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**UNIVERSITY EDUCATION, TRAINING AND RESEARCH
IN WATER AND WASTE-WATER ENGINEERING
IN THE CONTEXT OF CYPRUS**

By

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A Master's Thesis

Submitted in partial fulfilment of the requirements for the award of

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ABSTRACT

Human resources development (education at university level and training) linked to parallel research activity is one of the inputs and the key to develop and sustain water and sanitation provision. The specific objectives of this work are:

- (a) to consider the background context globally and for the case of Cyprus;
- (b) to find out what is the current potential in Cyprus, that is achievements so far in education, training and research (at university or as part of employment) in the sector of water and waste-water engineering at both the individual and the organisation levels;
- (c) to find out about the current university courses and research in the sector in various countries and also about training organisations;
- (d) to identify the educational, training and research needs and future plans for Cyprus and Cypriot water and waste-water engineers so as to benefit the country and the people of Cyprus (bearing in mind what the local characteristics, problems and needs are);
- (e) to develop guidelines and consider possibilities of how to fulfil needs for Cyprus, either in Cyprus or abroad;
- (f) to consider wider application of the results in other countries; and
- (g) to recommend further enquiries.

The main research methods employed were: literature survey, surveys (questionnaires), personal communication and case studies.

The research has shown that the international trend is for an increase in the number of courses in the sector. It was found out that some changes in university curricula are needed since gaps were identified by Cypriot professionals. As concerns Cyprus, part-time studies is a recent trend. Two-thirds of professionals are willing to follow postgraduate courses (almost all by part-time or distance learning mode); two-thirds of them are prepared to follow them in Cyprus (if offered). As concerns continuing education, there are good prospects and the majority prefers short courses. There is a trend for greater interest in research work in the future but problems of sponsorship, motives and time were identified. Performing research for firms is a field to consider in the future.

Opportunities overseas include full-time/part-time studies, and customised programmes for Cypriots. The needs can be fulfilled in Cyprus by local institutions and through overseas institutions (whilst in Cyprus) by part-time, distance learning, and transfer of programmes. One possibility could be joint courses with EU Universities. Various useful modern techniques are available.

Keywords: Human resources development (university level education; training) and research in water and waste-water engineering; background context globally; potential, needs, plans and recommendations for the case of Cyprus.

1

CHAPTER ONE

INTRODUCTION

1.1 HYPOTHESES

The purpose of this introductory section is to set the context of this investigation.

The overall aim is to provide sufficient quantities of water of adequate quality to satisfy the needs of all the people in the world and at the same time provide adequate sanitation managing the waste-water. Why is water and sanitation needed? Why is the goal justified? Providing water and sanitation services is a very important and cost-effective activity to undertake to improve people's health and raise productivity. Clean water is an absolute prerequisite for healthy living. There is a cost of water-related diseases, both in terms of human suffering and healthcare costs (WHO, 1997a). Two of the major causes of mortality and morbidity in the 'developing' (or less industrialised) countries are unsafe water supplies and the absence of appropriate means of handling and disposal of human excreta (WHO, 1996). About half of the population of less industrialised countries suffers from diseases that are related to lack of water (Politis, 1999). The poor – especially infants and young children – in rural areas, rapidly expanding urban slums, and squatter settlements suffer most from these inadequate services and from the misery and death resulting from diarrhoeal disease. The ultimate goal of universal coverage of water supply and sanitation services is a prerequisite to the attainment of the primary health care approach to Health for ALL (WHO, 1996). If liquid wastes are not adequately collected, treated and/or disposed of, damage to the aquatic environment and to water resources may ensue (WHO, 1997a). Time and energy is spent to carry water over long distances. Women bear the brunt of the labour associated with inadequate services, that is carrying the water required for family and household needs over long and often arduous distances (WHO, 1996). Every year 771 million Africans need 40 billion hours for their movements that will secure drinking water (Politis, 1999). Water and sanitation inadequacies also hinder economic and social development, constitute a major impediment to poverty alleviation, and inevitably lead to environmental degradation (WHO, 1996). In many regions, freshwater scarcity is increasing and leading to severe ecological degradation, which in turn is limiting agricultural and industrial production, threatening human health, and increasing the potential for international conflict over water resources (WHO, 1997a).

The dimensions of the problem of provision of water supply and sanitation and also the constraints on solutions and the available alternatives are detailed in section 2.1 on page 7. Dealing with the problem involves various disciplines that are inter-related. The

considerations required and the inputs needed involve political, legislative, institutional, economic, financial, technical, sociocultural, environmental and educational / human resources development aspects. The approaches, strategies and policy measures (see section 2.1) are inter-related.

To develop and sustain water and sanitation provision requires good/appropriate technical knowledge, management and planning linked to knowledge of human and physical resources. Human resources development, that is education and training, linked to parallel research activity is key to achieve this. Human resources development is needed in all countries. Many skills need integration. All actors in the water and sanitation sector require, in addition to skills in their own specific discipline, knowledge of or some skill in other related/relevant/necessary disciplines, such as social, technical and financial ones.

This investigation focuses on education. Investment in human potential is both a moral imperative and sound economics. Education is a good investment both for the individuals concerned and for society as a whole. In other words, both the private and social rates of return indicate that university education is likely to be a sensible use of scarce resources (Demetriades, *et al.*, 1995). Greater priority should be assigned to human resources (and institutional) development to increase the capacity to absorb investments. Properly trained technical and administrative personnel and strengthened local and centralised institutions are required. Training at all levels should be relevant to actual needs. There should be greater collaboration between technologists and community development and health education officers. The education offered should be based on certain values. The engineers and other professionals should adopt right / appropriate, not necessarily high or low, technologies in individual contexts that will be compatible with social, economic, cultural and environmental conditions and at the same time exploring the feasibility of utilising local skills and materials. Thus, the selection depends on the local context: in some places it may be high technology/cost, in others low, and in others a mixture.

The specific concern of this study is human resources development (education at university level and training) and research in the sector of water and waste-water engineering for professional (that is, university graduates) scientists and (primarily) engineers.

The hypothesis is that against a background of increasing demands on water supply, the current training and education infrastructure in Cyprus is insufficient to allow effective management of water resources in a sustainable manner. The level of the professionals should improve so as to close the gap of needs in education, training and research in the sector in Cyprus.

