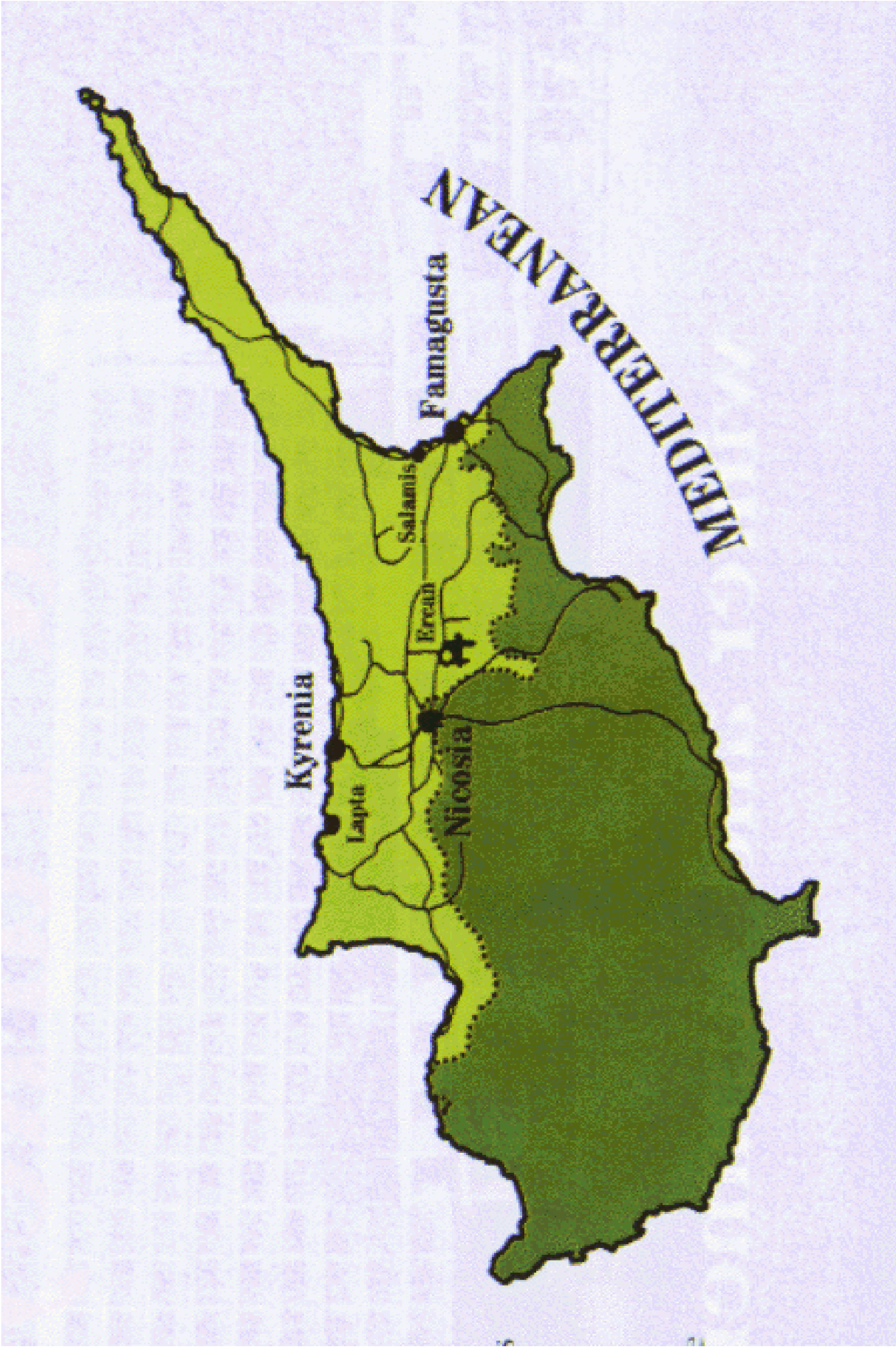


Figure 1.2 The Three Cities Location

Rapid development of industrial projects, tourism investment, Universities and growing population in the island brings about the problems of unplanned civilization as shown in Table 1.1. Thus, the beauty of the island unfortunately is under the threat of environmental pollutants, especially due to the uncontrolled spread of wastewaters to the nature.

The very first study about this problem has shown that, there are no effective's studies in municipalities to deal with such environmental problems. Thus, the main objective of the study is to identify, and provide environmental justification for priority project to define the urgent precautions within the three pre-identified municipalities in the Northern Cyprus.

The study is required to:

Assess the current situation in the three municipalities with respect to

1. Water supply
2. Wastewater generation and disposal
3. Environmental conditions
4. Propose evaluation data criteria and complete a selection process to identify municipality suitable for investment.
5. Develop a population prediction study for the three municipalities to the year 2020
6. Identify Priority projects within the three municipalities for a design horizon to justify which municipality has the urgent requirement for investment.

Table 1.1 Growing Population of North Cyprus upto Year 2002.

Years	Year Mid	Annual Rate of Increase (%)	Year end	Annual Rate of Increase (%)
1996	199,618	1.13	200,675	1.06
1997	201,857	1.12	203,046	1.18
1998	204,219	1.17	205,398	1.16
1999	206,562	1.15	207,732	1.14
2000	208,886	1.13	210,047	1.11
2001	211,191	1.10	212,342	1.09
2002	213,491	1.09	214,464	1.09

(Planning Department)

1.2 Project Area

The rapid growth in three cities, both in population, due to tourism and Universities, and industrial development, and the associated increased water supply to the area has resulted in a vast increase in the generation of wastewater and its disposal to the environment. Development has also resulted in large areas of impervious construction leading to large increases in surface water runoff in the region, also leading directly or indirectly into the Sea of Mediterranean. Nicosia has been already developing its sewage collection and treatment facilities in a nearby village so that it has relieved the pollution load quite considerably. Kyrenia, have been developing its sewage collection in the region but unfortunately although there is a treatment system, it is not efficiently used and the wastewater is directly disposed without proper treatment into the Sea of Mediterranean.

Famagusta, with rapid growth in population due to the university, is deficient in wastewater collection and nearly all the city is covered with septic tank systems. The situation is clearly putting stress on the various ecosystems within the Island, which includes, agricultural lands, groundwater environments, fishing areas, marine environment, tourist areas, residential and industrial areas and the municipalities considered under this study are briefly described below.

1.2.1 Nicosia

The city of Nicosia is the provincial and administrative center of the island. It is situated at the middle of island with 26 km from the north coast and 70 km from the east coast of island. Being capital, there is a considerable scale of industry distributed around the city and thus the population has grown due to employees of industry. Rapidly growing universities is also affecting the population of the city as shown in (Figure 1.3). [1]

1.2.2 Famagusta.

The city of Famagusta lies in the eastern part of the island. It is the provincial university capital and an important seaport. All the citrus grown and packed in western side of island is transported to the port to be distributed to the world as shown in (Figure 1.4). [1]

1.2.3 Kyrenia

Kyrenia is primarily a resort town to the residents of Nicosia. It is located on the northern shore of the island and is within a short commuting distance from Nicosia. With its attractive beaches many families have constructed summerhouses in Kyrenia and thus there is a significant increase in population during the summer season. Kyrenia is a seaport town where two ports, ancient and new, are situated as shown in (Figure 1.5). [1]

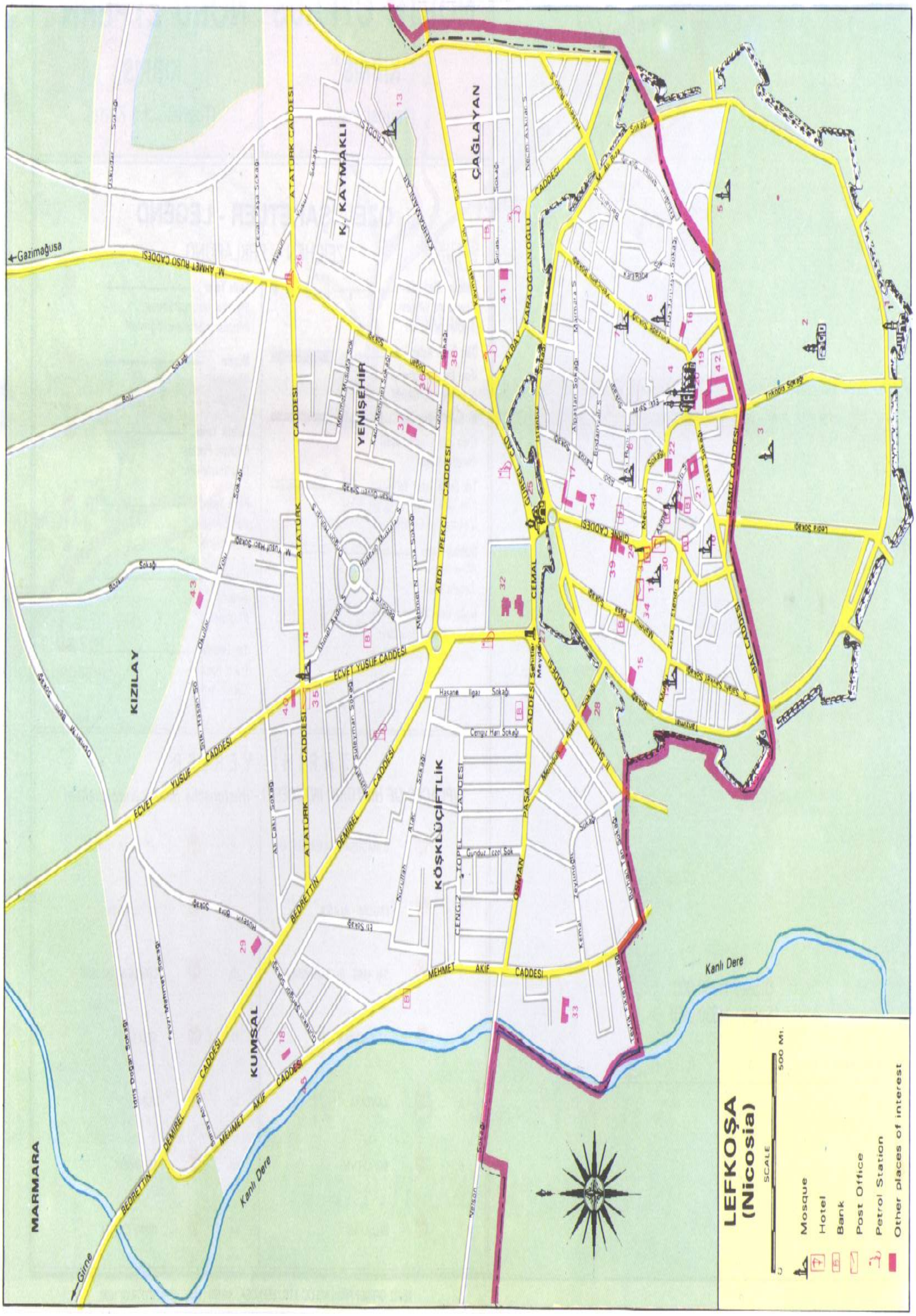


Figure 1.3 Nicosia City

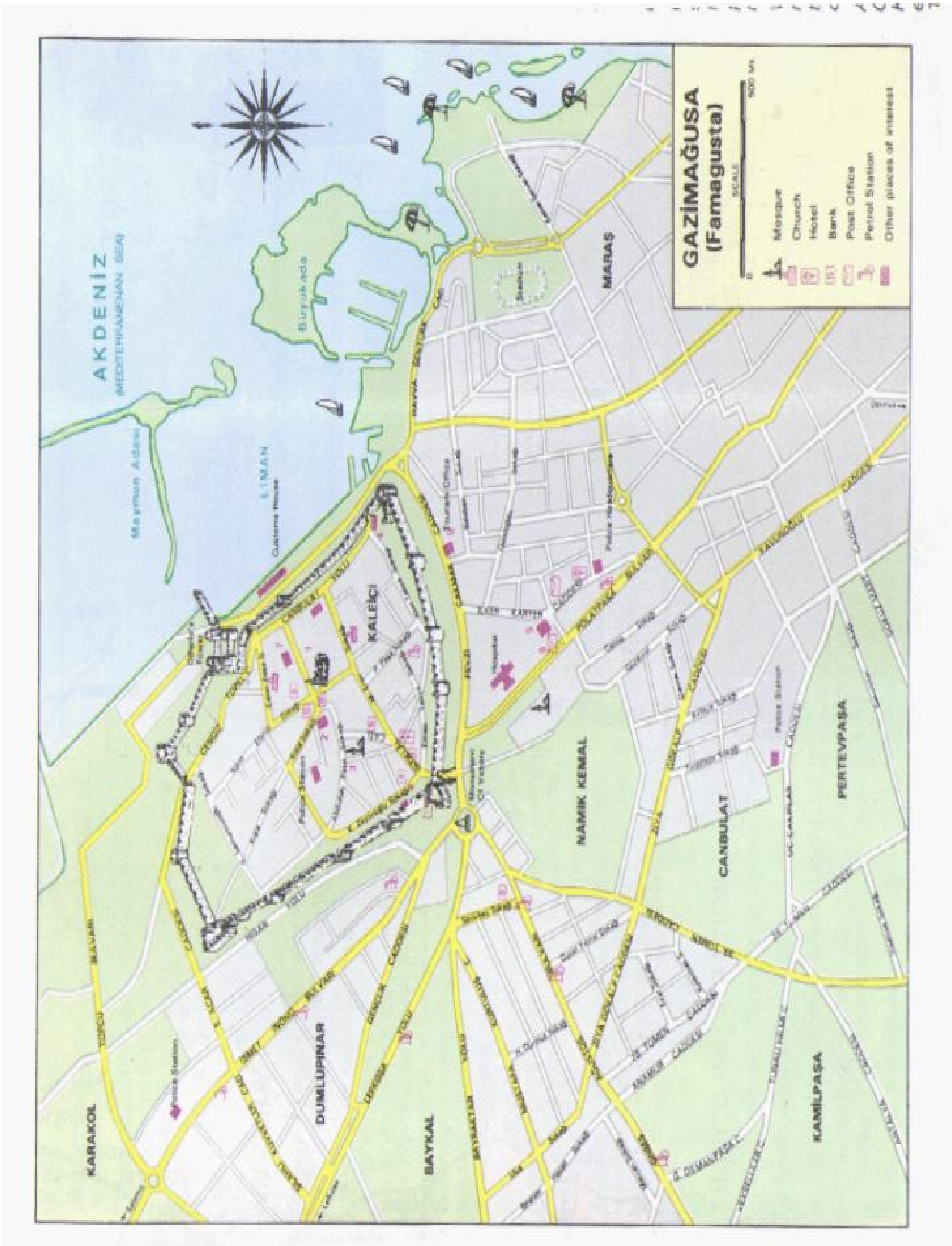


Figure 1.4 Famagusta City

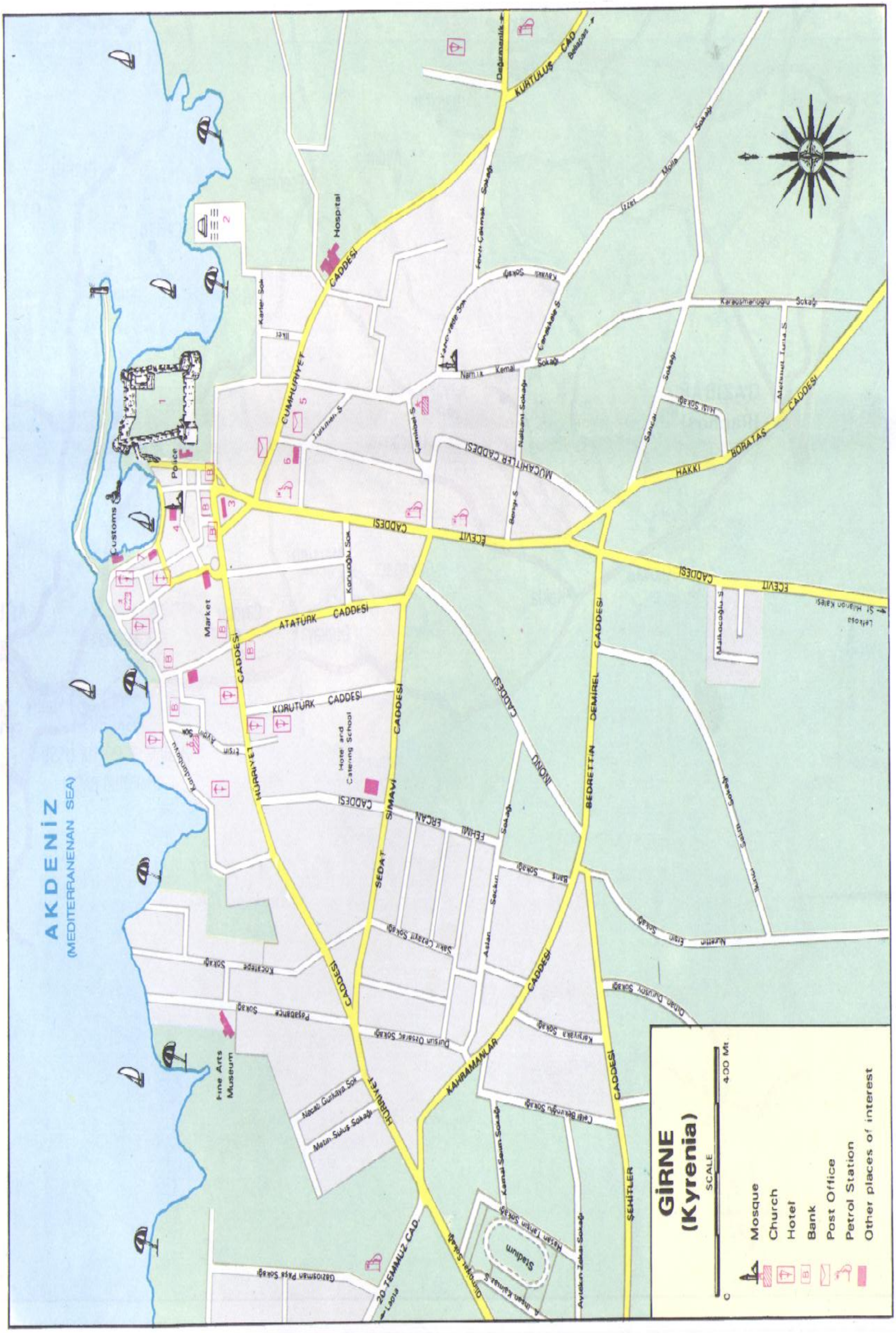


Figure 1.5 Kyrenia City

1.3 Population

Generally, the population in these cities has shown remarkable growth over recent years, which has mirrored the continued development as the center for educational and tourism activities in island. The high population growth rate throughout these cities is also a reflection of the general trend of migration from rural to urban habitats.