In light of the discussion above, the aim of the research is to identify the requirements for and ways to provide human resources development and research in various countries in the field of water and waste-water engineering so that they can develop and sustain their water and sanitation provision. Cyprus is the major example and case study of this investigation.

The specific basic objectives of this research study are.

- (a) One objective is to consider global needs, strategies and actions for education, training and research in engineering at university level (primarily) in the sector, as well as the global position in water and waste-water.
- (b) Another objective is to set the background for the case of Cyprus: general characteristics and needs of the country; the water and waste-water situation; and the human resources development and research activities in general (not in the sector of water and waste-water) in Cyprus and of Cypriots.
- (c) A third objective is to find out what is the current potential of human resources working in Cyprus, that is, achievements so far in education, training and research in Water and Waste-water Engineering. This will be investigated both at the individual level and the organisation/authority level. Research achievements will be examined both at university or as part of employment. Emphasis will be given on research work related to the characteristics and needs of Cyprus.
- (d) A fourth objective is to find out about the current university courses and research in water and waste-water engineering in various countries and also about training organisations.
- (e) A fifth objective is to identify the educational, training and research needs and future plans for Cyprus and Cypriot water and waste-water engineers both at the individual and the organisation levels. The overriding aim is improvement. The goal is to benefit the country and the people of Cyprus, bearing in mind what the local characteristics, problems and needs are and at the same time considering global experiences and trends.
- (f) The last but most ambitious objective is to develop guidelines of how to fulfil needs for Cyprus, either in Cyprus or abroad for the context of Cyprus; to consider wider application of the results of the study, that is in other areas; and to recommend further enquiries.

If various aims/hypotheses are classified, then the overriding aim is to suggest ways to improve the quality of human resources and the research potential of Cyprus and other areas of the world in the sector, and consequently improve the water and waste-water situation and systems in ways that they are sustainable. Sub-hypotheses are the details. For

example, the author could develop appropriate courses or suggest training provisions in Cyprus itself as well. However, a wealth of experiences and opinions of different/other people is required before suggestions are made.

This study is original and is a contribution to new knowledge in the sense that no other similar study has been carried out for the case of Cyprus. Moreover, there is no university level education in water and waste-water engineering offered in Cyprus itself at the moment.

After considering the conceptual analysis (section 1.3 on page 5) and the background context (Chapter 2), the “strategy” of the author to research the “hypotheses” of this section will be analysed in section 2.6 on page 46.

1.2 STRUCTURE OF THESIS

In this chapter the context of the investigation is set. The overriding hypotheses and the sub-hypotheses are defined. The researcher will attempt to verify or refute these in the light of the investigation. The conceptual framework follows. Also, a Glossary has been included on page 156.

Chapter 2 deals with the background context. Firstly, the global position in water and waste-water as far as dimensions of the problem, constraints on solutions and available alternatives is analysed. Then, global needs, strategies and actions for education, training, research and development are considered for Engineering, Civil Engineering, Environmental Engineering and Water and Waste-Water Engineering and in particular for the university curriculum. The sections that follow deal with the case of Cyprus. The water and waste-water situation, including general characteristics and needs, in Cyprus is discussed. Human resources development and the research and development activities in general (not in the sector of water and waste-water) in Cyprus and of Cypriots is described. In the end, the researcher’s strategy of the investigation is finalised.

Chapter 3, the methodology of the research, provides the means to specifically address the hypotheses that were defined. The subject of educational research is introduced. The methodologies used include literature survey, questionnaires for individuals and organisations, personal communication and interviews, and case studies. The questionnaires and standard letters are given in Appendices.

The potential (or achievements so far) of human resources in education, training and research in the sector of water and waste-water engineering in Cyprus is outlined in Chapter 4. The academic qualifications, academic research (if especially this work is related to the characteristics and needs of Cyprus), training, employment and research as part of it, and co-operation with foreign experts for individual professionals are given. The potential of several organisations in the sector is also reported: governmental; semi-

governmental; the private sector; professional associations; multigovernmental; foreign institutions in Cyprus; and training organisations abroad.

Current university courses and research in water and waste-water engineering in several countries are examined in Chapter 5. These countries are Cyprus, the UK, the USA, Canada, Australia, Singapore and Malaysia. A database of the courses is presented in Appendix D on page 195.

The needs and future plans for Cyprus and Cypriot water and waste-water engineers is the subject of Chapter 6. The needs and plans of individual professionals are identified for university education; for short courses, seminars and workshops; and for both academic research and research as part of employment. This matter is also considered for governmental organisations. The characteristics, problems and needs of Cyprus in water and waste-water systems, as identified by workers in the field, are examined.

Chapter 7 includes discussions and the recommendations of the author. A general discussion is the initial part of this final chapter. The limitations and difficulties in carrying out this study are explained. Fulfilling needs for Cyprus involves the relationship of global provision and trends to the needs of Cyprus; studying, training, and researching overseas; guidelines for developing courses and research in Cyprus; and considering possibilities in Cyprus or whilst in Cyprus. Wider application of the results of the study is examined and discussed. Ideas and recommendations for further enquiry are offered.

A summary is provided at the end of each Chapter.

1.3 CONCEPTS

The conceptual framework selected depends on the theoretical base adopted for the research design. The work reflects concepts from the research field. The conceptual framework is related to the methods adopted.

An analysis of the terms ‘engineering’, ‘civil engineering’, ‘environmental engineering’, ‘water supply and water engineering’, ‘waste-water engineering’, ‘curriculum and syllabuses’, ‘training’, ‘research’, ‘sustainability’ and others is needed. The aim is to define these concepts so as to know how to treat them in collecting and analysing information useful for the project. The definitions are in the Glossary.

1.4 SUMMARY

The subjects of this introductory chapter are: the hypothesis of this investigation; the structure of this Thesis; and definitions of the basic concepts or key words this research study deals with.

The overall target is the provision of water and sanitation and the sustainability of the systems involved. Justification of this goal is provided in this chapter. The reasons for justification are endless. Quantifying as many benefits of improved water supply and

sanitation as possible will influence decision-making, thus, re-ordering priorities. One of the inputs in providing water and waste-water systems is education, training and research. This is the input this study focuses on. The importance of education is stressed. The basic objectives of this research work are: (a) to consider global experiences, requirements, strategies and actions for human resources development and research in the sector of water and waste-water; (b) to investigate the current potential as well as the needs and future plans for Cyprus and for professionals working in Cyprus in education, training and research in the sector of water and waste-water engineering; (c) to examine current university courses and research in the sector world-wide; (d) to consider ways of how to fulfil needs for the context of Cyprus; and (e) to consider wider application of the results of the study in other countries. In the end, further enquiries could be recommended.

CHAPTER TWO

THE BACKGROUND CONTEXT

2.1 GLOBAL POSITION IN WATER AND WASTE-WATER

2.1.1 Importance

The importance of providing adequate water and sanitation was pointed out in section 1.1 on page 1. It is important in various respects. Freshwater may well be the oil of the early 21st century - an essential and increasingly scarce resource. Where water is not only scarce but also shared by more than one region or state, competition for limited supplies is a likely source of conflict, particularly in the Middle East (World Bank, 1997a).

Water of insufficient quality, quantity and accessibility, and inadequate sanitation gravely affect human health and productivity and severely impede development progress. Water-related diseases are responsible for 5 to 7 million deaths of people annually. Half of the developing world population suffers from a water-related disease at any time (World Committee for Water in the 21st Century, 1999). Without sufficient water reserves, food production will also be in danger.

2.1.2 Water sources and availability

By far the greatest part (97.4%) of the water on earth is salt water in oceans and seas. 1.8% is frozen fresh water which is locked in ice caps and glaciers. Fresh water, needed by human beings to sustain life, health and productive activities, constitutes only 0.8% of the world's supply but a portion of it is contaminated. The freshwater resources of the world were 8641 cubic metres per capita in 1995 (World Bank, 1997a). The total amount of world water is constant and is a renewable resource. But the traditional sources of water supply, surface runoff and groundwater stores, are inequitably distributed among people and countries.

Available alternative water sources to surface water, groundwater, and springs are waste water reuse, desalination, rainwater harvesting, artificial recharge, and cloud-seeding.

2.1.3 Water use

As the water use indicators show (World Bank, 1997a), in most countries agriculture consumes the lion's share (60-80 per cent in most countries and as much as 90 percent in some). Other major uses are domestic, industrial and commercial.

Water demand has increased five-fold over the last fifty years in Europe and seven-fold during the 20th century in the whole world (International Institution for Water Management, 1999). Water use figures differ significantly in terms of continent, region, country and area, and type of use. The per capita water use in 1000 x m³ by continent for

1995 were: North America 1.46, Europe 0.62, Oceania 0.57, Asia (1987 data) 0.53, South America 0.33, and Africa 0.19 (WHO, 1997a).

2.1.4 Dimensions of the problem

In 1980, over half the peoples of the Third World did not have safe water to drink and three quarters had no sanitation (WHO, 1980). In 1997, 71% of the population (urban 89% and rural 61%) had access to safe water, and 40% (urban 75% and rural 22%) had access to adequate sanitation (UNICEF, 1997). Today, nearly 500 million people in 29 countries suffer because of lack of water, whilst 1.5 billion people (nearly one-quarter of the planet's population) have no access to safe water. The problem will become worse in the 21st century if there is no change. In the year 2025, it is estimated that one billion people in 48 countries will face lack of water and in the year 2050, nearly 2,5 billion people in 55 countries will face lack of water directly. These figures were estimated by the organisation "Population Action International" (World Committee for Water in the 21st Century, 1999). The International Institution of Water Management (1999) which is based in USA is even more pessimistic: they predict that the decrease of world water reserves will affect one-third of the population in the next 25 years.

It must be pointed out that there is imbalance between urban and rural coverage and between water and sanitation (see UNICEF statistics above). There are also regional variations. Coverage in Asia and the Americas is better than in Africa. The percentage water coverage in 1994 was 88 in Western Asia, 80 in Asia and the Pacific, 79 in Latin America and the Caribbean, and 46 in Africa. The percentage sanitation coverage in 1994 was 68 in Western Asia, 63 in Latin America and the Caribbean, 34 in Africa, and 29 in Asia and the Pacific (WHO, 1996). Wide variation occurs within countries too. Statistics should be treated with caution. One reason is that definitions of "access to safe water" and "access to sanitation" may not be standard. Moreover, statistics really only tell us the numbers of people who are supposed to have this water and sanitation; supplies may be intermittent or systems out of order. Unaccounted for water is a major water supply problem. In many large developing country cities it has been reported as amounting to more than 50% of supplies (WHO, 1997a).

2.1.5 Strategies

The United Nations General Assembly launched the "International Drinking Water Supply and Sanitation Decade" for the 1980s in November 1980. The "Decade" created an awareness of the problems and the strategies required to overcome them. Some useful lessons were learnt. Over-generalisation about how to solve problems is likely to lead to failure. Each local situation is unique. An awareness of the variation in humanity's way of

life, the availability of natural and human resources is a prerequisite to fulfilling the goals. Nowadays, the keyword is sustainability (see the Glossary on page 159).

The author was involved in research in water and sanitation in developing countries in the 1980s (Michaelides, 1982 and Michaelides, 1986). Based on his conclusions obtained from those studies the major policy measures concerned the need for: water supply and sanitation programmes to be accompanied by complementary health education; maximum community participation (people applying strategies; devolving down to community); assigning greater priority to human resources and institutional development; increasing emphasis on services for underserved rural and urban fringe populations; adopting appropriate technologies; redesigning programmes to reduce the per capita cost; integrating water and sanitation programmes with other development projects; assuring higher priority to public information programmes; and exploring new sources of financing. These measures revealed the constraints. Other constraints included the population growth; population distribution (globally, according to the World Committee for Water in the 21st Century (1999), two-thirds of the people live in areas that receive one-quarter of the rainfall); the difficult questions of national priorities raised; and tied aid. Some of the policy measures required indicated priorities. As concerns technology, greater resources should be allocated to operation and maintenance, to sanitation programmes that will yield usable fuel, manure or water, and to accessibility of water supply. Recently, strategies by WHO and UNICEF (WHO, 1996) advocate that adequate planning is essential for the implementation of effective programmes to expand water supply and sanitation services to the unserved. The UN organisations believe that the question is not only one of providing facilities, although it is of prime concern in the first instance, but also of sustaining them through adequate provision for operation and maintenance of systems, and ensuring their proper utilization through adequate health and hygiene education. PHAST is an innovative approach (WHO, 1997b) that promotes hygiene, sanitation and community management of water and sanitation facilities. A recently founded Committee that carries out research on the world water reserves (World Committee for Water in the 21st Century, 1999) proposed certain possibilities: desalination to become economically attractive; better methods of identifying the large quantities of unexploited ground water; to increase the use of recycled water; technology to convey water over long distances should be developed; and edible plants that use less water should be developed. Environmental changes and effects (for example changes in climate) should be considered.