1.4 Scope of the thesis

Chapter 1 of this thesis makes a brief introduction to the study. Chapter 2 are deals with the fundamentals of wastewater engineering and there components. Also contains the standards has been used and pollution methods. Chapter 3 is structured in three parts, each describing the present situation of the municipalities involved in this study. This chapter covers the physical description of the municipal area, the status of urban development, the existing water supply infrastructure and the existing wastewater facilities. Chapter 4 identifies the priority investment to be taken forward for the municipalities by using the method defined in Chapter 2 under the information given in Chapters 3 and 4.

FUNDAMENTAL of WASTEWATER ENGINEERING

2.1 General

Every community produced both liquid and solid wastes. The liquid portion wastewater is essentially to the water supply of the community after it has been fouled by a variety of uses. From the standpoint of sources of generation, wastewater may be defined as a combination of the liquid- or water-carried wastes removed from residences, institutions, and commercial and industrial establishments, together with such groundwater, surface water, and stormwater as many be present.

If untreated wastewater is allowed to accumulate, the decomposition of the materials it contains can lead to the production of large quantities of malodorous gases. In addition, untreated wastewater usually contains numerous pathogenic, or disease-causing, microorganisms that dwell in the human intestinal tract or that may be present in certain industrial waste. Wastewater also contains nutrients which can stimulate the growth of aquatic plants, and it may contain toxic compounds. For these reasons, the immediate and nuisance-free removal of wastewater from its courses of generation, followed by treatment and disposal, is not only desirable but also necessary in an industrialized society. In the United States, it is now mandated by numerous federal and state laws. Wastewater engineering is that branch of environmental engineering in which the basic principles of science and engineering are applied to the problems of water pollution control. The ultimate goals of wastewater management are the protection of the environment in a manner to commensurate with public health, economic, social and political concerns.

In order to determine the urgency criteria for the three cities, it is essential to establish the methods of prioritization. For the need of such work, all project municipalities have been visited and the data is being collected for analysis. It is proposed to set prioritization criteria in the beginning of work to leave the flexibility of assigning different weightings to the defined criteria during the data analysis.

The proposed design criteria are set to conform to European standards and Turkish Water Pollution Control Regulations, taking into account criteria used for other similar projects hold in Turkey. Reference has been made to the design criteria used for:

EU Wastewater Directives, Turkish Water Pollution Control Regulations, British Standard BS 8005, Istanbul Water Supply, Sewerage and Drainage Master Plan preliminary study, Iller Bank projects and METAP studies.

Nowadays Northern Cyprus is the footprints of defining its global position which will held to join. It is assumed that EU standards will be adopted as a minimum, and Turkish Water Pollution Control Regulations shall also be considered in some cases. [2]

2.1.1 New Directions and Concerns

With the passage of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) , Congress established a far-reaching program for the control of pollution in U.S. waterways.

New directions and concerns are also evident in various specific areas of wastewater treatment including (l) the changing nature of the wastewater to be treated; (2) the problem of indusial wastes; (3) the impact of storm water and nonpoint sources of pollution; (4) combined sewer overflow; (5) treatment operations, processes, and concepts; (6) health and environmental concerns; (7) treatment process effectiveness; and (8) small systems including individual onsite systems. [2]

2.1.2 Changing Wastewater Characteristics

The numbers of organic compounds that have been synthesized since the turn of the century now exceeds half a million and some 10,000 new compounds are added each year. As a result, many of these compounds are now found in the wastewater from most municipalities and communities. Currently the release of Volatile Organic Compounds (VOC) and Volatile Toxic Organic Compounds (VTOC) found in wastewater is of great concern in the operation of both collection system and treatment plants. The total emission of VTOCs from municipal wastewater treatment plants in California been estimated to be as high as 800 Mega tone per year (725 Mt/yr). [3]

The control of odors and in particular the control of hydrogen sulfide generation is of concern in collection systems and at treatment plants. Some of the increase in sulfide generation observed in collection systems has been attributed to the decrease of metals in industrial waste discharges with the implementation of effective industrial pretreatment programs, (for the control and treatment of industrial wastes prior to discharge into municipal collection systems). The quantity of metals present in municipal wastewater has decreased significantly. Concomitant with this decrease in the metals, an increase in the release of hydrogen sulfide to the atmosphere above sewers and at treatment plant headwork has been observed in a number of locations.

The sulfide produced in sewers, which is now released as hydrogen sulfide, had reacted previously with the metals present in the wastewater to form metallic sulfides (e.g., ferrous sulfide). The release of excess hydrogen sulfide has led to the accelerated corrosion of concrete sewers and headwork structures and to the release of odors.

The control of odors is of increasing concern as residential and commercial development approaches existing treatment plant locations and in the sitting of new facilities. [3]

2.1.3 The Problem of Industrial Wastes

The number of industries that now discharge wastes to domestic sewer has increased significantly during the past 20 to 30 years. In view of the toxic effects often caused by the presence of these wastes, even at very low concentrations, the general practice of combining pretreated or partially pretreated industrial and domestic wastes is being reevaluated by number of communities.

In the future, many municipalities may either provide separate treatment facilities for these wastes or require that they be treated to a higher degree at the point of origin to render them harmless before allowing their discharge to domestic sewers. [4]

2.1.4 Combined Sewer Overflows

Overflows from combined sewers have been recognized as a difficult problem requiring solution, especially for many of the older cities in the United State. Combined sewers carry a mixture of wastewater and stormwater runoff and when the capacity of the interceptors is reached, overflows occur to the receiving waters. Large overflows can significantly impact the after quality and can prevent attainment of the mandated standards.

Methods of control may involve significantly modifications to the collection system, construction of storage facilities for containing all or a portion of the peak flows, or provision of additional and special treatment facilities. Many of these methods of control are very costly to implement, and little governmental financial assistance is available to local municipalities. [4]

2.1.5 Health and Environmental Concerns

In meeting the requirements of the Clean Water Act and its amendments, public health and environmental concern have come to play an increasingly important part in the selection and design of both collection and treatment facilities. Discharge of contaminants to the environment is receiving close scrutiny.

For example, the release of VOCs and VTOCs from collection and treatment facilities, as noted earlier, is becoming of greater concern to regulatory agencies. Odors are not of the most serious environmental concerns to the public. New techniques for odors that may emanate from wastewater facilities and special efforts are being made to design facilities that minimize the development of odor, contain them effectively, and provide proper treatment for their destruction. [4]

2.2 Wastewater Flowrates

Determining the rates of wastewater flow is a fundamental step in the design of wastewater collection, treatment, and disposal facilities. Reliable data on existing and projected flows must be available if these facilities are to be designed properly and if the associated costs are to be minimized and also shared equitably when the facilities serve more than one community or district. In situations where wastewater flowrates data are limited or unavailable, wastewater-flowrates estimates have to be developed from water consumption records and other information.

The purposes are to develop a basis for properly assessing wastewater flowrates for a community. The subjects considered including of (1) definition of the various component that make up the wastewater from a community, (2) water supply data and its relationship of wastewater flowrates, (3) wastewater sources and flowrates, (4) analysis of flowrate data, and (5) methods of reducing wastewater flowrates. [4]

2.2.1 Component of Wastewater Flows

The components that make up the wastewater flow from a community depend on the type of collection system used and may include the following:

1. Domestic (Sanitary) wastewater: Wastewater discharged from residences and from commercial, industrial and similar facilities.

2. Industrial wastewater: Wastewater in which industrial wastes predominate.
3. Infiltration/Inflow (I/I): Water that enters the sewer system through indirect and direct means. Infiltration is extraneous water that enters the sewer system through leaking joints, cracks and breaks, or porous walls, Inflow is stormwater that enters the sewer system from storm drain connections (eaten basins), roof leader's foundation and basement drains, or through manhole covers.
4. Storm water: Runoff resulting from rainfall and snowmelt.

Three types of sewer systems are used for the removal of wastewater and stormwater: sanitary sewer systems, storm sewer system, and combined sewer system. Where only combined sewer is used, wastewater flows consist of these three components plus stormwater. In both cases, the percentage of the wastewater components varies with local conditions and three times of the year.

For areas now served with sewers, wastewater flowrates are commonly determined from existing records or by direct field measurements. For new developments, wastewater flowrates are derived from an analysis of population data and corresponding projected unit rates of water consumption or from estimates of per capacity wastewater flowrates from similar communities. [4]

2.2.2 Estimating Wastewater Flowrates from Water Supply Data

If field measurements of wastewater flowrates are not possible and actual wastewater flowrate data are not available, water supply record can often be used as an aid to estimate wastewater flowrates. Where water records are not available, useful data for various types of establishments and water-using devices arc provided for making estimates of wastewater flowrates. [4]

2.2.3 Municipal Water Use

Municipal water use is generally divided into four categories: (1) domestic (water used for sanitary and general purposes), (2) industrial (nondomestic purposes), (3) public service (water used for fire fighting, system maintenance, and municipal landscape irrigation), and (4) unaccounted for system losses and leakage.

1. Domestic Water Use

Domestic water use encompasses the water supplied to residential areas, commercial districts, institutional facilities, and recreation facilities, as measured by individual water meters. The uses to which this water is put include drinking, washing, bathing, culinary, waste removal, and yard watering. Over one-third of the water used in a municipal water supply system is for domestic purposes.

- **Residential area**

Water used by residential households consists of water for interior use such as showers and toilets and water for exterior use such as lawn watering and car washing. Water use for exterior applications varies widely depending upon the geographic location, climate, and time of year and mainly consists of landscape irrigation.

- **Commercial facilities**

The water used by commercial facilities for sanitary purposes will vary widely depending on type of activity (e.g., an office as compared to a restaurant). For large commercial water-using facilities such as laundries and car washes, careful estimates of actual water use should be made.

- **Institutional facilities**

Water used by facilities such as hospitals, schools, and rest homes is usually based on some measure of the size of the facilities and the and the type of housing function provided (e.g., per student or per bed).
Water use for schools will vary significantly depending on weather the students are housed in campus or are day students.

- **Recreational facilities**

Recreational facilities such as swimming pools, bowling alleys, camps, and country clubs perform a wide range of functions involving water use.

2. Industrial (Nondomestic) Water use

The amount of water supplied by municipal agencies to industries for process (nondomestic) purposes is highly variable. Large water-using industries such as canneries, chemical plants, and refiners usually have their own supply and are not dependent on public agencies. Other industries such as those involved in “high technology,” which have more modest process water requirements, may depend wholly on municipal supplies. Because industrial water use varies widely, it is therefore desirable in practical design work to inspect the plant concerned and to make careful estimates of the quantities of both water used from all sources and the wastes produced. [4]

2.3 Public Service and System Maintenance

Public service water represents the smallest component of municipal water use. Public service water uses include water used for public building, fire fighting, irrigation public parks and greenbelts, and system maintenance.
System maintenance water uses include water for disinfecting new water lines and storage reservoirs, line and hydrant flashing, and hydraulic flushing of sewers. Only small amount of water used for these purpose reach the sanitary sewer system, expect that from public building. [4]

2.3.1 Unaccounted System Losses and Leakage

Unaccounted System Losses include unauthorized use, incorrect meter calibration or readings, improper meter sizing, and inadequate system controls. Leakage is due to system age, materials of construction, and lack of system maintenance. Unaccounted System Losses and leakage may range from 10 to 12 percent of production for newer distribution system (les than 25 years old) and from 15 to 30 percent for older systems. In small water system, unaccounted system Losses and leakage may account for as much as 50 percent of production. As much as 40 to 60 percent of the unaccounted water may be attributed to meter error. (Brainard, September, 1984). Therefore, while water records may be useful in forecasting wastewater flowrates, the accuracy of the records must be checked carefully. [4]

2.3.2 Estimating Water Consumption from Water Supply Record

Water records of various types are kept by water supply agencies. These records usually include information on the amount of water produced or withdrawn and discharged to the water supply system and the amount of water actually used (consumed). The distinction is important because more water is produced than is usually used by the consumer.

The difference between these two values is the amount of water lost or unaccounted for in the distribution system plus the amount used for various public services that my be unmetered.

Therefore, in using water supply record to estimate wastewater flowrates, it is necessary to determine the amount of water actually used by the customers. Unaccounted water and losses do not reach the wastewater system and have to be exclusive in making flow estimates. [4]

2.4 Factors Affecting Municipal Water Use

Factors that affect water use in a community water system include climate, size of the community, density of development, economics, dependability and quality of the supply, water conservation, and the extent of metered services.

1. Climate

Climate effects such as temperature and precipitation can significantly impact consumption. Water use is at peak when it is hot and dry, due to largely increased need for exterior use such as landscape irrigation. The ecological seasons may also vary in different parts of the world and may also affect consumption patterns.

2. Community size

Community size affects not only the average per capita water use but also the peak rate of use. The rate of use fluctuates over a wider range in small communities with higher peak flows (as compared to average use) and lower minimum flows.

3. Density of development

The density of development (i.e., single-family housing, condominiums, and apartments) affects both interior and exterior water use. Single-family homes may have more water-using appliances such as washing machines and dishwashers than apartments. Exterior water use for condominiums and apartments is generally much less than single-family homes because of reduced needs for landscape watering.

4. Economics

The affluence or economic capabilities of community affects water use (and resulting wastewater flows) as the assessed value of property increases, so does water use and wastewater flowrates (Geyer, 1962). Part of the increase in consumption may be due to greater use of water-using appliances such as dishwashers, garbage grinders, and washing machines.

5. Dependability and quality of supply

The water supply that is dependable of its good quality will encourage use by its customers. Supplies that are not dependable in terms of poor pressure and limited quantities during peak or dry periods or that have objectionable taste or mineral content may have lower use.

6. Water conservation

Water conservation may take different forms: (1) the cutback of water use during emergencies, such as droughts, to achieve a short-term reduction, or (2) the institution of a long-range program including the installation of water-conserving fixtures to effect a permanent reduction in water use. In emergencies, voluntary or mandatory conservation may be required for supplies impacted by drought or dry period occurrences. For example, in the Oakland area during the California drought of 1977 and 1978, total water use was reduced from 25 to 35 percent by water conservation measures. (Harnett, 1978). A major share of the reduced was due to the decrease in exterior eater use. The use of low-flow toilets is now specified in many local building codes. In the future, the use of water-conserving devices and appliances is expected to increase significantly.

For estimating wastewater flowrates from water use, the effect of conservation on interior water use is of particular interest. The extent of the water saving actually achieved depends on the overall scope of the water conservation measures. [4]

2.4.1 Reduction of Wastewater Flowrates

Because of the importance of conserving both resources and energy, various means for reducing wastewater flowrates and pollutant loading from domestic sources are gaining increasing attention. The reduction of wastewater flowrates from domestic sources result directly from the reduction in interior water use. Therefore, the terms “interior water use” and “domestic wastewater flowrates” are used interchangeably.

A comparison of residential interior water use (and resulting per capita wastewater flowrates) for homes without and with water-conserving fixtures has to be taken in consideration. Two levels of water-conserving fixtures are (1) retrofit devices such as flow restrictors and toilet dam, and (2) which uses water-conserving devices and appliances such as low-flush toilets and low water-use washing machines. [4]

2.4.1.1 Infiltration/Inflow

Infiltration: Water entering into a sewer system, including sewer service connections, from the ground through such means as defective pipes, pipe joints, connections, or manhole walls.

Steady inflow: Water discharged from cellar and foundation drains, cooling-water discharges, and drains from springs and swampy areas. This type of inflow steady and is identified and measured along with infiltration.

Direct inflow: Those types of inflow that have a direct stormwater runoff connection to the sanitary sewer and cause an almost immediate increase in wastewater flow. Possible sources are roof leaders, yard and areaway drains, manhole covers, cross connections from storm drains and catch basin, and combined sewers.

Total inflow: The sum of the direct inflow at any point in the system plus any flow discharged from the system upstream through overflows, pumping station bypasses, and the like. Delayed inflow: Stormwater that may require several days or more to drain through the sewer system. This category can include the discharge of sump pumps from cellar drainage as well as the slowed entry of surface water through manholes in ponded areas.

A cost-effectiveness analysis has to be made to determine if it is more economical to make repair to the collection system to correct infiltration/inflow or to design the treatment facilities for larger flows. By correcting infiltration/inflow problems and "tightening" the collection system, the community benefits with (1) no overloaded or surcharged sewers and the associated problems of wastewater backups and overflows, (2) more efficient operation of wastewater treatment facilities, and (3) the use of the collection system hydraulic capacity for wastewater requiring treatment instead of for infiltration/inflow. [4]

2.4.1.2 Infiltration into Sewers

One portion of the rainfall in a given area runs quickly into the storm sewers or other drainage channels; another portion evaporates or is absorbed by vegetation; and the remainder percolates into the ground, becoming groundwater. The proportion of the rainfall that percolates into the ground depends on the character of the surface and soil formation and on the rate and distribution of the precipitation. Any reduction in permeability, such as that due to buildings, pavements, or frost, decreases the opportunity for precipitation to become groundwater and increases the surface runoff correspondingly.

The amount of groundwater flowing from a given area may vary from a negligible amount for a highly impervious district or a district with dense subsoil to 25 or 30 percent of the rainfall for a semipervious district with sandy subsoil permitting rapid passage of water. The percolation of water through the ground from rivers or other bodies of water sometimes has considerable effect on the groundwater table, which rises and falls continually.