2.1.6 Education

Education is one of the inputs needed to achieve the goals. It cannot stand alone, but its contribution is significant. This research work concentrates on education (at

university level), training and research. The right (academic and numerical) level of engineers and managers and the right subject of research is sought. Training is important. [In the majority of the poorer countries, efforts are needed to increase the capacity to absorb investments and to maintain systems.]

Education, training and research in water and waste-water engineering is the subject of this Thesis. In the section that follows, the global needs, strategies and actions for education, training, research and development are discussed so as to give the background context.

2.2 GLOBAL NEEDS, STRATEGIES AND ACTIONS FOR EDUCATION, TRAINING, RESEARCH AND DEVELOPMENT

Some of the basic terms used in this section are explained in the Glossary. These are: curriculum and syllabuses, engineering, civil engineering, environmental engineering, water engineering, waste-water engineering, training, research, and sustainability.

2.2.1 University Curriculum

Curriculum in general is discussed together with aspects of curriculum planning, syllabuses, curriculum design and development, and curriculum evaluation, with particular reference to defining terms.

Curriculum is a term which is used with several meanings and a number of different definitions have been offered. Curriculum is simplistically (Taylor and Richards, 1987) what an educational institution is for. A more explicit definition by Taylor and Richards (1987) is that the curriculum is the sum total of the activities planned by the educational institution with the aim to promote learning. These activities may take place both inside and outside the classroom or laboratory or workshop. Kelly (1988) concludes that the most useful kind of definition we can adopt is one which is loose enough and broad enough to embrace all the learning that goes on in an educational institution and all dimensions of the educational process. Taylor and Richards (1987) offer a list of the terms that have been used to mean the curriculum: content of education; course of study; educational experiences; subjects to be studied; subject matter; and educational activities. None of the terms used to mean the curriculum is necessarily preferable to another; very much depends on the content to which reference is being made.

According to Kelly (1988) we must distinguish in our curriculum planning what we are hoping to achieve, the ground we are planning to cover in order to achieve it, the kinds of activity and methods that we consider likely to be most effective in helping us towards our goals and the devices we will use to evaluate what we have done. This is essentially what this study is doing.

As concerns the syllabus, it could be argued that there are actually three syllabuses, not one. There is the one that forms the list of topics to be examined, the one that the teacher presents and thirdly the one that the student learns. Sutton (1993) supports the view that these are progressively less and less: that is, what the student learns is less than what the teacher presents and that is less than what the printed syllabus contains. This may not, however, always be the case.

The planning and creation of alternative curricula is what curriculum development is about. The author believes that development in education can be conceptualised as a process to move on. Curriculum development must be a continuing process of evolution and planning. Knowledge continues to develop; society evolves; people change; and the curriculum must keep pace with all of these. Curriculum does not develop in a vacuum but proceeds on the basis of beliefs - seldom made explicit - about how people learn, what human beings should be like, and what society is (Hooper, 1971). Is there a need for development? A precondition for curriculum development is the awareness of such a need. First a need is identified. It may be seen as an anticipated change. No educator should be working in precisely the same way as he or she did ten years ago. It should be ensured that there is continual but gradual change and development (Dean, 1987) in curriculum and of staff.

Development can be initiated from the educational institution itself or focused on the educational institution even if the initiative springs from outside. Development can take place on or off site and be provided internally or externally. Curriculum development involves people, groups, roles, interrelationships, values, established institutional practices and customs as well as the distribution of resources (Skilbeck, 1984). The main concern must be that teachers and all others who are involved in curriculum planning should be aware of all the factors involved (Kelly, 1988). Change agents are needed for development. These are the teachers, the employers and the demand from the students. The role of the teacher is central in curriculum planning and development. Two categories of teachers, as regards the awareness of the need for change, should be considered (Kelly, 1988): the 'restricted', that is the one who achieves certain objectives, and the 'extended' that is the one who interprets and moves beyond what is required in objectives. It seems reasonable to suppose that curriculum development will be strongly influenced by the extent to which the head and senior staff encourage it.

Different kinds of curriculum evaluation, that is how good is the curriculum, can be identified: monitoring, student assessment, staff appraisal, review of policy, performance and procedures. Development acquires more importance if one considers tendencies

towards greater examination of educational institutions, professional accountability, professional development and small-scale curriculum development.

It would be very helpful when discussing curriculum problems to look at solutions to them as were adopted in various countries (Nicholas, 1983) and various educational sectors.

A simple model of curriculum by Kerr (1971) includes four components: objectives, knowledge, learning experiences and evaluation. The model does not give guidance as to choice of objectives, content, and so on. To achieve this, some sort of curriculum theory is required. Two approaches to the building of curriculum theory were discussed in Kerr - one deductive, one inductive. Kerr went on to apply an operational model for the curriculum to the immediate problems of the educational institution.

Commonly, curriculum discussion in universities, and other institutions is about the content of syllabuses and methods of teaching. The really important questions are about objectives and this component of the curriculum is the logical starting point. For the purposes of curriculum design and planning, it is imperative that the objectives should be identified first, as we cannot, or should not decide 'what' or 'how' to teach in any situation (Ayres, 1996) until we know 'why' we are doing it. The objectives are derived from a needs analysis. Goals and broad targets are needed.

2.2.2 Engineering

According to the World Bank (1997a), rapid progress in science and technology is changing the global economy and increasing the importance of knowledge as a factor of production.

To become a fully qualified Chartered Engineer, it is necessary to acquire appropriate education, training and experience. It is the role of the University to provide the specific education and some of the training, as well as increasing the general knowledge, judgement and sensitivity of its students. According to the Engineering Council of the UK, Chartered Engineers are concerned with the progress of technology through innovation, creativity and change. The Engineering Council is the body that sets overall standards for British engineering qualifications. It monitors and maintains standards in education and training through professional Institutions, some of which are authorised to accredit degrees. Accredited degrees automatically satisfy the education element of the formation of a Chartered Engineer. After graduating with a BEng degree, further training and experience are required. Overall the formation of a professional engineer in the UK takes at least five years, of which only part is spent at University. Since 1997 all courses in the UK have to be accredited against the requirements of SARTOR (Standards and Routes to Registration) 3rd edition (Engineering Council, 1997).

Nominated bodies of the Engineering Council may be licensed by the Council to accredit programmes of education and initial professional development (Goy, 1998).

The Engineering Council of the UK suggested changes in courses for engineers (Marsh, 1997). It is expected to set minimum standards for the first time. The length of many courses will increase by a year. The average length now is between two and three years. Engineers are to be given a more rounded education at university, taking in communication and management skills. Earlier, a discussion document (Engineering Council, 1993) suggested that engineering competence should be based on 'Foundation Learning' and 'Lifetime Learning'. The initial education of engineers would provide breadth of learning and the necessary skills and attitudes for the future, while continuing professional development should lead to full competence in the working environment.

In the US, the Accreditation Board for Engineering and Technology (ABET) specify what society and the professional world should reasonably expect engineering students to be able to do, rather than what courses they must pass, in its new ABET criteria 2000. Engineering Credential Evaluation International (ECEI) of ABET is the engineering credentialing service in the USA specializing exclusively in the assessment of engineers educated outside the USA (ECEI, 1998). The outcomes ABET requires engineering educators to demonstrate their students have achieved are as follows (Schachterle, 1997): An ability to apply knowledge of mathematics, science and engineering; design and conduct experiments, as well as to analyse and interpret data; design a system, component or process to meet desired needs; function on multi-disciplinary teams; identify, formulate and solve engineering problems; an understanding of professional and ethical responsibility; an ability to communicate effectively; the broad education necessary to understand the impact of engineering solutions in a global/societal context; a recognition of the needs for and an ability to engage in life-long learning; a knowledge of contemporary issues; and an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

Read (1997) supports the view that the 21st century will see a vastly changed environment for the engineer. We are already witnessing tremendous upheavals in the universities that train engineers, in the industries that employ engineers and in governments who set the rules and to a large degree have funded basic research of the professionals. Read believes that there must be a self-generated comprehensive plan for formal and continuing education which suits the engineer's personal needs. Read also suggests that engineers must stay close to what is happening in their fields of endeavour; make it a habit to monitor new technology developments; read the current literature; take advantage of short course offerings; and network with others in the profession.

McKenzie (1997) of the World Federation of Engineering Organisations gave ideas of how to define a complete engineer. Simple advocacy of subjects either outside or peripheral to the essentials of engineering would be possible. Certain aspects of engineering such as environmental impact and sustainability in each development have taken greater prominence. There has also been renewed interest in ethics in engineering. Communication skills should include computer skills - for example E-mail and Internet - and both verbal and written prose skills. To improve the situation a modern adaptation of the tutorial system needs to be incorporated in many courses. Flexibility in the student is desirable. Individuality rather than cloning is what is needed and competence in the use of their knowledge rather than learning being set against a check list. Students who are accustomed to working in teams will have an advantage. The length of the course has a direct relationship with cost wherever that cost falls. The other balance which we need to address is how long the course at University may be to give maximum advantage. According to Beder (1999), engineering is evolving from an occupation that provides employers and clients with competent technical advice to a profession that serves the community in a socially responsible manner. A new educational approach is needed to meet changing requirements. A broader, more general approach is required that not only helps students to understand basic engineering principles but also gives them the ability to acquire more specialized knowledge as the need arises.

McIsaac and Morey (1998) examined some ideas about sustainable development and considered implications for the culture of engineering. They argue that promoting a variety of approaches to sustainable development would seem to be a prudent means of spreading the risks associated with uncertainty.

Duffell (1998) believes that the engineering profession must embrace the ethic of environment and sustainability in engineering education, in continuing professional development, and in practice.

The global nature of engineering development and the need to educate engineers to operate in it are illustrated by (a) the fact that several organisations on engineering education function world-wide; and (b) the subjects of recent conferences on engineering education. Some of the organisations on engineering education are: European Society for Engineering Education (SEFI); International Association for Continuing Engineering Education (IACEE); International Society for Engineering Education (I.G.I.P.); The European Federation of National Engineering Associations (FEANI); Committee for Continuing Professional Development (CPD); Association for Engineering Education in S. E. Asia and the Pacific; American Society for Engineering Education (ASEE); and National Engineering Education Coalition in USA.

The subjects for recent important Conferences on Engineering Education were: 'Future trends and challenges in engineering education' held in Singapore in 1993; 'World Congress on Education by Communication' by I.G.I.P. held in Vienna/Budapest in July 1996; 'Congress of Engineering educators and industry leaders' by WFEO and UATI held in Paris in July 1996; 'Educating the Engineer for lifelong learning' by SEFI held in Vienna in September 1996; 'International Conference on Engineering education and practice' by ASEE in June 1996; 'Engineering Education '97' by I.G.I.P. held in Klagenfurt (Austria) in 1997; 'Humanities and Arts in a balanced engineering education' by SEFI held in Cracow, Poland in September 1997; Conference for industry and education collaboration "Pathways to the future-emerging challenges and opportunities' by ASEE held in Tampa, Florida in January 1997; 'Engineering Education and the Information Revolution' by ASEE held in Milwaukee, Wisconsin in June 1997; "The importance of CPD for the competitiveness of European industry" by FEANI held in Lillehammer in September 1997; 'The knowledge Revolution - the impact of technology on learning' by IACEE held in Turin, Italy in May 1998; and "Innovation strategies for economy and environment" by ENTREE held in Deventer in November 1998.

2.2.3 Civil Engineering

It has been said that the definition of a civil engineer is a person who adapts and creatively uses the power of ever-changing advancements in technology to better serve the public. He or she must be able to develop a safe, cost-effective, technologically advanced design every time a project is attempted.

Civil engineering has advanced a long way from the trial and error methods of design and construction used one hundred years ago, which had little scientific basis (CRAC, 1997). Civil engineers must now have a broad scientific knowledge combined with practical experience and common sense. The rapid development of plant and machinery has enabled engineers to construct on a larger scale and with much greater efficiency and speed than could have been imagined a few decades ago. Civil engineers working on major projects have to select and bring together a wide range of resources, and this requires a creative mind as well as an analytical and rigorous approach. They need to look beyond the drawings and calculations to the completed work.

Civil engineers' work can dominate the environment locally and on a larger scale, both during construction and after. Furthermore, they can expect their work to last for decades or even centuries. The building of a new bypass, bridge or tunnel can completely transform a large number of communities over a wide area, and not always for the good. All civil engineers must appreciate the social and environmental aspects of the work, and be able to communicate with clients, the general public and public representatives. They

must also be able to participate as members of a team and co-ordinate the contribution of other specialists to a project as a whole.