The sewers first built in a community usually follow the watercourses in the bottoms of valleys, close to (and occasionally below) the beds of stream. As a result, these old sewers may receive comparatively large quantities of groundwater, whereas sewers built later at high elevation will receive relatively small quantities of groundwater. With an increase in the percentage of area in a community that is paved or built over comes (1) an increase in the percentage of stormwater conducted rapidly or the storm sewers and watercourses and (2) a decrease in the percentage of the stormwater that can percolate into the earth and tend to the to infiltrate the sanitary sewers.
The rate and quantity of infiltration depend on the length of sewers, the area served, the soil and topographic conditions, and, to a certain extent, the population density (which affects the number and the total length of house connections).

Although the elevation of the water table varies with the quantity of rain and melting snow percolating into the ground, the leakage through defective joint, porous concrete and cracks has been large enough, in some cases, to lower the groundwater table to the level of the water. Most of the pipe sewers built during the first half of this century were laid with cement mortar joint or hot-poured bituminous compound joints. Manholes were almost always constructed of bricks masonry.

Deterioration of pipe joints, pipe-to-manhole joints, and the waterproofing of brickwork has resulted in a high potential for infiltration into these old sewers. The use of high-quality pipe with dense walls, precast manhole section, and joints sealed with rubber or synthetic gaskets in standard practice in modern sewer design. The use of these improved materials has greatly reduced infiltration into newly constructed sewers, and it is expected that the increase of infiltration rates with time will be much slower than has been the case with the older sewers. [4]

2.4.2 Variations in Wastewater Flowrates

Short-Term Variation: The variations in wastewater flowrates observed at treatment plants tend to follow a somewhat diurnal pattern. Minimum flows occur during the early morning hours when water consumption is lowest and when the base flow consists of infiltration and small quantities of sanitary wastewater.

The first peak flow generally occurs in the late morning when wastewater from the peak morning water use reaches the treatment plant. A second peak flow generally occurs in the early evening between 7 and 9 p.m., but this varies with the size of the community and the length of the sewers.

Seasonal Variations: Seasonal variations in domestic wastewater flows are commonly observed at resort area, in small communities with college campuses, and in communities with seasonal commercial and industrial activities. The magnitude of the variations to be expected depends on the size of the community as well as the influence of infiltration/inflow is like Arrowhead, California. Flowrates increase in the summer season because of a higher recreational occupancy rates. The high flow periods occur in the winter and early spring when groundwater levels rise and infiltration increases.

Industrial Variation: Industrial wastewater discharges are difficult to predict. Many manufacturing facilities generate relatively constant flowrates during the production, but the flowrates change markedly during cleanup and shutdown. Although internal process changes may lead to reduced discharge rates, plant expansion and increased production may lead to increased wastewater generation. Where joint treatment facilities are to be constructed, special attention should be given to industrial flowrate projections, whether they are prepared by the industry or jointly with the city’s staff or engineering consultant. Industrial discharges are most troublesome in smaller wastewater treatment plants where there is limited capacity to absorb shock loading. [4]

2.5 Analysis of Wastewater Flowrate Data

Because the hydraulic design of both collection and treatment facilities is affected by variations in wastewater flowrates, the flowrate characteristics have to be analyzed carefully for existing records.

Flowrates in the collection system may differ somewhat from the flowrate entering the treatment plant because of the flow-dampening effect of the sewer system. Peak flowrates may be attenuated by the available storage capacity in the sewer system. [4]

2.5.1 Flowrates for Design

Where flow record are kept for treatment plants and pumping stations, at least two years of the most recent data should be analyzed. Longer-term record may be analyzed to determine changes or trends in wastewater generation rates. Important information that needs to be obtained through the analysis of wastewater flowrate data includes the following:

Average daily flow: the average flowrate occurring over a 24-hour period based on total annual flowrate data. Average flowrate is used in evaluating treatment plant capacity and developing flowrate ratios used in design. The average flowrate may also be used to estimate such items as pumping and chemical cost, sludge solids, and organic-loading rates.

Maximum daily flow: The maximum flowrate that occurs a 24-hour period based on annual operating data. The maximum daily flowrate is important particularly in the design of facilities involving retention time such as equalization basin and chlorine-contact tanks.

Peak hourly flow: The peak sustained hourly flowrate occurring during a 24-hour period based on annual operation data. Data on peak hourly flows are needed for the design of collection and interceptor sewers, wastewater-pumping stations, wastewater flowrates, grit chambers, sedimentation tanks, chlorine-contact tank, and conduits or channels in the treatment plant.

Minimum daily flow: The minimum flowrate that occurs on a 24-hour period based on annual operating data. Minimum flowrates are important in the sizing of conduit where solid deposition might occur at low flowrates.

Minimum hourly flow: The minimum sustained hourly flowrate occurring over a 24-hour period based on annual operation data. Data on the minimum hourly flowrate are needed to determine possible process effects and for sizing of wastewater flowrates, particularly those that pace chemical-feed systems. At some treatment facilities, such as those that using tricking filters, recirculation of effluent is required to sustain the process during low-flow periods. For wastewater pumping, minimum flowrates are important to ensure that the pumping system have adequate turndown to match the low flowrates.

Sustained flow: The flowrate value sustained or exceeded for a specific number of consecutive days based on annual operating data. Data on sustained flowrates may be used in sizing equalization basins and other plant hydraulic components. [4]

2.5.2 Statistical Analysis of Wastewater Flowrates

In developing wastewater management system, it is often necessary to determine the statistical characteristics of wastewater flowrates. The firs step in assessing statistical characteristics of a series of observations is to determine whether the observations are distributed normally or are skewed. For more practical purposes, the type of the distribution can be determined by plotting the data on both arithmetic and log-probability paper and noting whether or not the data can be fitted with a straight line.

If the distribution is normal, statistical measures used to describe the distribution include the mean, median, mode, and standard deviation, coefficient of variation, coefficient of skewness, and coefficient of kurtosis. (Waugh, 1943.Velz, 1952. McCuen, 1985). If the distribution skewed, the geometric mean and standard deviation are noted. [4]

Also most factors affecting the flowrates can be described as:

1. Hydraulic Gradient

The vertical profile that defines the elevation of free surface (grade line) water as it flows through a sanitary sewer system.

2. Hydraulic Network

The interconnection of sanitary sewer pipes within a basin that terminates at a single discharge point and is defined by physical characteristics such as pipe length, diameter, invert elevation, and slope. Hydraulic networks are generally developed when constructing a hydraulic model of the sewer system.

3. Hydraulic Model

A computer-driven analysis too which, simulates the wastewater collection system response to rainfall-induced flows and average daily dry flows too.

4. Lift Station

Pumping facilities that convey wastewater flow from an area, which would not naturally drain to the wastewater treatment plant, into the gravity sewer system for delivery and treatment.

5. Manhole

Manholes are used at designated intervals in a sewer line as a means of access for inspection or cleaning. Manhole Cover/Lid is the lid which provides access to the interior of the manhole.

6. Overflow

A condition in which, the wastewater flow rate in a sewer system exceeds the capacity of the sewer to the extent that raw wastewater is discharged directly to storm and drainage systems.

7. Overloaded Sewer

A condition in which, the wastewater flow rate exceeds 100% of the hydraulic capacity of the sewer.

8. Preventive Maintenance

Scheduled and implemented maintenance of the municipality's sanitary sewer system through systematic inspection, cleaning and budgeted rehabilitation in order to maintain the hydraulic capacity of the system and reduce infiltration/inflow.

9. Surcharge

A condition in which the wastewater flow rate in a sewer system exceeds the capacity of the sewer lines to the extent that raw sewage begins to rise within manholes. A sewer surcharge is experienced in advance of a Backup and Overflow. [4]

2.6 Standards

2.6.1 Turkish Standards

In Turkey, all wastewater discharges must comply with the criteria and effluent standards imposed by ‘’WPCR-Water Pollution Control Regulations’’ issued on 4 September, 1988. Industries discharging their wastewaters directly to a natural receiving media are categorized and different effluent discharge limits are applied depending on their sectors. While discharging to a municipal sewerage system, the effluent standards are common for all industries. However, depending on the end treatment applied to the municipal sewage, secondary treatment or preliminary treatment followed by deep-sea disposal, two different industrial effluent standards are stated. The national discharge standards applicable for populations above 10, 000 or for raw pollution loads above 60 kg/day of BOD_5 are stated in ‘’WPCR’’ as shown in Table 2.1.

Table 2.1 Discharge standards for domestic wastewater after treatment [2]

Parameter	Unit	2-hour composite sample	24-hour composite sample
Biochemical Oxygen Demand,BOD_5	mg/l	≤ 50	≤45
Chemical Oxygen Demand ,COD	mg/l	≤ 140	≤100
Suspended Solids,SS	mg/l	≤ 45	≤30
Ph	-	6-9	6-9

Furthermore, for sensitive regions (national parks, touristic areas etc.) more stringent effluent standards are imposed through official decrees. The rapid growth in the country, both of population and industrial development, and the associated increased water supply has resulted in a vast increase in the generation of wastewater and its disposal to the environment. Most disposal routes load directly or indirectly to the Environmental problems mostly related with Mediterranean Sea countries.

2.6.2 EU Standards

As it is mentioned previously if the final disposal point is the sea via other river basins, EU-directives will be applied. Discharge Standards will be taken according to European Standards. Discharges from urban wastewater treatment plants subject to Articles 4 and 5 of the European directive concerning urban wastewater treatment of May 1991 shall meet the requirements shown in Table 2.2. According to Annex II A. a water body must be identified as a sensitive area if it falls into the following groups:

(1) natural freshwater lakes, other freshwater bodies, estuaries and coastal waters which are found to be eutrophic or which in the near future may become eutrophic if protective action is not taken. The following elements might be taken into account when considering which nutrient should be reduced by further treatment:

Lakes and streams reaching lakes/reservoirs/closed bays which are found to have a poor water exchange, whereby accumulation may take place. In these areas, the removal of phosphorus should be included unless it can be demonstrated that the removal will have no effect on the level of eutrophication. Where discharges from large agglomerations are made, the removal of nitrogen may also be considered; estuaries, bays and other coastal waters which are found to have a poor water exchange, or which receive large quantities of nutrients. Discharges from small agglomerations are usually of minor importance in those areas, but for large agglomerations, the removal of phosphorus and/or nitrogen should be included unless it can be demonstrated.

(2) surface waters intended for the abstraction of drinking water.

Table 2.2 EU Secondary Treatment Effluent Standards [2]

Parameters	Concentration	Minimum percentage reduction[1]
Biochemical oxygen demand (BOD_5 at 20°C) without nitrification[2]	25 mg/l O_2	70-90 40 under Article 4 (2)
Chemical oxygen demand (COD)	125 mg/l O_2	75
Total suspended solids	35 mg/l[3]	90[3]
(more than10.000 p.e[4].)	35 under Article 4 (2)	90 under Article 4 (2)
(2.000-10.000 p.e.)	60 under Article 4 (2)	70 under Article 4(2)

[1] Reduction in relation to the load of the influent.

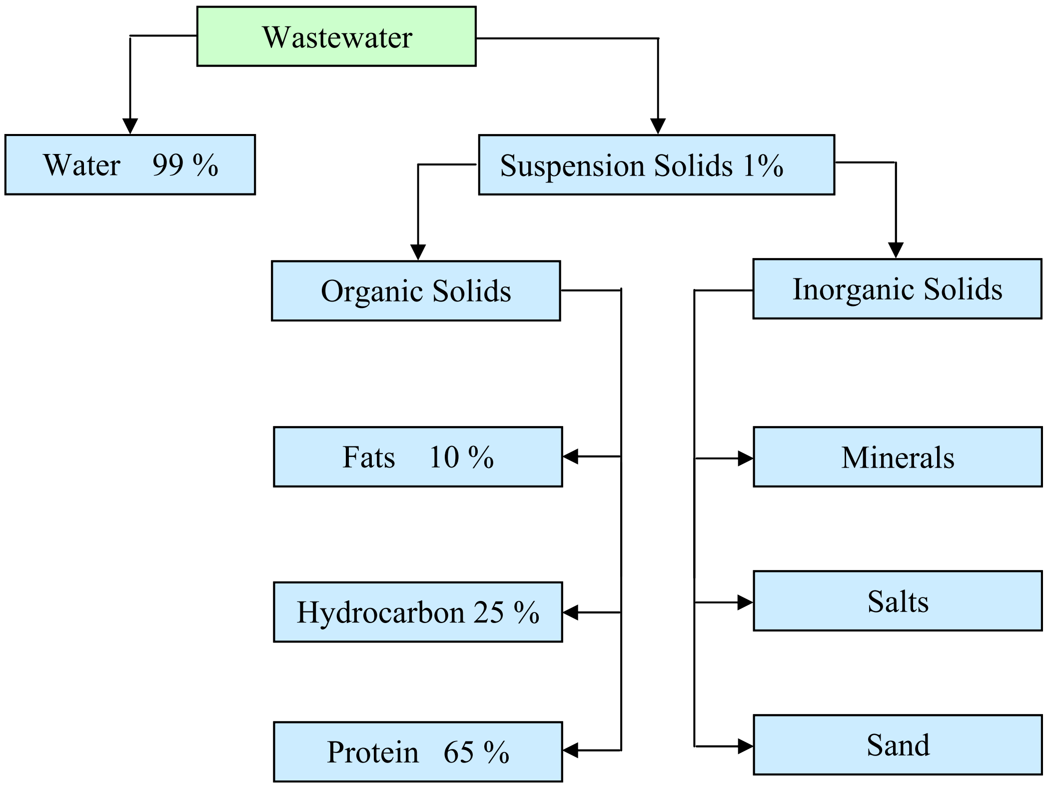
[2] The parameter can be replaced by another parameter: total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD_5 and the substitute parameter.

[3] This requirement is optional.

[4] Protective elements.

Wastewater and Sewerage Components

Chart No. 2.1



There are three ways to descrip the values of Oxygen: [5]

1. Theoretical Oxygen Demeand. (OD)
2. Biochemical Oxygen Demand. (BOD)
3. Chemical Oxygen Demand. (COD)

$$OD > COD > BOD_u > BOD_5$$

where,

BOD_5 needed Oxygen during five days oxidation at temperature of 20 C^0.

BOD_u needed Oxygen to complete oxidation operation processes.

It is difficult to find any relationship between Oxygen results, but there are some experimental relations:

$B.O.D_5$ / C.O.D ≈ 0.5

$B.O.D_u$ / $B.O.D_5$ ≈ 1.5

Table 2.3 Strength of Wasewater. [5]

C.O.D mg/l	$B.O.D_5$ mg/l	Concentration of Contamenation Level
400 >	200 >	Very weak
700	300	Weak
1000	500	Strong
1500<	750 <	Very strog

(Environmental Engineering, 1989)

2.7 Real Value of Effluent BOD_5

Effluent BOD_5 (Biological Oxygen Demand) is a misleading parameter in performance judgment of a lagoon treatment plant. It is important to differentiate between treatment performance and effluent performance. As many as 60 percent of the BOD_5 violations experienced may have been caused by nitrification in the BOD_5 test rather than by improper design or operation.

Nitrification may occur in the BOD_5 even when in plant nitrification is not apparent.

Whenever the BOD_5 values are greater than two-thirds of the corresponding TSS values, the BOD_5 values have been influenced by nitrification.

Algae growing in an aerated lagoon system will increase both the Total Suspended Solids (TSS) and the BOD_5 of the effluent. Correlation can be made between the number of algal cells and TSS. However, algal cell counts are tedious. An easier method involves the measurement of chlorophyll A (a photosynthetic pigment found in the cells of algae) where:

$$TSS = 115 * \text{chlorophyll A} \qquad (2.1)$$

Also, the respiration of each milligram per liter of algae will exert a BOD_5 of about 0.5 mg/lt. [4]

2.8 Wastewater Flows

2.8.1 Domestic Wastewater Contribution

According to the available data obtained from the municipalities, the following water consumption figures of the project areas in 2002 are calculated. It is normal to make provision for estimating the sewage flows from public offices and institutions, schools, hospitals, hotels, commercial premises and industrial sites. The water consumption is given in Table 2.4; however already take into account these components as recorded by the water departments. Therefore, there is no need for an additional allowance over domestic consumption for these other categories.

Table 2.4 Water Consumption

Nicosia	:	120	l/cap/day
Famagusta	:	120	l/cap/day
Kyrenia	:	120	l/cap/day

2.8.2 Industrial Wastewater

Quantities and strengths of industrial effluents are difficult to predict as industry practices vary as a result of changes in industrial throughput, technological developments and changes in the occupation of premises. In areas of existing industrial development, information has obtained from records of municipalities and statistical year books of Planning Department of the Government.

The discharge of industrial effluents to sewer is likely to be subject to conditions governing the quality and quantity of the effluent discharged. Compliance with such conditions requires the industries to undertake pre-treatment of the effluent before discharge to the sewer system.

The existing situation of the industries and their flow rates shall be figured out and their contribution shall be analyzed according to the following objectives of control:

1. Damage or harm to the sewerage system with increased maintenance costs

2. Interference with the effective and economic treatment of the sewage

3. Unacceptable effects on water resources or the environment generally from the products of treatment, in the form of effluent or residues

4. Location of the industries, cost of contribution of industry. [2]

2.8.3 Hydraulic Design Criteria for Sewerage System

The Darcy-Weisbach / Colbrooke-White formula is most often used for pipeflow computations. This formula provides reliable results for all pipe sites, and over the full range of pipe flow depth. The minimum pipe sizes required for constructing of sewerage systems is 150mm diameter for individual house connections and 200mm diameter public sewers (main pipeline).

Sewers should be laid at depths which will accommodate not only all existing properties but also any future properties within the area which the sewers are designed to serve. Under roads, the minimum design depth of cover should be 1.2m, measured from the top of the pipe barrel to the finished road surface.

Manholes should be constructed at every change of alignment or gradient, at the head of all sewers or branches, at every junction of two or more sewers, and wherever there is a change in size of sewer. Manholes should not be positioned further apart than:

1. 60m - for sewers less than 200mm in diameter
2. 90m - for sewers of 200-900mm diameter, beyond which it is not practicable to use drain rods or some form of pipe scraper

3. 150m – for sewers of 1000mm diameter and greater

The minimum design gradient for wastewater pipes is taken as 5-7 % and 1-3 % for stormwater. This gives a pipe full velocity of 0.75 m/s or greater for all sewers of 200 mm and above. The maximum gradients for sewer pipes are set to limit pipe full velocities to 5 m/s. [2]

2.9 Sewage Treatment and Disposal

Alternative Processes

Secondary biological treatment with respect to nutrient removal will be the minimum standard of treatment that should be adopted for the wastewater treatment plants for the municipalities selected within this study. In the longer term it will be desirable to improve the standard to include nutrient removal.

The following secondary biological treatment processes have been reviewed as alternatives and the recommended process is selected taking into the consideration the local conditions and technical constraints.

Waste Stabilization Ponds and Lagoons

Suspended Growth Systems (Activated Sludge)

- conventional activated sludge

- extended aeration

- sequencing batch reactors

Fixed Growth Systems (Biological filtration) [2]

2.9.1 Waste Stabilization Ponds

Stabilization ponds consist of a series of open, relatively shallow, flow-through lagoons which operate largely without mechanical treatment and with low maintenance requirements. The standard and reliability of treatment is high in adequately sized systems but the process is highly temperature dependent and relatively long detention times would be necessary to maintain performance during the colder winter months. Land requirements can be nearly halved by the use of anaerobic ponds before the facultative and maturation stages but the total land requirement is still large.

A small quantity of digested sludge is produced in the anaerobic ponds which can be removed infrequently as once a year or less. Operation and maintenance of waste stabilization ponds is simple and, although not advisable, it is one of the few treatment processes that will continue to operate for an appreciable period of time without adequate maintenance. [2]

2.9.2 Conventional Activated Sludge

The process basically involves the aeration of settled sewage mixed with return activated sludge in an aeration tank, the air being introduced into the liquid by either surface aerators or by a diffused air system. The biomass generated in the aeration process is normally flocculent and settles out relatively easily in the secondary settlement tanks. The majority of this secondary, or ‘activated’, sludge is recycled to the aeration tank. Thus the principal units required after preliminary treatment include primary settlement tanks, aeration tanks, secondary settlement tanks and a return activated sludge pumping station. The process produces a large quantity of unstable sludge that requires treatment before dewatering and disposal.

The conventional activated sludge is most commonly selected for large plants. However, the process requires skilled operation and has relatively poor resistance to shock loads. The system also requires a high proportion of electro-mechanical plant which results in relatively high construction and maintenance costs. [2]

2.9.3 Comparison of Treatment Systems

The advantages and disadvantages of each process are summarized in Table 2.5. One of the key factors that will determine the choice of technology will be the availability of land for the wastewater treatment plant. The land requirements for a secondary treatment plant of 20,000 m3/d capacity for each process are given below:

Waste stabilization ponds	50.0 ha
Conventional activated sludge	3.0 ha
Extended aeration	3.4 ha
Sequencing batch reactors	2.5 ha
Biological filtration	8.8 ha

[2]

Table 2.5 Advantages and Disadvantages of Treatment Processes [2]

Advantages	**Disadvantages**
Waste Stabilization Ponds	
Low or zero energy requirement	Very large area of land required
Simple and reliable operation with low maintenance requirement	Performance deteriorates significantly at low temperatures
Low construction cost	Possible odour and mosquito problems
Minimal electrical and mechanical plant	Algal growth can affect effluent quality
Small quantity of digested sludge produced	
Conventional Activated Sludge	
Higher biological treatment level	Skilled operation necessary
Moderate land requirement	Large quantity of unstable sludge produced
Lower energy requirement than some aeration processes (e.g. Extended Aeration)	High proportion of mechanical and electrical plant
Widely used for large wastewater treatment plants	

Extended Aeration (Oxidation Ditch)	
Robust process with good resistance to shock loads Relatively simple operation and maintenance Smaller quantity (compared to activated sludge) of stable sludge produced Nitrogen reduction readily achievable Moderate construction cost	High energy requirement Higher land requirement than other forms of activated sludge treatment
Sequencing Batch Reactors	
Small land area required Flexible operation including nitrogen and phosphorus removal if necessary Moderate construction cost	Relatively complex control system required High mechanical and electrical content when controls taken into account Skilled maintenance needed to modify operating cycle
Biological Filtration	
Low energy requirement Relatively low mechanical and electrical content Simple operation	Larger land area required than for for activated sludge processes Relatively large quantity of unstable sludge produced Possible odour and fly problem Loss of nitrification in cold weather

2.9.4 Effluent Disposal

The disposal of treated effluents for each of the municipalities will be planned as follows:

Table 2.6 Wastewater flow Direction. [2]

Municipality	Initial Disposal Media	Final Disposal Media
Nicosia	Soil 60 %	Groundwater
	Treatment Plant 40 %	Treatment Plant
Famagusta	Soil 100 %	Groundwater
Kyrenia	Soil 90%	Groundwater
	Sea outfall 10 %	Mediterranean Sea

2.10 Population Projection Methods

Prediction of the future population of the three municipalities for design purposes is complicated by the Turkish and EU standards. It is expected that the population trend must decrease as the rural population is further depleted and the rural – urban populations will approach a more balanced situation. The high growth rates of some municipalities cannot be sustainable as the developable areas become saturated.

i) Arithmatic Exploration.

$$K_a = \frac{P_2 - P_1}{t_2 - t_1}$$

$$P_n = P_2 + K_a (t_n - t_2) \quad (2.2)$$

Where: P_1 , P_2 = Population of the city at the years t_1 , t_2 respectively.

P_n = Projected Population of the city at the year t_n .

ii) Geometric Extrapolation.

$$K_g = \frac{LnP_2 - Ln\,P_1}{t_2 - t_1} \quad (2.3)$$

$$Ln\,P_n = LnP_2 + K_g (t_n - t_2)$$

iii) Method used by " İller Bankasi " .

$$K = \left[\left(t_2 - 1945 \right) \sqrt{\frac{P_2}{P_{1945}}} - 1 \right] \times 100$$

$$P_n = P_2 \left(1 + \frac{K}{100} \right)^{\left(t_n - t_2 \right)} \tag{2.4}$$

If K > 3 → Take K = 3

K < 1 → Take K = 1

1 < K < 3 → Take K as it is .

Population assumptions and calculation for year 2020

The total Population of North Cyprus at year 1996 is equal to 200587 and for the three cities populations are:

1) $P_{(1996\text{ , Nicosia})}$ = 62,295

2) $P_{(1996\text{ , Famagusta})}$ = 52,875

3) $P_{(1996\text{ , Kyrenia})}$ = 38,715

From statistical yearbook the percentage of the annual rate of increase in between years 1996 and 1997, is equal to 1.18 %, Prime Minster State Planning Organization. [7, 8, 9]

MUNICIPALITIES BACKGROUND

3.1 Nicosia Municipality

Nicosia, being the provincial and administrative center of Cyprus, has got the maximum population and industrial development throughout the last 10 years. Unfortunately, due to increase in population and uncontrolled development of industrial area, the municipality is sometimes has insufficient answer the demonstration of the city. The sewerage system of the city is somehow collecting the 40 % of the wastes to be treated in the nearby village. Thus, the Nicosia Municipality is to taken in consideration hereafter. Nicosia municipality border and other important information are shown in (Figure 3.1). [City Planning Department]

3.1.1 Climate

In Nicosia and vicinity the minimum temperatures are around 5 degrees centigrade whereas the highest temperatures run around 40 degrees Celsius. The overall picture for the city is clear enough and rain falls during the month of October to April, but the winters are not cold. The meteorological data representing the temperature changes in Nicosia is given in Table 3.1.

Table 3.1 Nicosia Climate. [7]

Monthly for Nicosia	Monthly Max. air Temp.(^{o} C)	Monthly Mean air temp.(^{o} C)	Monthly Min. air Temp.(^{o} C)	Precipitation (mm)	Humidity (%)
January	19.6	10.3	-1.1	45.2	75.5
February	21.6	10.6	1.0	38.6	73.1
March	30.4	15.4	7.3	21.8	69.2
April	33.6	17.0	8.4	11.1	65.2
May	37.9	22.2	10.3	58.3	58.8
June	40.2	26.5	16.3	0.0	56.0
July	40.6	29.1	19.2	0.0	62.0
August	41.7	29.0	20.5	Little	67.8
September	37.9	25.6	17.0	Little	68.8
October	34.0	21.4	10.9	38.2	69.0
November	28.8	15.6	3.5	39.5	71.9
December	20.5	11.8	1.5	120.3	78.9

3.1.2 Agriculture

For a country of its size, North Cyprus has an astonishing variety of agricultural product. This is due to the geological formation and the various climate conditions which differ substantially depending on altitude and rainfall. The main products are: potatoes, citrus, fruits, grape products, cereals and carrots. These products are marketed through government purchase, cooperative, and private companies, sometimes also through direct sale by the producer. The history of the northern part of the island shows it to have always been a predominantly agrarian community. Vegetation is surprisingly variable and plentiful although Cyprus is a small island. Some parts of the island are without vegetation whereas some are covered with forest.

3.1.3 Industry

Nicosia is an industrial city and most of the industries made inside municipality border, the list of industries in Nicosia are presented in Table 3.2. it is understood that the data for the industries are not available to the authorities and that most of the industries has not applied for a discharge license and some of the industries or factories are generally not heavy water-using. In the table of Nicosia industries we have chosen the largest number of workers that means above 49.

Table 3.2 List of Industries in Nicosia. [9]

Industry Name	Type of Industry	Quantity of Industry
Preparation and storing	Fruits and Vegetables	1
Production of Clinker	Cement Industry	1
Ready Animals food Production	Food Industry	1
Oven food Production	Bread and Other	1
Production of Drinks	Without Alcohol Wine	1
Production of raw Material for Textile	Clothes Industry	1
Clothes Production except fur	Clothes Industry	2
Printing House	Books, Newsletter, etc.	1
Production of Colors	Varnish and other	1
Crushing of Stones an Shaping	Gravel and other	1
Production of Metallic Construction Materials	Steel and other	1
Production of Metallic	Reservoir	1
Furniture Construction	Kitchen, Bed, etc.	2

3.1.4 Management Capacity

This is as a distribution of the Municipality staff and water operations department capacity for Nicosia Municipality. The total number of staff employed by Nicosia Municipality amount of 249 persons, consisting of 234 permanent and temporary staff. The total number of technical staff is stated to consist of 13 engineers and 13 technicians.

The organization structure is shown in chart No 3.1. separate department exists within the Municipality responsibility for water supply, wastewater and sewerage facilities and transportation, served by 6 engineers, 5 technicians, and 214 permanent labor force and temporary labor force. For Municipality, staff is served by 7 engineers, 8 technicians, and 29 permanent labor force and temporary labor force. The service levels for engineers and technician's staff is presented in Table 3.3.

Municipality Staff		Water Operation Department	
234	Permanent and Temporary staff	29	Permanent and Temporary staff
7	Engineers	6	Engineers
8	Technician	5	Technician

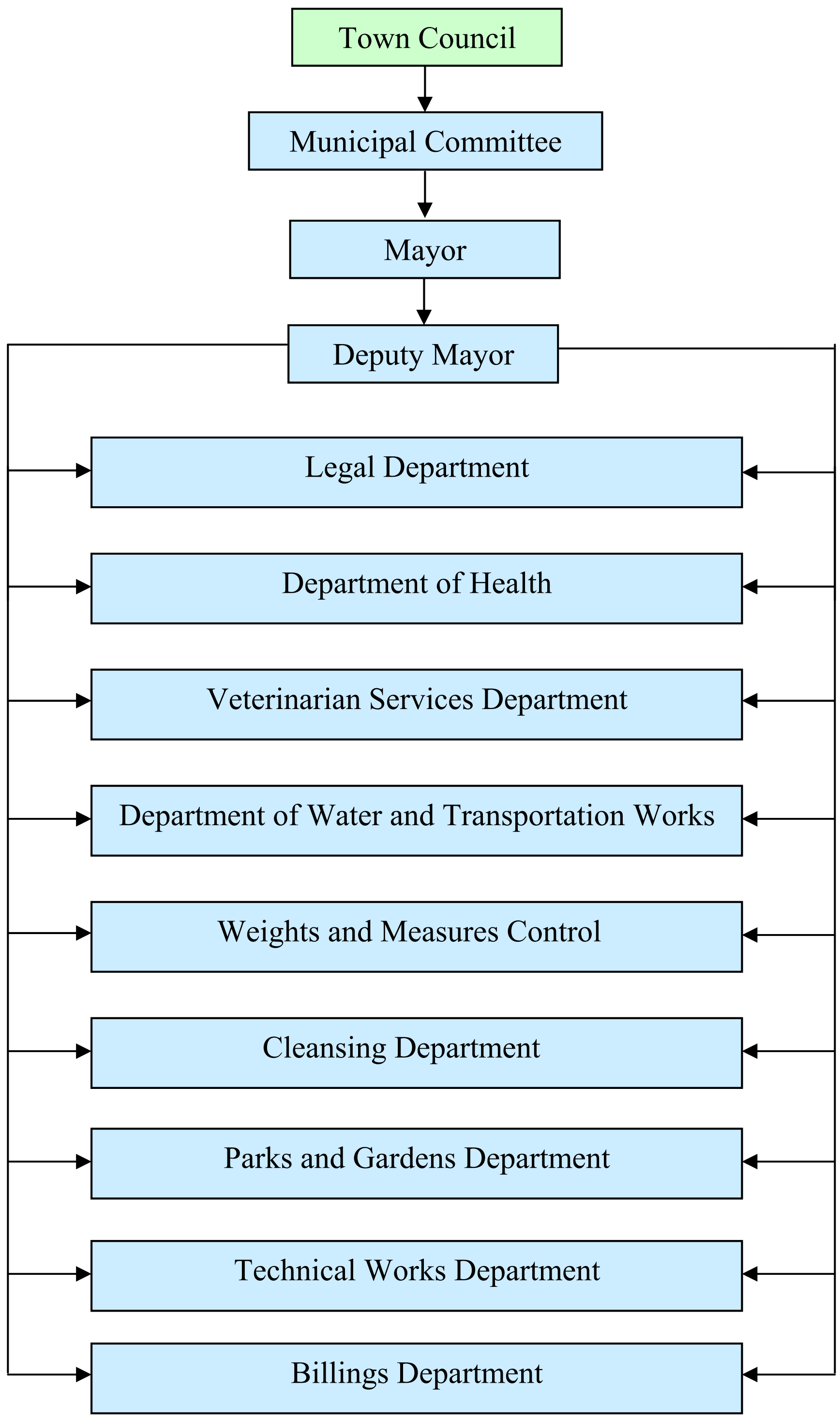
Table 3.3 Nicosia Municipality Technical Service Levels.

Total Population – 2002 Estimate	36,834
No. of Engineers in Water/Wastewater Department	6
Population served per Engineer in Water/Wastewater Department	6,139
No. Engineers and Technicians in Water/Wastewater Department	11
Population served per Engineer/Technician in Water/Wastewater Department	3,349
Total No. of Engineers in Municipality	13
Population served per Engineer in Municipality	2,833
Total No. of Engineers and Technicians in Municipality	36
Population served per Engineer/Technician in Municipality	1,023

CHART NO. 3.1

NORTH CYPRUS SEWERAGE STUDY

NICOSIA MUNICIPALITY ORGANISATION



3.1.5 Water Supply

The water supply of Nicosia municipality comes from reservoirs and well, but in this time all the water comes only from reservoirs because all the wells are dried or due to salty water comes from the wells and the reservoir location is shown in the (Figure 3.2-a,b,c). [City Planning Department]

3.1.5.1 Water Sources

Until recently the water supply for Nicosia municipality has been taken from the reservoirs and wells are located in Omorfo region. The freshest water in North Cyprus is founded in the Omorfo region and very little water comes from the South Cyprus. Due to political issues the water supplied from South Cyprus decreasing day by day.

3.1.5.2 Water Distribution System

The existing water supply distribution system is constructed depending on the pollution by different diameters and pipe types. Pipe diameter depends on the population and developing regions where pipe diameter changes from 2 to 6 inches and the main line may be more thane 6 inches which comes from omorfo Famagusta through the Nicosia area from the omorfo.

3.1.6 Operation of the Municipality

Nicosia Municipality has done many operation and other activities like projects of pipeline network for fresh water supply to the city when comes from the wells to the reservoirs and from reservoirs to the city. Other projects like sanitary sewers system and renovation of old network for sewer pipe line or expansion of sewage treatment plant, Nicosia has already been under two main projects.

First project has been done at April 1983, for the expansion of the Nicosia sewage treatment plant. This project done by EMEK and ZHM Construction Company, under control of the Turkish Municipality of Nicosia. The project is made by Asbestos cement sewer pipe; with different diameter depend on the flowrates.

Second project has been done at June 1986, for the installation of sanitary sewers and associated works. This project done by the same company, under the Turkish Municipality of Nicosia and the project is Asbestos cement sewer pipe.

3.1.7 Nicosia Sewage Treatment Plant

Nicosia sewage treatment plant was designed for treating domestic effluent. Sewage treatment consisted of two aerated lagoons and four facultative lagoons. The sewage treatment plant and the sewage system were put into operation in the year 1980. In summer time, daily flow to Nicosia sewage treatment, plant is approximately 8,000 m^3 and in winter season, 12,000 m^3 of water respectively. On the average, the treatment plant treads wastewater discharge by about 100,000 people. Some industrial factories which do not pre-treat wastewater are also connected to the treatment plant.

Nicosia, general daily consumption rate of water is 100lt/person. The effluent water is composed of 85 % of the influent wastewater. The wastewater is carried in the pipe of about 3 hours. The flow is coming through gravitational feed pipe from Nicosia with pipe diameter of 1,100 mm made by asbestos cement. [6]

3.1.7.1 Septage Tanks in Nicosia

The resident population in North Cyprus at the end of 1996 was 45,000. the sewerage network currently active in North Nicosia can only serve about 25,000 people.

Sewage disposal from the area, not connected to the sewerage network, is uses to septic tanks followed by absorption pits or holding tanks. It is a common practice to discharge only WC wastes to the septic tank, from which the effluent may pass to absorption pits in the case of houses or to holding tank in the case of multi-story dwellings. Wastes from other domestic water uses (sullage) are discharged direct to the absorption pit or holding tank after first passing through grease trap.