Civil engineering encompasses a very wide range of activity, but individual engineers often specialise in one particular type of work. In recognition of this, there are in addition to the Institution of Civil Engineers (of the UK), which covers all types of civil engineer, a number of professional bodies catering for more specialised branches of the profession. A number of Nominated Bodies that are licensed to accredit educational courses, relevant to the chartered engineer section, have joined together as the Joint Board of Moderators (JBM) to accredit courses in the broad fields of civil engineering (Goy, 1998). Because of the great variety of work involved in civil engineering, nearly all courses begin with general coverage, but most provide opportunities for specialisation later. Of course, you may not want to become a specialist, and even when a course has a wide choice of options, many students decide to continue with a fairly broad range of subjects, only specialising once they have graduated and entered the profession.

One direction in which to look concerns research on the adequacy or otherwise of education and training of engineers. Another direction is whether training in civil engineering has remained more or less the same for years, or it has changed to reflect changes in society.

The university contribution in civil engineering was considered by a book edited by Isaac (undated). Some of the topics were: (a) the development of civil engineering courses; (b) project work in education for engineers and architects; and (c) postgraduate engineering education in developing countries.

In a conference on the future needs in civil engineering education and training that was organised by the Institution of Civil Engineers of the UK (I.C.E., 1982) the following issues were emphasised: the commendable aim for quality requires that the maintenance of standards be investigated in greater detail; there is a need for greater flexibility in the approach to education and training; and there is a real need to consolidate what has been achieved.

Another Conference by the Institution of Civil Engineers of the UK (I.C.E., 1986) was entitled 'Civil Engineers for the 1990s'. The theme was what sort of engineers would be needed in the 1990s and how (levels of resources) education and training could best be carried out to meet the need. The matters with which the Conference was involved were: where we stand today and pointers to the future; future needs (views by public sector, Contractors and Consulting Engineers); professional development (undergraduate education, continuing education and off-the-job training; on-the-job training); and the impact of new technologies.

In 1993 civil engineering university educators and a few industrialists from the UK, Ireland and elsewhere met in Conference in Belfast to debate the many changes which were taking place in university civil engineering education then. The major themes were: course planning - the need for change; course content - competing interests; innovative learning methods; learning by projects; the industrial interface; towards professional development; and quality and assessment (Montgomery, 1993). The Conference revealed that there were strong pressures for change which could have a deleterious effect on the educational foundation of the civil engineering profession. Because of financial pressures on universities, departments were having to do more with fewer resources (space, equipment and personnel). Consequently, both teaching and research activity were suffering. Furthermore, because of calls to provide greater access, class sizes were generally increasing and the ability of students with weaker entry grades was lower than in the past. Because universities were imposing uniform modular structures, there was a need to reduce the amount of formal teaching in civil engineering degrees to be comparable with that in other disciplines. It was also expected that civil engineers would have the option within their study of taking some other subjects outside engineering. One likely effect of such changes would be to reduce the number of technical topics which could formally be covered; another was to make it more difficult to provide even the traditional amount of staff-student contact inherent in coursework activities of tutorials, laboratories, design exercises and field courses. On the other hand civil engineering lecturers increasingly recognise the benefit of student centred-learning and group exercises in developing many of the qualities that students require in order to do well in an engineering career. One of the biggest questions was how to find the resources and time to develop innovative teaching ideas while at the same time preserving as much as possible of the traditional teaching leading to understanding of basic engineering principles. Initiatives which would help university civil engineering staff to maintain and enhance the strength of courses were: (a) a greater awareness of the situation in education by practising engineers, and assistance, where appropriate, with improvements in curricula, and (b) resolution of the controversies about what is required to fulfil the academic requirements for the chartered professional engineering qualification.

To compete within the single European Market, the UK must train its engineers to enable them to take advantage of the opportunities offered (Thorburn, 1993). To achieve this, the UK's traditional emphasis on practical skills and sound theoretical knowledge must be tempered with the commercial advantages of the more flexible European system of education. A theme is developed by Thorburn (1993) that the European Engineer will be a product of teamwork and co-operation between the European educational

establishments with recognition by industry of the commercial advantages of a flexible European system of education. With the development of the European Community, the real European Engineer will emerge, whose education and training is truly European and whose skills will be accepted and used throughout the European Community.

It is impossible to forecast the precise nature and extent of change in future times and only trends can be anticipated, such as the introduction of new technologies and advances in automation and communication. We can anticipate the reduction of mineral resources and traditional energy sources, such as gas and oil. All human activities involve risk and there exists the probability that environmental problems and disasters will be experienced. The possibility of geographical movements of peoples will place great demands on society to provide adequate facilities for the health and welfare of populations. According to Thorburn (1993), there is a limit to the period of time available for acquisition of knowledge and development of understanding during a first degree course and it seems inevitable that post-graduate education will be a necessity for the European Engineer. In this age of rapid technological change the education of the European Engineer will be a continuous process throughout his or her career. There may be intervals of simple further education through self-study, but the demands of business competition on a European and international scale will necessitate some form of mid-career education. Training for new tasks would be essential to maintain the efficiency and competitiveness of companies competing in the European and international markets and the European Engineer must be prepared to change his or her role within a company. International competition may be expected to emphasise the importance of establishing close links between universities and industry and of creating a flexible system of post-graduate education.

Nine years of discussion and debate on the harmonisation of engineering education in Europe had produced quite poor results (Juan-Aracil, 1993). Hardly anyone would dispute the following points. (a) There is no common European educational system for engineers, and there is no indication that there will be one in the next few years. (b) To allow civil engineers to practice freely within the European Community, the problem of national regulations governing the eligibility of engineers to practice their profession within some European countries must be solved. (c) Two ways have been tried to overcome this barrier: harmonisation and mutual recognition. (d) Any solution should aim to maintain, and increase if possible, the quality and competitiveness of the European civil engineer compared to any other civil engineer of the world. (e) From a professional point of view there are two types of engineers in Europe: the 'know why' (or theoretical) engineer', and the 'know how' (or practical) engineer'. Of the four fields of infrastructure-

planning, design, construction and management - 'know why' civil engineers work in all of them. 'Know how' engineers are usually restricted to construction and maintenance. (f) It seems that Europe needs more engineers. Juan-Aracil (1993), however, does not say if all types of engineers are needed.