Saturation problems occur with the absorption pits and in any areas, it is necessary to pump out at regular intervals. The contents of the absorption pit and septic tank, when disposed of on land, may give rise to problems of odor and pose a potential public- health hazard. The percolation of Nitrates in septage tanks may also contaminate the surrounding groundwater sources. [6]

3.1.7.2 Septage Quality Characteristics in Nicosia

Septic tank must be pumped out at regular intervals. The mixture of sludge and supernatant pumped out is defined as septage. Pumping frequencies vary for efficient septic-tank operation. The time interval between each pumping out is usually not greater than 1-4 years.

Samples of septage were collected from a number of septic tanks, absorption pits and tankers and the analytical results are presented in Table 3.4.

Composite samples were collected from 10 tankers at the time of discharge at the disposal area.

Grab samples were taken from 3 hours septic tanks and absorption pits, and from 3 medium-size buildings tanks. [6]

Table 3.4 Septage Characteristics in Nicosia. [6]

Parameter (mg/lt)	Septic tanks		Absorption pits	Tankers
	house	flats		
pH	7.3	7.1	7.3	8.5
T. Solids	2,969	1,698	2,853	4,266
SS	1,256	297	1,688	773
VS	74	85	64	62
BOD	418	264	454	334
COD	1,820	857	1,750	1,488
Org. N	27	11.8	30	7
Amm. N	293	94	247	139
PO_4	8.3	7.5	8.2	8.2

T. Solids Suspended Solids

SS Suspended Solids

VS (Volatile Solids)

COD (Chemical Oxygen Demand)

Org.N (Organic Nitrogen)

Amm. N (Ammonium Nitrogen)

PO_4 (Potassium Oxide)

3.1.8 Population Projection Method

3.1.8.1 Calculation for Nicosia

a) Nicosia City

P_{1996} = 62,295 with the factor 1.18 %. [8,9]

P_{1997} = 63,030

i) Arithmatic Exploration.

$$K_a = \frac{63030 - 62295}{1997 - 1996} = 735$$

$$P_{2020} = 63030 + 735\,(2020 - 1997)$$

$$\Rightarrow P_{2020} = 79{,}200$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln}\,63030 - \text{Ln}\,62295}{1997 - 1996} = 0.01173$$

$$\text{Ln}\ P_{2020} = \text{Ln}\ 63030 + 0.01173\,(2020 - 1997)$$

$$\Rightarrow \text{Ln}\ P_{2020} = 11.3211$$

$$\Rightarrow P_{2020} = 82{,}549$$

iii) Method used by " İller Bankasi " .

$$K_a = \frac{62295 - P_{1945}}{1996 - 1945} = 735$$

$$\Rightarrow P_{1945} = 24{,}810$$

$$K = \left[\sqrt[(1996 - 1945)]{\frac{62295}{24810}} - 1 \right] \times 100 = 1.822$$

$$P_{2020} = 62295 \left(1 + \frac{1.822}{100}\right)^{(2020 - 1996)}$$

$$P_{2020} = 96{,}074$$

b) Nicosia Municipality Border

$P_{2002} = 36{,}834$ with the factor 1.09 %.[8,9]

$P_{2003} = 37{,}235$

i) Arithmatic Exploration.

$$K_a = \frac{37235 - 36834}{2003 - 2002} = 401$$

$$P_{2020} = 37235 + 401\,(2020 - 2003)$$

$$\Rightarrow P_{2020} = 44{,}052$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln}\,37235 - \text{Ln}\,36834}{2003 - 2002} = 0.0108$$

$$\text{Ln P}_{2020} = \text{Ln } 37235 + 0.0108\,(2020 - 2003)$$

$$\Rightarrow \text{Ln P}_{2020} = 10.709$$

$$\Rightarrow \text{P}_{2020} = 44{,}760$$

iii) Method used by “ İller Bankasi ” .

$$K_a = \frac{36834 - \text{P}_{1945}}{2002 - 1945} = 401$$

$$\Rightarrow \text{P}_{1945} = 13{,}977$$

$$K = \left[\sqrt[(2002-1945)]{\frac{36834}{13977}} - 1 \right] \times 100 = 1.715$$

$$\text{P}_{2020} = 36834 \left(1 + \frac{1.715}{100}\right)^{(2020 - 2002)}$$

$$\text{P}_{2020} = 50{,}024$$

3.2 Famagusta Municipality

Famagusta is one of the most important, greatly fortified ports on the shores of the Mediterranean. To the north of Famagusta lie the fabulous ruins of Salamis. This one great city is believed to have been founded in the 11th century BC and after the influences of the many conquering nations -notably the Romans- the city was finally abandoned in 648 AD following the combined catastrophes of earthquake and raids by Arab pirates, when the population moved to Famagusta. Famagusta municipality border and other important information are shown in (Figure 3.3). [City Planning Department]

Famagusta (Gazimağusa) was originally a small commercial and fishing port but with the advent of the Crusades and the reign of the Lusignans it attained much greater significance. The old town is surrounded by magnificent walls, 17 meters high and 9 meters wide, which were constructed by Lusignans and further reinforced by the Venetians in 1489. There are reputed to be 365 places of worship in Famagusta and among the foremost of these is the Lala Mustafa Paşa Mosque.

Formerly St. Nicholas Cathedral, where the Lusignan kings were crowned, its name was changed after the Ottoman conquest of the island in 1571. It remains as one of the finest examples of Gothic architecture to this day. The knights Templar, the knights Hospitable and Othello also share in the great history of the city.

3.2.1 Climate

The level present in this section are compiled from the monthly meteorological bulletins, also the station and heights above sea level for Famagusta city is 3 m. Climate is as described in the following Table 3.5

Table 3.5 Famagusta Climate. [7]

Monthly for Famagusta	Monthly Max. air Temp. (^{o} C)	Monthly Mean air temp. (^{o} C)	Monthly Min. air Temp. (^{o} C)	Precipitation (mm)	Humidity (%)
January	20.2	12.5	1.7	61.9	83.7
February	20.7	11.7	2.1	25.2	83.6
March	29.4	15.2	8.0	5.7	86.2
April	30.8	17.5	9.3	18.3	82.2
May	33.6	21.3	12.1	6.2	73.9
June	36.0	25.2	16.8	0.0	75.4
July	35.6	27.5	21.5	0.0	82.2
August	35.8	28.1	22.3	0.0	98.1
September	31.7	25.2	19.0	1.4	82.6
October	32.8	21.6	11.0	5.3	76.2
November	26.5	16.4	3.0	51.8	73.2
December	19.9	12.8	3.8	146.5	77.8

3.2.2 Industry

The lists of industries in Famagusta are presented in Table 3.6. it is understood that the data for the industries are not available to the authorities and that most of the industries has not applied for a discharge license and some of the industries or factories are generally not heavy water-using.

Table 3.6 list of Industries in Famagusta. [9]

Industry Name	Type of Industry	Quantity of Industry
Oven food Production	Bread and Other	2
Production of Drinks	Alcohol Wine	1
Production of Drinks	Beer	1
Textile Production	Except Clothes	1
Ship Construction and Repair	Ship Industry	1

3.2.3 Management Capacity

This is as a distribution of the Municipality staff and water operations department capacity for Famagusta Municipality. The total number of staff employed by Famagusta Municipality amount of 424 persons, consisting of 318 permanent and temporary staff. The total number of technical staff is stated to consist of 8 engineers and 115 technicians.

The Organization structure is shown in chart No.3.2. A separate department exists within the Municipality responsibility for water supply, wastewater and sewerage facilities and transportation is served by 1 engineer, 15 technicians, a 38 No. total number of permanent labor force and temporary labor force. For Municipality staff is served by 1 engineer, 15 technicians, a 318 No. total number of permanent labor force and temporary labor force. The service levels for engineers and technician's staff is presented in Table 3.7.

Municipality Staff	Water Operation Department
315 Permanent staff	38 Permanent staff
3 Temporary staff	no Temporary staff
7 Engineers	1 Engineers
100 Technician	15 Technician

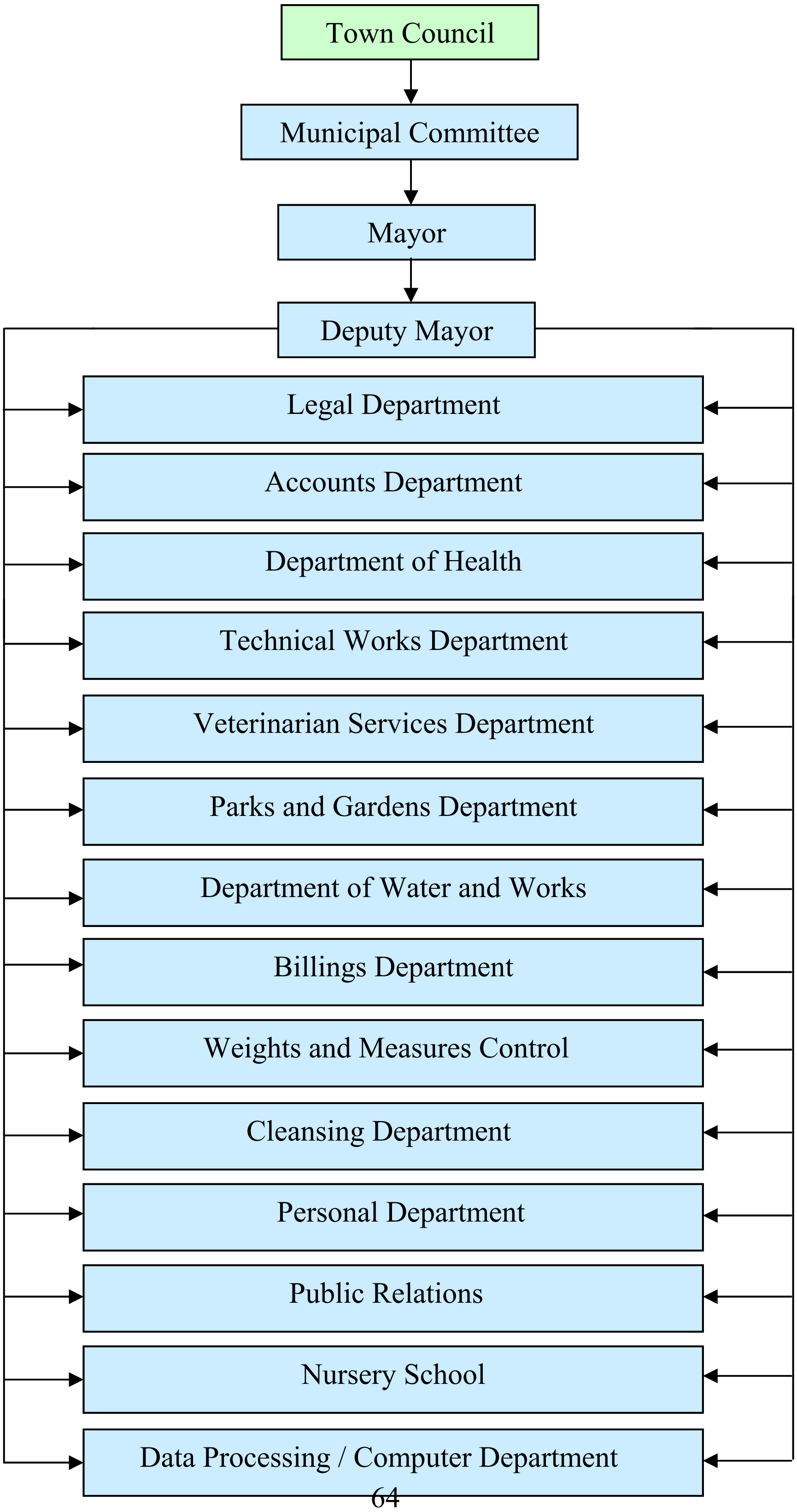
Table 3.7 Famagusta Municipality Technical Service Levels.

Total Population – 2002 Estimate	23,295
No. of Engineers in Water/Wastewater Department	1
Population served per Engineer in Water/Wastewater Department	23,295
No. Engineers and Technicians in Water/Wastewater Department	16
Population served per Engineer/Technician in Water/Wastewater Department	1,456
Total No. of Engineers in Municipality	8
Population served per Engineer in Municipality	2,912
Total No. of Engineers and Technicians in Municipality	123
Population served per Engineer/Technician in Municipality	189

CHART NO. 3.2

NORTH CYPRUS SEWERAGE STUDY

FAMAGUSTA MUNICIPALITY ORGANISATION



3.2.4 Water Supply

The water supply of Famagusta municipality it comes from reservoirs and well, but in this time all the water comes only from reservoirs because all the wells are dried.

3.2.4.1 Water Sources

Until recently the water supply for Famagusta municipality has been taken from the reservoir only, there are three reservoirs. First one is located at Marash region with a capacity of 2,500 m^3, and other two reservoirs each of them have capacity of 3,750 m^3, they are connected together as one. The water for the two reservoirs comes from morphou (Güzelyurt) region by a pipeline diameter of 200 mm, and changes from 4 to 8 inches as it comes into the city.

The total fresh water that comes from omorfo and other reservoir is not enough for Famagusta city, therefore the demand for water is taking from South Cyprus amount of 300 $m^{3,}$ of water is supplied, but this amount of water decreases every year and will make problem in the future. The pipeline network comes from omorfo passes through Nicosia and flows to Famagusta city and other region around it.

3.2.5 Operation of the Municipality

Famagusta municipality has many activities and some projects like pipeline network for supplying fresh water from wells to the reservoirs and from reservoirs to people or any new developed region.

For example, due problems of fresh water in North Cyprus it's effected by salt water intrusion and some of them become completely dried.

The main objectives of the project done by municipality to make a pipeline network to the new developed regions which will be inside Famagusta municipality border and the capacity of the project are 300 m^3/ day.

Length of the pipeline	4,275 m
Depth of excavation	80 cm
Diameter of the pipeline	203 mm
Type of the pipeline	P.V.C

This project made under control of Famagusta municipality and it has a total cost of 154,000 $ including the Government taxes. All this information are supplied from a Manager of Famagusta municipality Mr. Ali Murat and Mr. Naci Taşeli from water department.

3.2.6 Calculation for Famagusta

a) Famagusta City

P_{1996} = 52,875 with the factor 1.18 %.[8,9]

P_{1997} = 53,499

i) Arithmatic Exploration.

$$K_a = \frac{53499 - 52875}{1997 - 1996} = 624$$

$$P_{2020} = 53499 + 624\,(2020 - 1997)$$

$$\Rightarrow P_{2020} = 67{,}851$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln}\,53499 - \text{Ln}\,52875}{1997 - 1996} = 0.01173$$

$$\text{Ln}\ P_{2020} = \text{Ln}\ 53499 + 0.01173\,(2020 - 1997)$$

$$\Rightarrow \text{Ln}\ P_{2020} = 11.157$$

$$\Rightarrow P_{2020} = 70{,}071$$

iii) Method used by " İller Bankasi " .

$$K_a = \frac{52875 - P_{1945}}{1996 - 1945} = 624$$

$$\Rightarrow P_{1945} = 21,051$$

$$K = \left[{}^{(1996 - 1945)}\sqrt{\frac{52875}{21051}} - 1 \right] \times 100 = 1.822$$

$$P_{2020} = 52875 \left(1 + \frac{1.822}{100}\right)^{(2020 - 1996)}$$

$$P_{2020} = 81,560$$

b) Famagusta Municipality Border

P_{2002} = 23,295 with the factor 1.09 %.[8,9]

P_{2003} = 23,549

i) Arithmatic Exploration.

$$K_a = \frac{23549 - 23295}{2003 - 2002} = 254$$

$$P_{2020} = 23549 + 254 \, (2020 - 2003)$$

$$\Rightarrow P_{2020} = 27,867$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln } 23549 - \text{Ln } 23295}{2003 - 2002} = 0.0108$$

$$\text{Ln } P_{2020} = \text{Ln } 23549 + 0.0108\,(2020 - 2003)$$

$$\Rightarrow \text{Ln } P_{2020} = 10.25$$

$$\Rightarrow P_{2020} = 28{,}316$$

iii) Method used by " İller Bankasi " .

$$K_a = \frac{23549 - P_{1945}}{2003 - 1945} = 254$$

$$\Rightarrow P_{1945} = 8{,}817$$

$$K = \left[\sqrt[(2003 - 1945)]{\frac{23549}{8817}} - 1 \right] \times 100 = 1.708$$

$$P_{2020} = 23549 \left(1 + \frac{1.708}{100}\right)^{(2020 - 2003)}$$

$$P_{2020} = 31{,}407$$

3.3 Kyrenia Municipality

Kyrenia (Girne) Castle***:*** Founded by the Byzantines in the 10th century, improved by the Lusignans in the 13th century and later re-fortified by the Venetians, the huge castle with its thick walls and massive bastions dominates the picturesque harbor of Kyrenia. It also houses a museum with the remains of one of the world's oldest shipwrecks (300 BC) ever recovered, complete with its cargo. Kyrenia municipality border and other important information are shown in (Figure 3.4). [City Planning Department]

3.3.1 Climate

The monthly meteorological bulletins, and heights above sea level for Kyrenia city is 8 m. Climate is as described in the following Table 3.8.

Table 3.8 Kyrenia Climate. [7]

Monthly for Kyrenia	Monthly Max. air Temp. (^{o}C)	Monthly Mean air temp. (^{o}C)	Monthly Min. air Temp. (^{o}C)	Precipitation (mm)	Humidity (%)
January	20.2	14.0	6.0	100.3	72.4
February	20.0	14.2	5.6	53.2	71.5
March	23.5	17.5	10.2	19.5	73.2
April	29.7	18.7	11.0	15.8	72.6
May	31.2	22.3	13.4	11.0	68.8
June	31.4	25.5	17.7	0.0	69.6
July	35.6	28.5	20.7	0.0	74.7
August	35.4	29.7	22.8	0.0	67.9
September	31.8	27.6	22.2	0.1	77.8
October	32.0	24.5	16.0	9.3	72.7
November	26.2	18.8	9.8	82.9	72.5
December	21.5	15.5	8.2	182.4	74.1

3.3.2 Industry

Kyrenia is an industrial city and the industries made inside centralized industrial regions, the list of industries in Kyrenia are presented in Table 3.9.