Becoming an engineer involves something more than university studies. Similar levels of engineering ability can be reached by engineers with differing education experiences, very different backgrounds and probably very different continuous training. Why not accept that many of them are capable of successfully performing the tasks of a competent European civil engineer? Experience of many multi-national companies could confirm this question. The uniformity is not a 'must' to guarantee the quality of all European engineers, nor to maintain the confidence with which European society and industry have in their civil engineers. Juan-Aracil (1993) does not feel the need to have a single type of education for civil engineers in Europe, if each national system has a high enough level of quality to be accepted by all the other countries. Surely, with the change in engineering, there is a need for engineers who have basic skills but are flexible or adaptable.

What about the developments in USA? Sample (undated) suggested that the American Society of Civil Engineers (ASCE) should direct its attention to the education of engineers. The professional society should have a more active role in determining the curriculum and course content. Because of the wealth of knowledge required in the practice of engineering and due to the overlapping of disciplines in today's problems, perhaps it would be wise to require a professional degree, consisting of one or two additional years of study beyond the bachelor's level, before one is qualified to do engineering. The ASCE's Board of Direction approved a resolution endorsing the master's degree as the first professional degree for the practice of civil engineering in April 1998.

Recent innovations in undergraduate civil engineering curriculums in the USA were examined by Pauschke and Ingraffea (1996), from which the following themes emerged: (a) A decrease in the number of credit hours for the undergraduate degree; (b) new degree options and degrees in environmental engineering; (c) strong emphasis in design courses on multidisciplinary approaches, team dynamics, industry projects and practitioner input/evaluation; (d) increasing emphasis on communication skills in civil engineering classes; (e) innovative course materials in the forms of multimedia presentations, simulation software, and communications via the Internet and the World Wide Web; (f) new and revised laboratories to provide hands-on design and analysis experiences; (g) synthesis of previously separated courses; and (h) increasing interest in evaluation and assessment.

A two-year process of rewriting accreditation criteria for civil engineering programmes at US universities and colleges was completed by an ASCE group that was charged with the task (ASCE, 1997a). The accreditation process will now be more qualitative - and more dependent on an assessment of the ability of an engineering education programme to meet an outcome consistent with its stated goals - as well as the Accreditation Board for Engineering and Technology (ABET)'s specific programme criteria. The critical need now is to train future civil engineering programme evaluators to apply the new criteria.

ASCE's Department Heads Council, which addresses societal concerns related to education and research, is the executive arm of the Departmental Heads Forum, an organisation that comprises all the civil engineering department heads in the US (ASCE, 1997b). Discussions focus on some of the major changes that are occurring in the way that programmes are accredited by ABET. Departmental goals and objectives are needed, and each programme must identify the market it serves (and then assess its ability to meet that market's goal). Another area that has become increasingly important is the tracking of graduates, as well as exit interviews and independent assessments of student qualifications. Staying in lockstep with civil engineer practitioners is a must for progressive, successful education programmes. The council works closely with the Society's Committee on Educator Practitioner Interface to identify ways to foster such exchanges.

A recent survey of civil engineering curriculums (Elliot, 1998) revealed a crisis in engineering education. Within the past few years another (note: there were reductions in the past too) course reduction movement has been initiated in some areas of the USA. The impetus for this reduction appears to be rooted in economics and primarily fuelled by state legislatures; and, the movement is not restricted to engineering degree programmes. To meet this requirement, engineering programmes must cut four or five courses, and the courses cut are likely to be technical, engineering courses. According to Bordogna (1998), the context for change in civil engineering education is shaped by society's increasingly integrated, complex civil systems and the engineer's task as society's master integrator.

Links with industry can be used to develop professionalism and engineering awareness in undergraduate education. The successful professional deploys skills in personal organisation, communication and engineering awareness. In the UK, Crisp and Fordyce (1993) postulate that these skills can be developed and deployed by undergraduates to improve their performance in their studies. Therefore, in order to facilitate this development, Crisp and Fordyce have devised the Industrial Liaison Scheme. The scheme has been implemented into the first year of the undergraduate degree programme within the Department of Civil and Offshore Engineering, Heriott-Watt

University. The scheme involves selected civil engineers from local companies working with the first year undergraduates to address the areas of personal organisation, communication and engineering awareness through direct discussion and project work. As part of the discussions the effectiveness both of the scheme and of the course is reviewed. This provides feedback which is used to assist continual course improvement. Early feedback from the students and the industrialists is very encouraging. End of year marks would indicate that the scheme is having a positive effect on the overall course. From discussions with students they would seem to have an increased appreciation of how their first year studies could be applied in practice. The implementation of the scheme (by Chrisp and Fordyce) has now led the student to expect that future years will contain similar schemes where professional issues are developed. These are currently being developed and included into the MEng degree courses.

A book by Macdonald Steels (1994) on training for civil engineers explores methods by which 'on-the-job training', or experiential learning, can be made more efficient and effective. The book addresses problems which appear to be widespread, offering possible reasons and making suggestions as how they can be overcome. Training is 'creating an environment' in which all staff learn all the time. This environment encourages self-help and mutual help, with external help only added when internal resources prove inadequate. It is necessary to structure work situations to optimise the learning process: planned experience is the first stage in experiential learning. However, experience only becomes training when it is correctly monitored - by reflection, questioning and discussion. It is the responsibility of the trainee, but it needs the reactive co-operation and understanding of other people in the organisation. Training is only successful after the lessons have been utilised in new experience. There is therefore a need for the organisation to allow the trainee to carry progressively more responsibility with progressively less supervision.

As concerns research and development, a report was commissioned jointly by the Science and Engineering Research Council and the Departments of the Environment and Transport of the UK and prepared by a Civil Engineering Task Force to review long-term needs for research and development (R and D) in civil engineering (Civil Eng. Task Force, 1981). Account was taken of foreseeable changes in the applications of civil engineering, the new problems that may be encountered and the associated advances in techniques that may be required. The Task Force identified some advances taking place in other technologies which either change the demand for construction or provide new and improved tools for civil engineers to adapt and exploit. For a variety of reasons, the size and complexity of projects were increasing, as were the demands for cost and quality

control procedures, the constraints of health, safety and environmental regulations, and demands for financial reporting. Particular attention was paid to the opportunities which exist in the areas of water, energy conservation and production, transport, building and housing, and some of the related R and D required was defined to take advantage of those opportunities. The Task Force was particularly concerned that the national structure for organising and funding should be such as to permit and encourage R and D to be undertaken efficiently and applied to best advantage.