Table 3.9 list of Industries in Kyrenia. [9]

Industry Name	Type of Industry	Quantity of Industry
Clothes Production except fur	Clothes Industry	2
Production of Metalic Construction Materials	Steel and other	1

3.3.5 Management Capacity

This is as a distribution of the Municipality staff and water operations department capacity for Kyrenia Municipality.

The total number of staff employed by Kyrenia Municipality amount of 168 persons, consisting of 141 permanent and temporary staff. The total number of technical staff is stated to consist of 2 engineers and 25 technicians.

The Organization structure is shown in chart No.3.3. A separate department exists within the Municipality responsibility for water supply, fresh water facilities and transportation is served by 8 technicians and without any engineer, a 117 No. total number of permanent labor force and temporary labor force. For Municipality staff is served by 2 engineers, 17 technicians, a 24 No. total number of permanent labor force and temporary labor force. The service levels for engineers and technician's staff is presented in Table 3.10.

Municipality Staff		Water Operation Department	
24	Permanent and Temporary staff	117	Permanent and Temporary staff
2	Engineers	no	Engineers
17	Technician	8	Technician

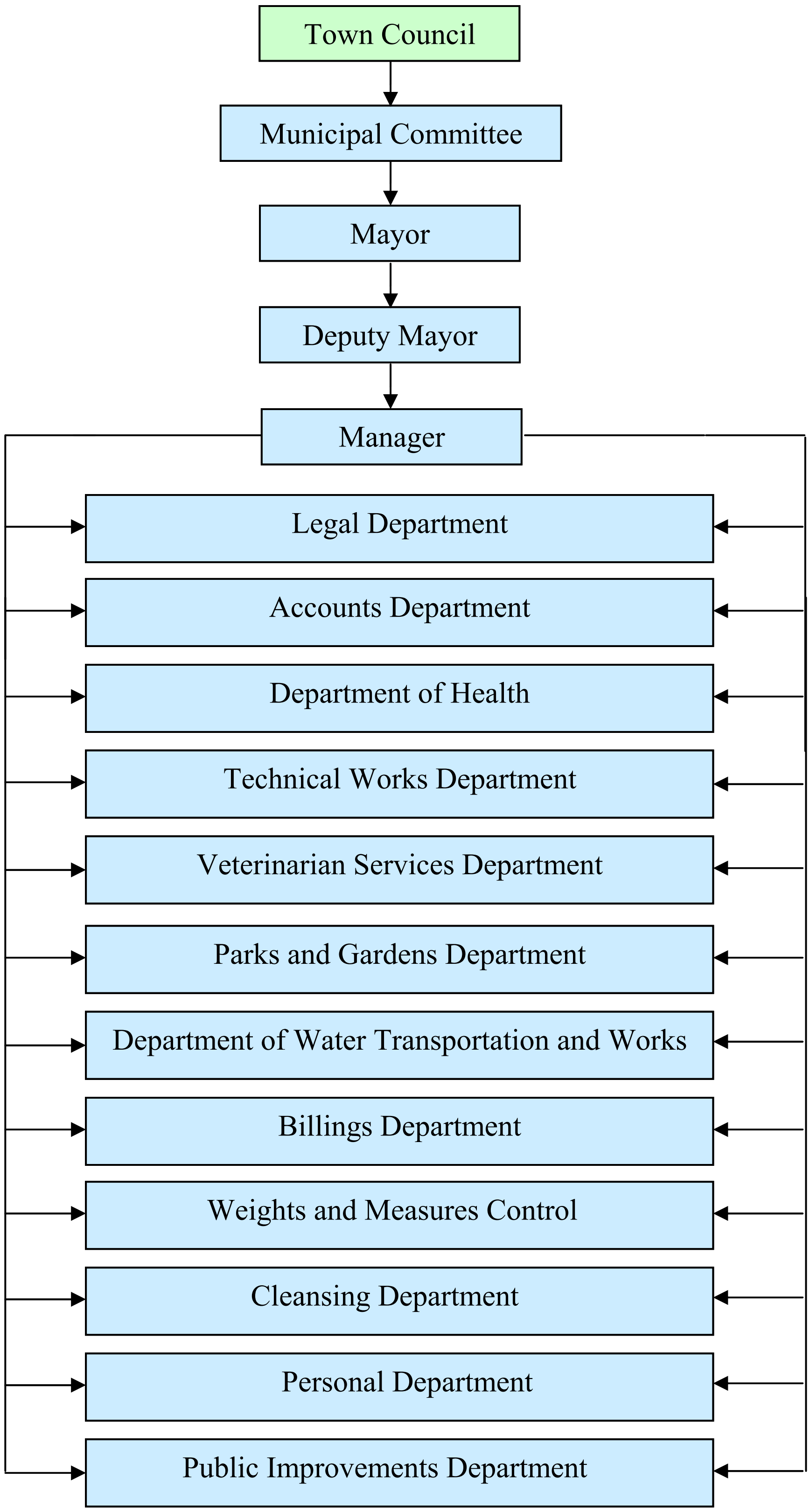
Table 3.10 Kyrenia Municipality Technical Service Levels

Total Population – 2002 Estimate	12,917
No. of Engineers in Water/Wastewater Department	No
Population served per Engineer in Water/Wastewater Department	12,917
No. Engineers and Technicians in Water/Wastewater Department	8
Population served per Engineer/Technician in Water/Wastewater Department	1,615
Total No. of Engineers in Municipality	2
Population served per Engineer in Municipality	6459
Total No. of Engineers and Technicians in Municipality	27
Population served per Engineer/Technician in Municipality	478

CHART NO. 3.3

NORTH CYPRUS SEWERAGE STUDY

KYRENIA MUNICIPALITY ORGANISATION



3.3.3 Water Supply

The water supply and some other facilities like reservoirs and wells location for Kyrenia Municipality are out of the border of the city.

3.3.3.1 Water Sources

Until recently the water supply for Kyrenia has been solely taken from the six wells water supply system in Boz Mountain and Karmi, but some of the wells are located over the mountain area. All the wells are located out of Kyrenia municipality border, from this wells water is taking water to the reservoir by connection of different pipes diameter and quality, all pipeline network are depending on to the area which they are going to supply and capacity needed to be enough for two times per week, because the total fresh water in North Cyprus is decreasing day by day and the population increases that's why they can't supply fresh water for every day to the same area. The amount of supplied water from wells to the Kyrenia city is 210 m^3/hr, there is no need for pumping station because all these wells are higher than the Kyrenia elevation.

3.3.3.2 Water Distribution System

The main water supply from wells to the two places Boz mountain and Karmi are to supply for a 12 main reservoirs and its located inside the Military region, also its very closed to the same region of wells so, that no need of pumping station.

The pipelines networks are connect by different diameters and a type has been constricted from the wells to the reservoirs and from reservoirs to the municipality area, this pipeline network distribution diameter in between 2 to 6 inches.

3.3.4 Operation of the Municipality

Kyrenia municipality has many activities and some operation like pipeline network for supplying fresh water from wells to the reservoirs and from reservoirs to people or any new developed region.

For example the municipality has constructed a project for fresh water supply at October 2000, this project pipeline network for the region called Neşet İkiz Sokağine with a cost around 2000 $. The pipe diameter is 90 mm for the main line and 15 mm for the inner distribution with different in length, also the pipeline network are constructed from P.V.C quality.

Another project has recently constructed at April 2002, for the area called Cemil Akin Sokağine street with a cost around 2500 $. The pipeline network diameter is 90 mm with 300 m long and these additional works are given below includes with the total pries of the project, also this information are supplied from Mr. Faik AKTÜL (Water Department)

3.3.5 Calculation for Kyrenia

a) Kyrenia City

P_{1996} = 38,715 with the factor 1.18 %. [8,9]

P_{1997} = 39,172

i) Arithmatic Exploration.

$$K_a = \frac{39172 - 38715}{1997 - 1996} = 457$$

$$P_{2020} = 39172 + 457\,(2020 - 1997)$$

$$\Rightarrow P_{2020} = 49{,}683$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln}\,39172 - \text{Ln}\,38715}{1997 - 1996} = 0.01174$$

$$\text{Ln}\ P_{2020} = \text{Ln}\ 39172 + 0.01174\,(2020 - 1997)$$

$$\Rightarrow \text{Ln}\ P_{2020} = 10.85$$

$$\Rightarrow P_{2020} = 51{,}309$$

iii) Method used by " İller Bankasi " .

$$K_a = \frac{38715 - P_{1945}}{1996 - 1945} = 457$$

$$\Rightarrow P_{1945} = 15,408$$

$$K = \left[\left(1996 - 1945 \right) \sqrt{\frac{38715}{15408}} - 1 \right] \times 100 = 1.822$$

$$P_{2020} = 39715 \left(1 + \frac{1.822}{100} \right)^{\left(2020 - 1996 \right)}$$

$$P_{2020} = 59,728$$

b) Kyrenia Municipality Border

P_{2002} = 12,917 with the factor 1.09 %.[8,9]

P_{2003} = 13,058

i) Arithmatic Exploration.

$$K_a = \frac{13058 - 12917}{2003 - 2002} = 141$$

$$P_{2020} = 13058 + 141 \left(2020 - 2003 \right)$$

$$\Rightarrow P_{2020} = 15,455$$

ii) Geometric Extrapolation.

$$K_g = \frac{\text{Ln}\,13058 - \text{Ln}\ 12917}{2003 - 2002} = 0.01086$$

$$\text{Ln}\ P_{2020} = \text{Ln}\ 13058 + 0.01086\ (2020 - 2003)$$

$$\Rightarrow \text{Ln}\ P_{2020} = 9.49$$

$$\Rightarrow P_{2020} = 13{,}200$$

iii) Method used by “ İller Bankasi ” .

$$K_a = \frac{13058 - P_{1945}}{2003 - 1945} = 141$$

$$\Rightarrow P_{1945} = 4{,}880$$

$$K = \left[\sqrt[(2003 - 1945)]{\frac{13058}{4880}} - 1 \right] \times 100 = 1.71$$

$$P_{2020} = 13058 \left(1 + \frac{1.71}{100}\right)^{(2020 - 2003)}$$

$$P_{2020} = 17425$$

PRIORITISATION CALCULATION

The selection criteria are proposed fewer than three headings as follows:

Level of Sanitation

Environmental and Public Health Impacts

Financial sustainability

4.1 Level of Sanitation Services

Population is considered to be a very important criterium for the selection of prioritised municipalities suitable for investment. Generally the capital cost of sewerage facilities per capita decrease with increasing city population and higher densities, and the benefit of the investment is maximised. For this project there are two key population estimates to be considered:

1. Present population not served by a sewer collection system

2. Present population not connected to a municipal sewage treatment / disposal system

This gives the following population figures as the basis for this criterium evaluation:

After the application of population projection method by the three different ways, Arithmatic Exploration, Geometric Extrapolation, and Method of "İller Bankasi", the results are demonstrated in Table 4.1a,b.

Table 4.1 Population Assumptions and Calculation for Year 2020

a) For each city

Town City	Heights above sea level in (m)	Popn. 1996	Popn. Factor (%)	Popn. 1997	Popn. By A. E., 2020	Popn. By G. E., 2020	Popn. By " İller Bankasi 2020
Nicosia	108	62,295	1.18	63,030	79,200	82,549	96,047
Famagusta	3	52,875	1.18	53,499	67,851	70,071	81,715
Kyrenia	8	38,715	1.18	39,172	49,683	51,309	59,728

b) For each Municipality Border

Town City	Heights above sea level in (m)	Popn. 2002	Popn. Factor (%)	Popn. 2003	Popn. By A. E., 2020	Popn. By G. E., 2020	Popn. By " İller Bankasi 2020
Nicosia	108	36,834	1.09	37,235	44,052	44,760	50,024
Famagusta	3	23,295	1.09	23,549	27,867	28,316	31,407
Kyrenia	8	12,917	1.09	13,058	15,455	13,200	17,425

4.1.1 Existing Population not Presently Provided with Waterborne Sewage Collection Facilities

Presently there are areas of each municipality that are not connected to the sewer network system and these will be considered within this criterium. The municipality with the greatest number of people that are not connected will be assigned a score of 15. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{p_{max.sew} - P_f}{p_{max.sew}} \right) \right] \times S_{max} \qquad (4.1)$$

Where , S_f is the score for Municipality "f"

P_{max} is the population not connected to a sewer system, from the municipality with the greatest number not connected.

P_f is the population of Municipality "f" not connected to a sewer system.

S_{max} is the maximum score as given to the municipality with P_{max}

4.1.2 Existing Population not Presently Connected to Municipal Sewage Treatment Facilities

Presently there are areas of municipality that are not connected to the waterborne sewerage system, where domestic wastewater is disposed of on site, and these will be considered within this criterium.

There are other areas of the municipalities that are connected to a piped system but the sewage is discharge without treatment. Such areas will also be considered within this criterium.

The municipality with the greatest number of people that are not connected will be assigned a score of 15. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{p_{max.tr} - P_f}{p_{max.tr}} \right) \right] \times S_{max} \qquad (4.2)$$

Where , S_f is the score for Municipality "f"

P_{max} is the population not connected to municipal sewage treatment facilities, from the municipality with the greatest number not connected

P_f is the population of Municipality "f" not connected to municipal sewage treatment facilities.

S_{max} is the maximum score as given to the municipality with P_{max}

4.1.3 Overall Evaluation Scores for Levels of Sanitary Services

The overall evaluation score for sanitary services is proposed as the sum of the scores for 4.1.1 and 4.1.2 above, for each municipality. This will give a maximum possible score of 30 points.

4.1.3.1 Calculation for First Table with Present Population

Nicosia, $P_{2002} = 36,834$

Famagusta, $P_{2002} = 23,295$

Kyrenia, $P_{2002} = 12,917$

Famagusta municipality it has the greatest number of people that are not connected will be assigned a score of 15. The scores for the other municipalities would be calculated from the following formula. In order to demonstrate the proposed selection criterium evaluation the results are given below for three towns with differing levels of sewerage services shown in Table 4.2.

$P_{max\text{-}sew} = 20,966$

$$S_{f,Nicosia} = \left[1 - \left(\frac{20966 - 14734}{20966} \right) \right] \times 15 = 10.5$$

$$S_{f,Kyrenia} = \left[1 - \left(\frac{20966 - 12917}{20966} \right) \right] \times 15 = 9.4$$

Table 4.2 Level of Sanitary Services

Item	**Nicosia Municipality**	**Famagusta Municipality**	**Kyrenia Municipality**
Population	36,834	23,295	12,917
%age residential area not connected to sewers	40	90	100
%age residential area not connected to treatment works	40	90	100
Population not connected to sewers	14,734	20,966	12,917
Scoring for population requiring sewer collection facilities	10.5	15	9.4
Population not connected to sewage treatment works	14,734	20,966	12,917
Scoring for population requiring sewage treatment facilities	10.5	15	9.4
Total Scoring for Level of Sanitary Services	**21**	**30**	**18.8**

4.2 Environmental and Public Health Impacts

4.2.1 Estimation of Pollution Loads

It is proposed to evaluate the environmental and public health impacts of existing wastewater discharge practices and associated pollution effects by consideration of the pollution loads and the nature of the receiving waters or discharge media. The pollution load will be derived from wastewater flow and BOD_5 strength, expressed as mg/l. For domestic sewage this will be assumed as 500mg/l.

For industrial premises there is a requirement for the firms to provide pretreatment to their wastewater to meet defined standards, and the BOD_5 strengths will be assumed to be at the minimum standards applicable. For discharges to the municipal sewer systems with subsequent deep sea disposal the 1988 Water Pollution Control Regulation permitted wastewater BOD_5 strength of 250mg/l and it is assumed that industry connected is also treating to this standard. For industrial discharges directly to the environment, such as to rivers, streams or by means of short sea outfalls wastewater discharges standards are defined in the same 1988 Water Pollution Control Regulation for various types of industry. Typical relevant BOD_5 maximum strengths are given in the regulations for wastewater discharges in terms of 24-hour composite samples as follows:

Leather industry	100mg/l
Cotton textiles	60mg/l
Food industry (processing plants)	40mg/l
Oil from oil seeds (food industry)	170mg/l
Chemical industry	30mg/l

It is proposed to use the above maximum limits to calculate the industrial BOD_5 loads discharged directly to the environment.

In most cases the wastewater that is collected in the municipal sewer systems is provided with preliminary treatment, screening and grit removal, before discharge. The preliminary treatment removes a small portion of the organic load from the wastewater, however the reduction of the BOD_5 loads is considered to be negligible due to, coarse screens used, and inefficient grit removal operations, screenings and grit are usually buried on site.

Generally, in unsewered areas domestic wastewater is discharged to soakage or absorption pits where the liquid part of the wastewater seeps into the soil and the solids are retained within the pits. Full raw sewage BOD_5 load will be assumed as discharge. [2]

4.2.2 Weighting Factors to Reflect the Vulnerability of the Recipient Water Bodies

The receiving waters or discharge media for the municipalities concerned may be considered as:

1. To the Mediterranean Sea by long sea outfall at depth of the order of 30m following preliminary screening and treatment – low risk to environment and public health due to dispersion and dilution effects of sea currents
2. To the Mediterranean Sea by short outfall to just below the water level – risk to public through contact with water, environmentally objectionable
3. To rivers and streams – risk to public through contact with water, environmentally objectionable and risk to river flora and fauna
4. To the ground from on-site disposal pits –not close to water supply boreholes, soil properties and water table level not considered to present a risk to public health and environment after filter effects of flow through the soil

5. To the ground from on-site disposal pits – close to water supply boreholes, or high water table or poor soil filter potential presenting potential risk to public health and environment
6. Overground to areas of vegetable gardening – high risk to public health through food-chain, environmentally objectionable
7. Overground to areas where there are groundwater boreholes for potable water supply – high risk to public health, environmentally objectionable

It is proposed to assign weighting factors to the calculated BOD_5 loads to reflect the sensitivity of the discharge media in respect of risk to public health and the environment will be given in Table 4.3.

Table 4.3 Weighting Factor for Different Types of Flow. [2]

Method of Discharge	**Weighting Factor**
To the plant with preliminary screening and treatment	1.0
To the ground from on-site disposal – low risk of groundwater contamination	1.5
To the ground from on-site disposal – potential risk of groundwater contamination	2.0
To the Mediterranean Sea by short outfall to just below sea level	2.5
To rivers and streams	2.5
Overground to areas of vegetable gardening	3.0
Overground to areas where there are groundwater boreholes for potable water supply	3.0

After application of the weighting factors it is proposed to assign a score of 50 to the highest municipality BOD_5 x weighting factor value. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{B_{max} - B_f}{B_{max}} \right) \right] \times S_{max} \qquad (4.3)$$

Where , S_f is the score for Municipality "f"

B_{max} is the BOD_5 x weighting factor value, from the municipality with the highest value

B_f is the BOD_5 x weighting factor value of Municipality "f".

S_{max} is the maximum score as given to the municipality with B_{max}

4.2.2.1 Evaluation Score Calculation

After application of the weighting factors it is proposed to assign a score of 50 to the highest BOD_5 x weighting factor value for Nicosia Municipality. The scores for the other municipalities would be calculated from the following formula. In order to demonstrate the proposed selection criterium evaluation the results are given below for three different towns with similar total BOD_5 loads as shown in Table 4.4.

$B_{max-sew}$ = 11,522

$$S_{f,Famagusta} = \left[1 - \left(\frac{11522 - 6491}{11522} \right) \right] \times 50 = 28.2$$

$$S_{f,Kyrenia} = \left[1 - \left(\frac{11522 - 3421}{11522} \right) \right] \times 50 = 14.9$$

Table 4.4 Evaluation Score for Each Municipality

Item	**Nicosia Municipality**	**Famagusta Municipality**	**Kyrenia Municipality**
Population	36,834	23,295	12,917
Domestic Wastewater Flow (based on 170 l/s)	6,262 m^3/day	3,960 m^3/day	2,196 m^3/day
Domestic BOD_5 load 500 mg/l	3,131 kg	1,980 kg	1,098 kg
Total Industrial BOD_5 load, as calculated from individual industry flows and max.	650 mg/l	320 mg/l	260 mg/l
Regulation BOD_5 limits	4,070 kg	1,267 kg	571 kg
Total Domestic and Industrial BOD_5 load	7,201 kg	3,247 kg	1,669 kg
BOD_5 load discharge by treatment planet	2,880 kg	0 kg	0 kg
Weighted BOD_5 load (BOD_5 x1.0)	2,880	0	0
BOD_5 load discharge by on-site disposal – potential risk to groundwater	4,321 kg	3,247 kg	1502 kg
Weighted BOD_5 load (BOD_5 x2.0)	8,642	6,491	3004
BOD_5 load discharge by short sea outfall	0 kg	0 kg	167 kg
Weighted BOD_5 load (BOD_5 x2.5)	0	0	417
Total of weighted BOD_5 loads	11,522	6,491	3,421
Evaluation Score	**50**	**28.2**	**14.9**

4.3 Financial Sustainability

In accordance with the comments and suggestions for the Addendum to the Inception Report, the following is proposed for assessing the financial sustainability component.

4.3.1 Affordability of the Beneficiaries

The proposed scoring system for this indicator will rank the potential affordability criterium of beneficiaries to pay as measured by the average household incomes, by assigning the highest value of 10 to the municipality with highest average income. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{AI_{max} - AI_f}{AI_{max}} \right) \right] \times S_{max} \qquad (4.4)$$

Where , S_f is the score for Municipality “f”

AI_{max} is the average household income, from the municipality with the highest value

AI_f is the average household income of Municipality “f”.

S_{max} is the maximum score as given to the municipality with AI_{max}

However, inclusion of only the domestic user's affordability criteria poses a problem for those municipalities where the industrial sector is responsible for generating substantially larger proportion of wastewater flows compared with the domestic users. [2]

It is therefore recommended that an additional element should be included which takes into account the proportion of industrial wastewater with respect to the total municipal flows. It is proposed that a simple scoring system is used which allocates a highest score of 10 to the municipality with the largest proportion of industrial wastewater flows. The scores for the other municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{I_{max} - I_f}{I_{max}} \right) \right] \times S_{max} \qquad (4.5)$$

Where , S_f is the score for Municipality “f”

I_{max} is the percentage of wastewater flow as industrial component, from the municipality with the highest value

I_f is the percentage of wastewater flow as industrial component of Municipality “f”.

S_{max} is the maximum score as given to the municipality with I_{max}

The two separate scores can then be added to arrive at a total score for this indicator. It is envisaged that the two parameters are unlikely to contradict each other because the municipalities with higher concentration of industry would also be expected to offer greater employment opportunities and thus higher average incomes.

4.3.2 Willingness to Participate

A simple statement of desire to participate or a simply stated acceptance to make a contribution to investment costs may not be a sufficiently reliable indicator for a prioritization process. For example if a majority of the municipalities are willing to participate it would not be possible to objectively assign them different scores for the purposes of ranking. It is therefore suggested that in addition to willingness to participate on the part of the municipalities, their ability to make a financial contribution be also examined. This can be done by analyzing each municipality's annual accounting statements to assess their recent financial performance.

The present financial status of the municipalities can be assessed by an analysis of their revenue and expenditure statements and balance sheets for the last five fiscal years. These statements would be a good indicator of the financial performance of a municipality over a sufficient time period.

Annual surplus/deficit ratio is proposed as a suitable performance indicator to give a fairly clear picture of the ability of the individual municipalities to make a financial contribution.

Surplus/deficit ratio is the ratio of the surplus/deficit over total expenditure taken from the municipality final account figures for the financial year and expressed as percentage values. The surplus/deficit ratios will therefore show the ability of the municipality to manage the financial budgets with their current operations and highlight their ability to control financial contributions to any capital investments. It is therefore proposed that the scoring system allocates the highest value of 10 to the municipality with the highest surplus/deficit ratios.

Where revenue is greater than expenditure, this will give a positive surplus ratio and is ranked higher than negative deficit ratios where expenditure exceeds revenue. The scores for the municipalities would be calculated from the following formula:

$$S_f = \left[1 - \left(\frac{SDR_{max} - SDR_f}{SDR_{max} - SDR_{min}} \right) \right] \times S_{max} \qquad (4.6)$$

Where , S_f is the score for Municipality “f”

SDR_{max} is the average surplus/deficit ratio, from the municipality with the highest value

DR_f is the average surplus/deficit ratio of Municipality “f”.

SDR_{min} is the average surplus/deficit ratio, from the municipality with the lowest value

S_{max} is the maximum score as given to the municipality with SDR_{max}

It would then be possible to superimpose the stated willingness to participate on to this criterium to verify that those municipalities with the greater ability to contribute are also willing participants. [2]

4.3.3 Overall Evaluation Scores for Financial Sustainability

The overall evaluation score for financial sustainability is proposed as the sum of the scores for 4.3.1 and 4.3.2 above, for each municipality. This will give a maximum possible score of 30 points which must then be factored by 0.6667 to allow the maximum defined score of 20 points.

In order to demonstrate the proposed selection criterium evaluation the results are given below for three hypothetical municipalities with differing financial conditions in Table 4.6.

$AI_{max} = 460$ $

$$S_{f,Nicosia} = \left[1 - \left(\frac{460 - 430}{460} \right) \right] \times 10 = 9.3$$

$$S_{f,Famagusta} = \left[1 - \left(\frac{460 - 400}{460} \right) \right] \times 10 = 8.7$$

Calculation for finding percentage of total wastewater flow as industrial component for each city:

Total wastewater for all the cities at the year 2002 is equal to $80*10^6$ m^3 /year, and $P_{2002} = 214{,}646$

Wastewater average = 373 m^3 /year/capita

Total industrials wastewater for all the cities at the year 2002 is equal to $5.7*10^6$ m^3 /year, and $P_{2002} = 6647$

Industrials Wastewater average = 858 m^3 /year/capita

[9]

a) For Nicosia municipality

4498 workers * 858 = $3.86*10^6$ m^3 /year/capita

36834 persons * 373 = $13.74*10^6$ m^3 /year/capita

Percentage = 28 %

b) For Famagusta municipality

1132 workers * 858 = $0.971*10^6$ m^3 /year/capita

23295 persons * 373 = $8.69*10^6$ m^3 /year/capita

Percentage = 11 %

c) For Kyrenia municipality

653 workers * 858 = $0.56*10^6$ m^3 /year/capita

12917 persons * 373 = $4.82*10^6$ m^3 /year/capita

Percentage = 12 %

$I_{max} = 28\ \%$

$$S_{f,Famagusta} = \left[1 - \left(\frac{28 - 11}{28} \right) \right] \times 10 = 4$$

$$S_{f,Kyrenia} = \left[1 - \left(\frac{28 - 12}{28} \right) \right] \times 10 = 4.3$$

Calculations for finding the average surplus/deficit ratio over at least three years are listed in Table 4.5.

Table 4.5 Financial Proposal for Each Municipality in $ (Municipality Union)

Year	**Nicosia Municipality**		**Famagusta Municipality**		**Kyrenia Municipality**	
	Surplus $x10^2$	Deficit $x10^2$	Surplus $x10^2$	Deficit $x10^2$	Surplus $x10^2$	Deficit $x10^2$
1999	6,986	6,539	5,161	5,356	3,379	3,417
2000	8,019	7,364	6,534	6,752	3,772	3,675
2001	6,259	5,426	4,524	4,538	2,535	2,407
Ratio of surplus/deficit	**1.13**		**-0.98**		**0.38**	

$SDR_{max} = 1.13$, $SDR_{min} = -0.98$

$$S_{f,Famagusta} = \left[1 - \left(\frac{1.13 - (-0.98)}{1.13 - (-0.98)} \right) \right] \times 10 = 0$$

$$S_{f,Kyrenia} = \left[1 - \left(\frac{1.13 - 0.38}{1.13-(-0.98)} \right) \right] \times 10 = 6.5$$

Table 4.6 Financial Sustainability for Different Conditions

Item	**Nicosia Municipality**	**Famagusta Municipality**	**Kyrenia Municipality**
Average household income per month (in US $)	430	400	460
Ranking score (1-10)	9.3	8.7	10
%age of total wastewater flow as industrial component	28	11	12
Ranking score (1-10)	10	4	4.3
Average surplus/deficit ratio over last Three years	1.13	-0.98	0.38
Ranking score (1-10)	10	0	6.5
Willingness to participate by financial contribution to investment costs	Yes	Yes	Yes
Total of Ranking Scores	29.3	12.7	20.8
Evaluation Score (Total of Ranking scores x 0.6667)	19.5	8.5	13.9

4.4 Selection of Three Municipalities

The three selection criteria will be compounded into a single evaluation table for determination of the three municipalities most suitable for investment under this study. The Evaluation Scores shall be added and the highest scoring municipality shall be recommended as the priority areas for consideration under investment of this study. The final results are given in Table 4.7.

Table 4.7 Final score for Each Municipality

Criteria	**Nicosia Municipality Scores**	**Famagusta Municipality Scores**	**Kyrenia Municipality Scores**
Level of Sanitation Services	21	30	18.8
Environmental and Public Health Impacts	50	28.2	14.9
Financial Sustainability	19.5	8.5	13.9
Total Score	90.5	66.7	47.6

From this hypothetical example Nicosia Municipality would be considered most suitable for investment under this selection process, because it has the highest scores number [2].

CONCLUSIONS

It has been long time taken for this study of Water supply and Sewerage investment for three municipalities out of 28 in North Cyprus, and this three municipalities has been chosen upon their population and its higher percentages with the total of 65% from the total population of the 28 municipalities. All chosen municipalities demonstrated a need of investment in wastewater collection, treatment and disposal facilities.

The selection process has been done depend on EU and Turkish standards with population projection method. The best data available were collected for the evaluations and entered into the agreed process. The selection process shows that the three municipalities whose wastewater has the greatest impact on public health and the environment, also the three municipalities results after using the standard, and its found all of them needs investment, but Nicosia municipality should be the first.

None of the existing municipal wastewater treatment and disposal would satisfy the requirements of the Turkish Aquatics Products Regulations 1971 or the EU Urban Waste Water Treatment Directive 1991, and all municipalities demonstrated a commitment to improve their facilities.

Presently the municipalities do not appear to exercise any control or monitoring of industrial wastewater treatment and discharge practices. That responsibility lies with the local environmental administrations. It is reported that enforcement of the wastewater discharge regulations is not effect and that in many cases industrial wastewater is being discharged without treatment and health control.

Maintenance of the sewerage facilities is generally poor and some treatment facilities are bypassed for long periods of time when repairs are required. It is sometimes the case that availability of funds may depend on other factors, beyond the control of municipality.

The existing treatment works are designed to provide for preliminary coarse screening and grit removal only, before discharge to the sea through along sea outfall such case of Kyrenia municipality. The treatment works are to be located on the coast, close to residential development and open to the atmosphere.

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LIST OF MAPS IN APPENDIX A

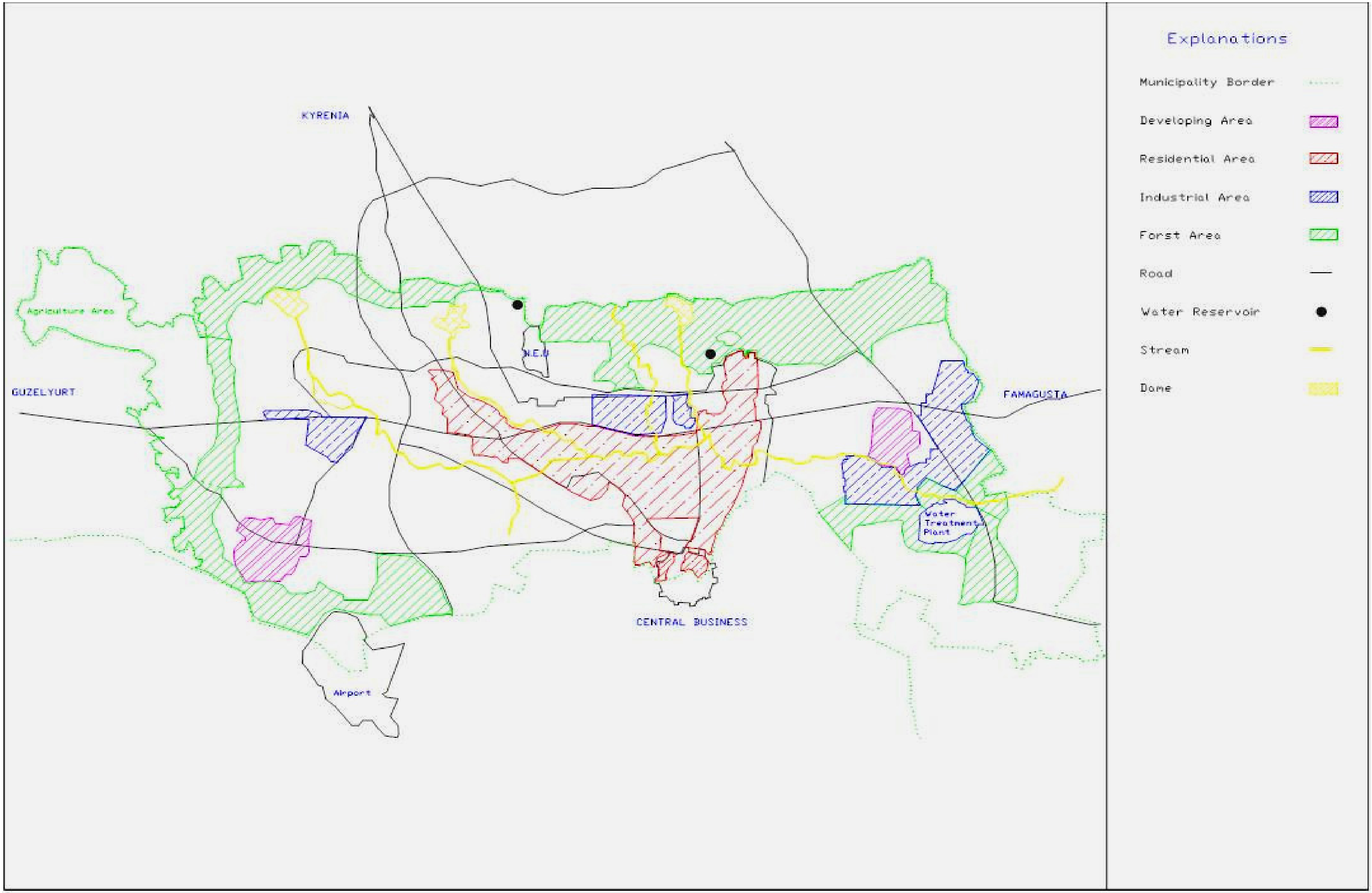

Figure 3.1 Water Supply and Sewerage Study for Nicosia Municipality (46a)

LIST OF MAPS IN APPENDIX A

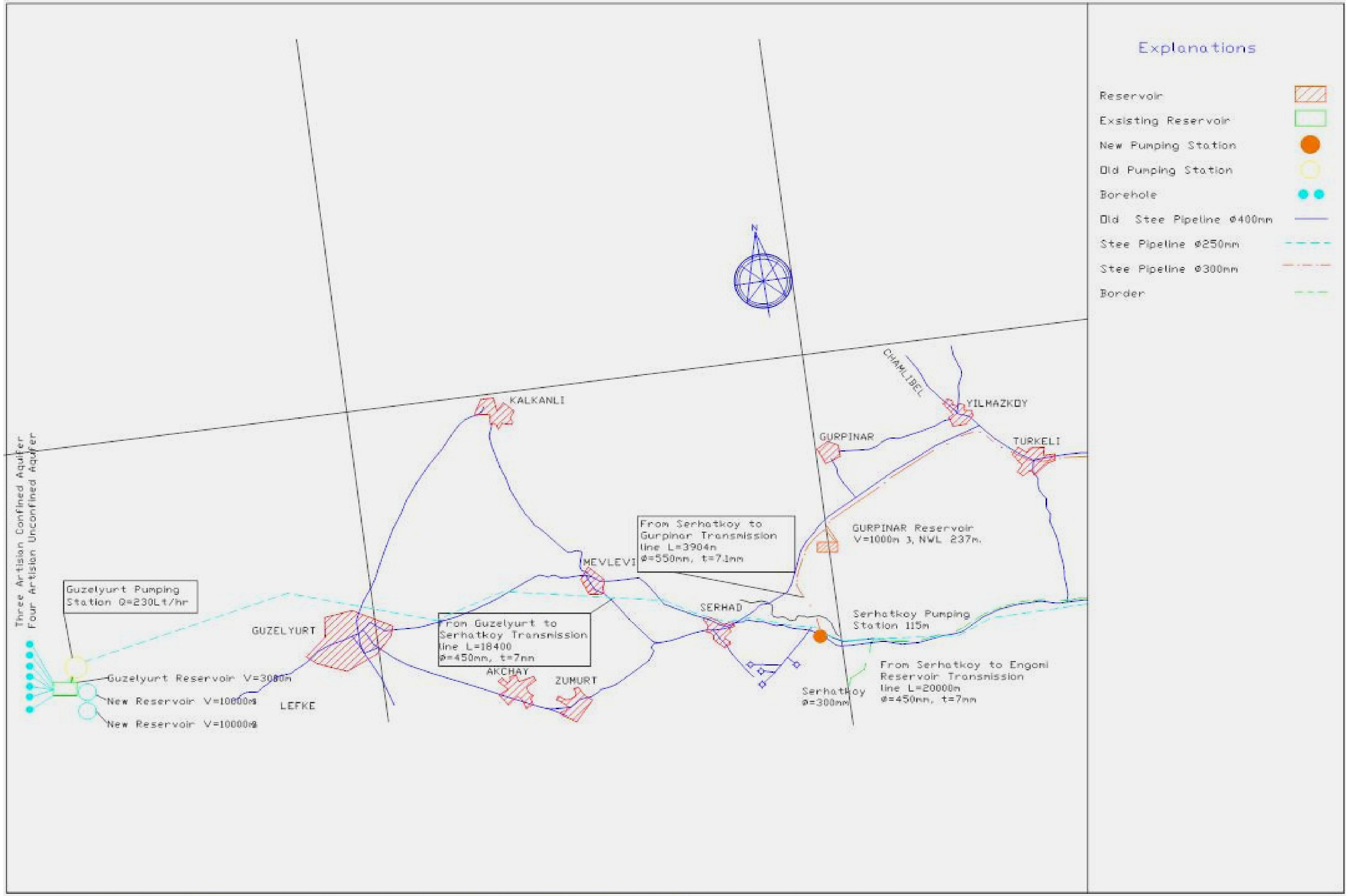

Figure 3.2a Nicosia_Famagusta Fresh Water Transmission Line (52a)

LIST OF MAPS IN APPENDIX A

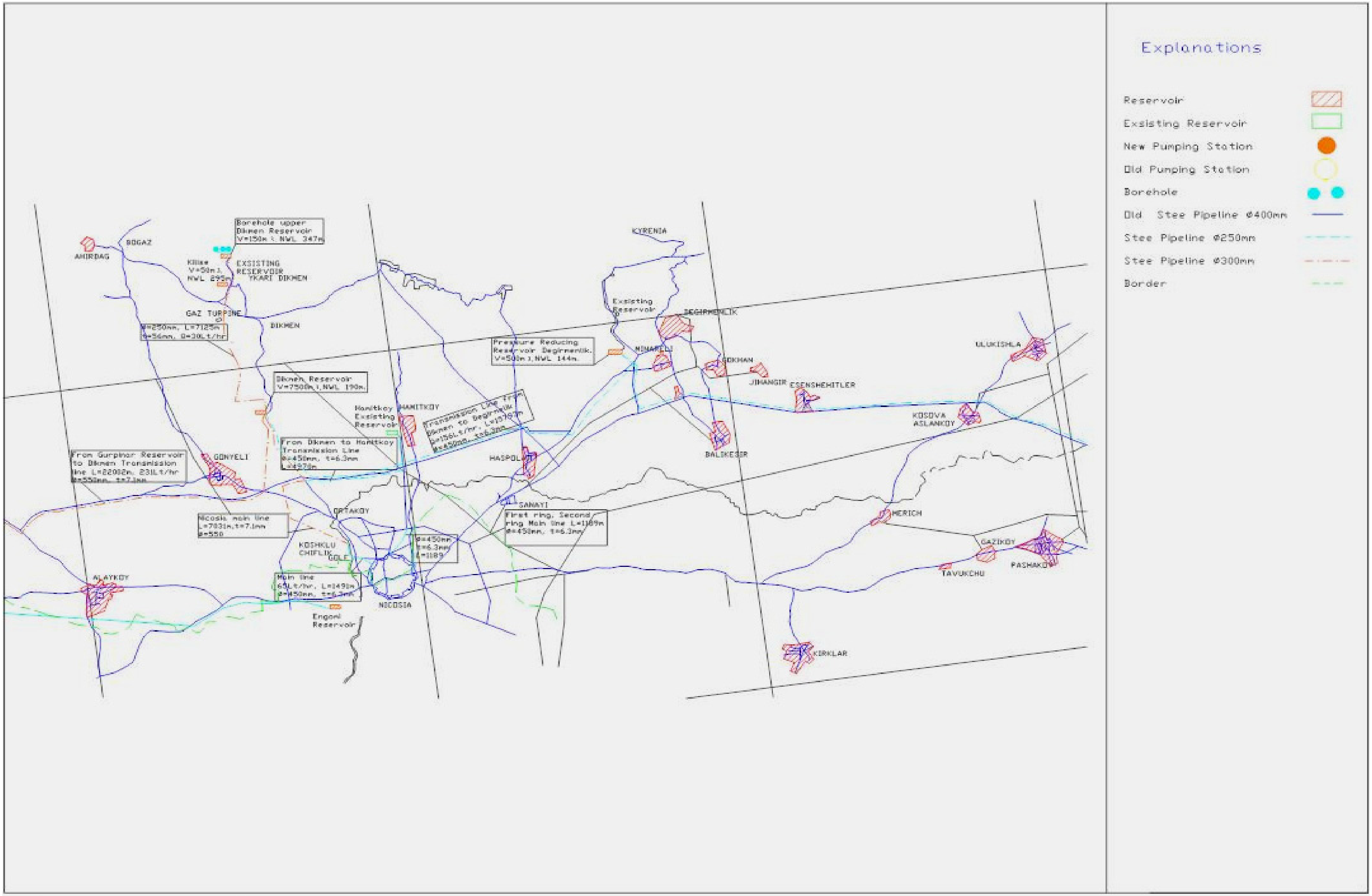

Figure 3.2b Nicosia_Famagusta Fresh Water Transmission Line (52b)

LIST OF MAPS IN APPENDIX A

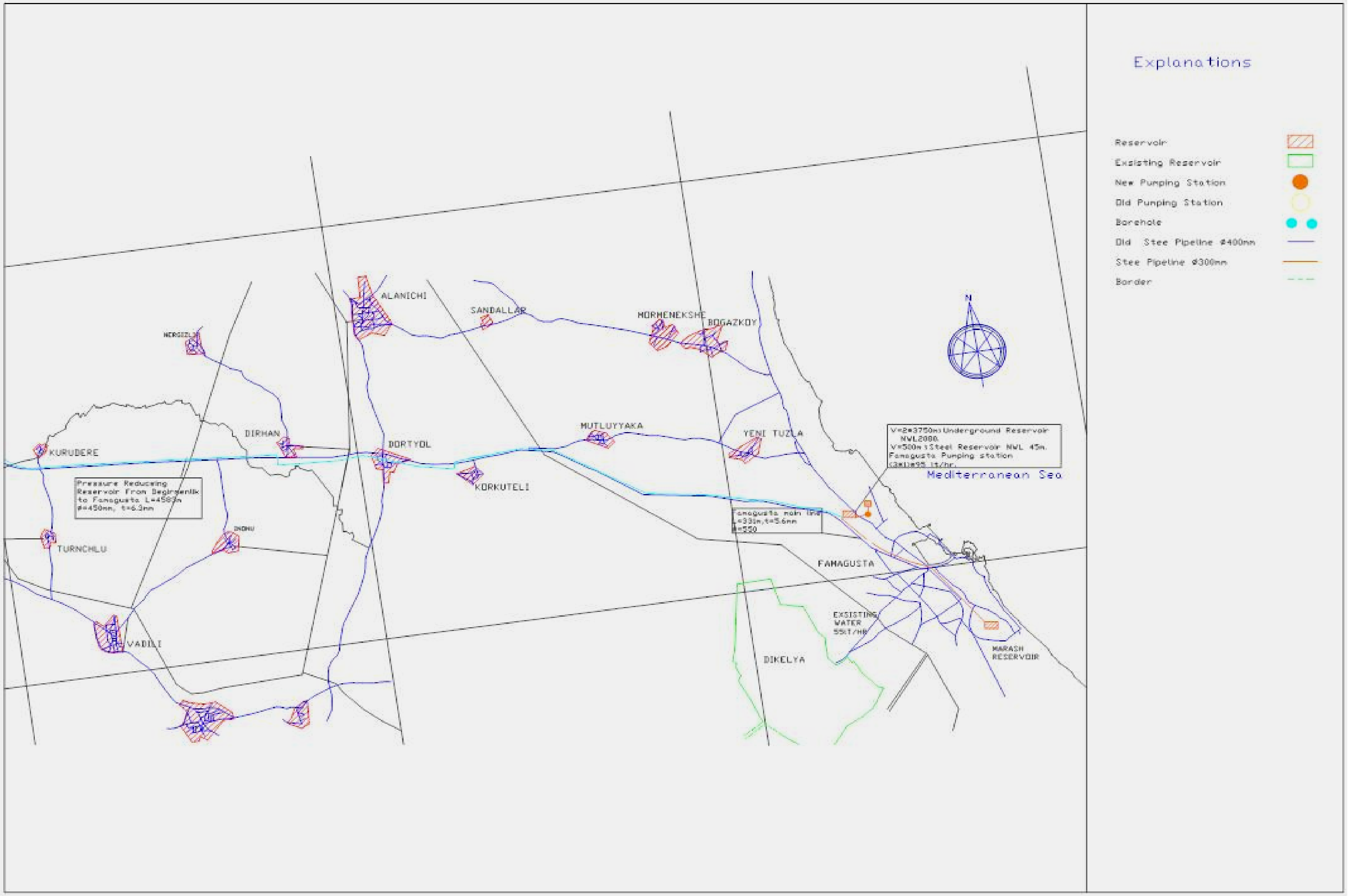

Figure 3.2c Nicosia_Famagusta Fresh Water Transmission Line (52c)

LIST OF MAPS IN APPENDIX A

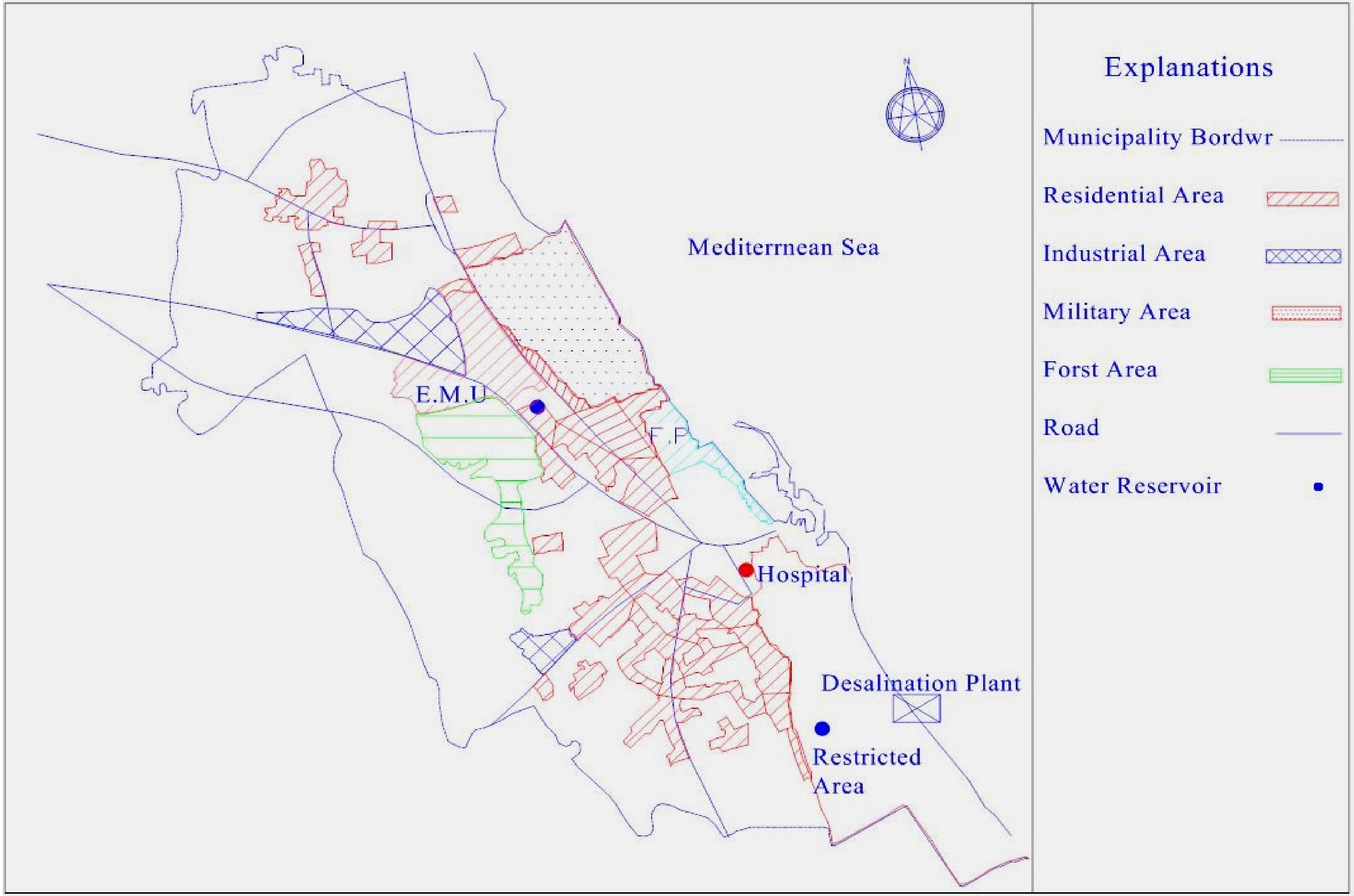

Figure 3.3 Water Supply and Sewerage Study for Famagusta Municipality (59a)

LIST OF MAPS IN APPENDIX A

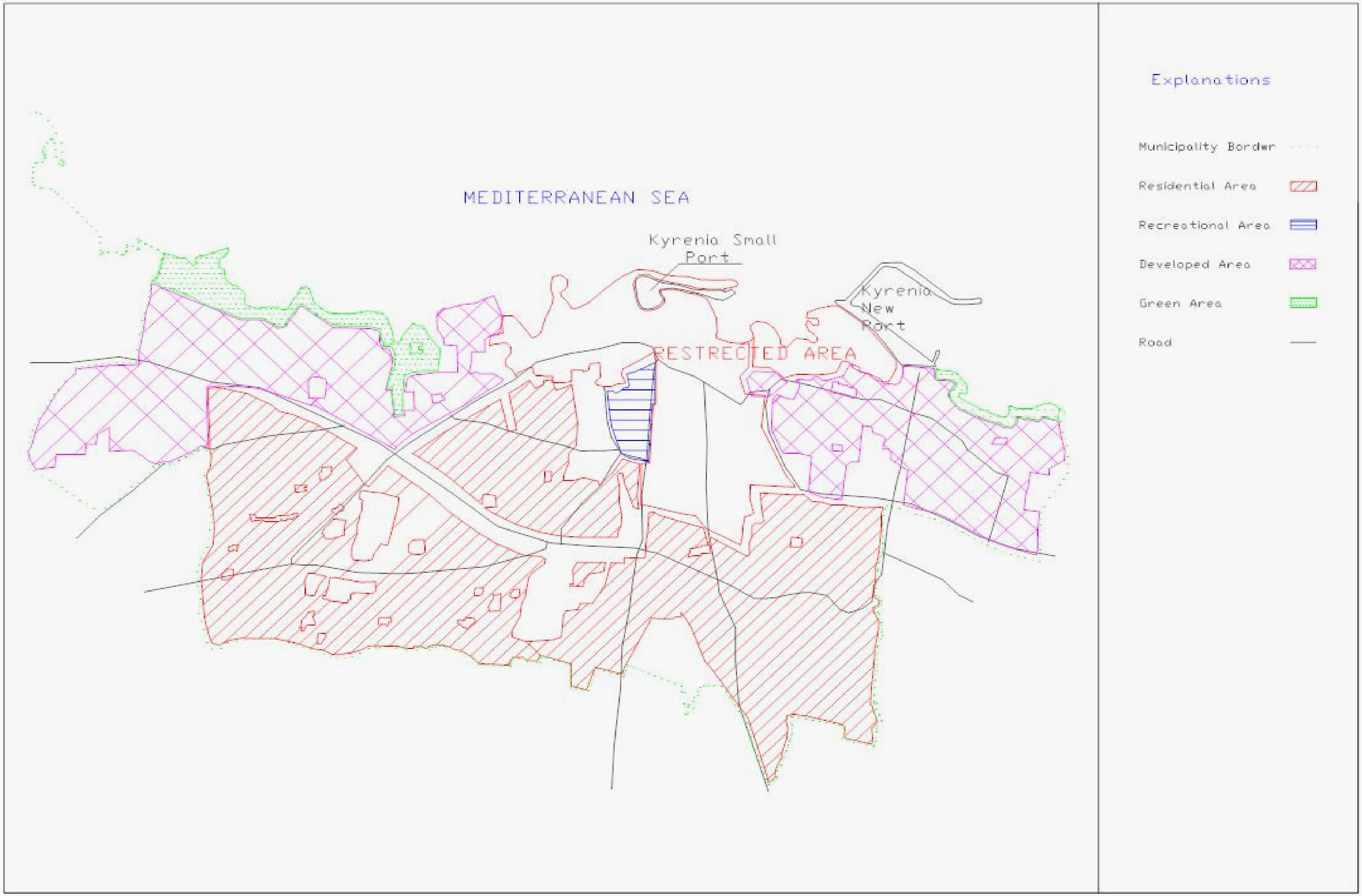

Figure 3.4 Water Supply and Sewerage Study for Kyrenia Municipality 70a