To define needed civil engineering research in the USA in the 1980's, approximately 60 engineers, primarily civil, selected from government, industry, consulting firms, and colleges, gathered in Virginia in 1979 (ASCE, 1982). The broad field of civil engineering was divided into ten subdisciplines: construction engineering and management; energy; environmental (sanitary) engineering; geotechnical engineering; hydraulics, coastal, ocean and irrigation engineering; land planning and development; materials engineering; structural engineering and structural mechanics; surveying and photogrammetry; and transportation engineering. The research needs were examined relative to the societal needs of (a) shelter; (b) food, air, and water; (c) conservation; (d) transportation; (e) energy; and (f) public safety. To assist the workshop participants in this task, experts in these areas provided overviews of each of the societal needs. In areas such as energy use, environmental quality, and water availability, priorities must be established. There are limitations on energy use, declining affordability of housing, and restrictions on water use. Research can help minimise costs and to make better resource - allocation decisions. Research in civil engineering promises big payoffs. The resulting research programme contained 182 research problem statements.

2.2.4 Environmental Engineering and Water and Waste-water Engineering

The Chartered Institution of Water and Environmental Management (CIWEM), the professional institution in the sector in the UK, considers that education for life, for all of us, is a fundamental necessity and the key to the future (Henton, 1996).

As it is a branch of engineering, environmental engineering takes a quantitative, mathematical and technical approach to environmental problems and aims to develop students' technical design competence to a high degree. There is room in environmental engineering for students and practitioners with backgrounds that are different from those of the traditional engineer (CRAC, 1997). Degrees in environmental engineering can cover a huge range of different areas, from engineering systems through to geology and conservation. The career opportunities for graduates of these degree courses are hence equally as varied. In the past, environmental engineers started as electrical, civil, mechanical, chemical or electronic engineers, focusing on environmental engineering as

their careers developed. Indeed, many of the current degree courses are based in one of these departments. Current university courses and research in environmental engineering and water and waste-water engineering in various countries and universities are given in Chapter 5.

Most graduates will be looking for chartered status and many of the courses offer accreditation from engineering professional bodies such as the Institution of Civil Engineers (ICE) in the UK. According to Weekes (1998), CIWEM has only been granted a conditional licence and will only undertake the accreditation of non-engineering courses for the time being. The Accreditation Board is currently reassessing its documentation and processes in order to ensure that they correspond with the new SARTOR document.

A workshop on the fundamentals of environmental engineering education was held in New Zealand (Elms and Wilkinson, 1995). The theme was the growing need for engineers to be environmentally aware and be able to respond to the demands of societies throughout the world for greater environmental sensitivity. The aim of the workshop was to discuss the foundations on which the education of environmentally involved engineers should, ideally, be built. It addressed such questions as (a) the needs of customers, (b) the kind of engineer required in the future, and (c) educational requirements for the environmentally involved engineer. The conclusions reached were that all engineers need to be environmentally educated, not as an 'add on' but as an integral part of an engineering course. They need an understanding of, and be able to respond to, the needs of the natural environment, have the skills to deal with the politically oriented issues involving the social environment, and be able to interact effectively with professionals from many different disciplines.

The primary objective of a publication (Cassel *et al.*, 1970) on education and training of engineers for environmental health was to indicate those trends which, it was hoped, would influence the drawing up and planning of curricula in the future. The publication was an outcome of a meeting of an Expert Committee convened by the World Health Organisation (WHO). The themes were: (a) The work of the environmental health engineer; (b) trends in modern engineering education - in particular environmental engineering (use of mathematical analysis; problem solving and engineering design; the humanities and social sciences; use of system analysis; and the role of computers); (c) new developments in environmental health engineering; and (d) examples of educational programmes in different regions of the world.

A conference on education and training for public health engineering and environmental management was held at Loughborough University (Pickford, 1974). Some of the topics with which participants were concerned were: The university contribution to

education; education and training of public health engineers for careers with local authorities and regional water authorities; and viewpoints of a consultant and a non-engineer.

An undergraduate college experience in the USA is outlined in Groves (1995). The recommended model is three or four separate design problems involving real-world (practice-oriented) experiences of the professors. Students work in groups in environmental (and other) sections, and present both oral and written design reports. Such a design experience is required by ABET.

A number of university graduates go on to do a higher degree, usually a master's degree in an area of specialisation. A number go on to do a research-based degree such as a PhD, researching new developments. These would normally be based within a university, though often they are linked with industry. In response to the need for a specialised, or "professional", degree programme, Texas Technical University offers an alternative to the traditional path to becoming an environmental engineer: the Master of Environmental Engineering (MEnvE) degree. This programme provides graduates with more concentrated preparation in biology, chemistry, chemical engineering and environmental engineering and is focused on environmental engineering design as compared to the BS/MSCE (environmental emphasis) path (Rainwater, *et al.*, 1999).

Reference to the workshop by ASCE (1982) on 'societal needs through civil engineering research' was made in section 2.2.3 on page 22. As concerns environmental (sanitary) engineering, the outcomes were as follows. Environmental research can provide knowledge, understanding, and technology for the resolution of the following basic issues: What are acceptable and desirable levels of environmental quality? What means shall be used to improve environmental quality which does not meet the desired levels? What must be done to protect and preserve environmental quality which does meet or exceed the desired levels? Research to resolve these issues falls into these five general categories:

- (a) Improve understanding of fundamental mechanisms, such as the relationship between soil loss on agricultural land and silt deposition in water bodies;
- (b) Development of new technical methods for the control of the environment;
- (c) Measurement of environmental conditions and storage and utilisation of environmental data. (An analysis and monitoring of the data will make possible establishing trends and providing early warning of dangerous conditions);
- (d) Developing and applying techniques of risk analysis for dealing with uncertainty. (This will aid the decision process by helping decide what are acceptable or desirable risk levels); and

(e) Environmental management.

The critical issues identified in the same workshop (ASCE, 1982) in hydraulics, coastal, ocean and irrigation engineering were: hydraulic structures; irrigation engineering; sediment transport; waves; circulation, mixing and biochemical processes in lakes and reservoirs; turbulent transport of effluents; risk analysis; and field data collection.

As concerns education in water engineering, several broad objectives need to be met so as to realise this process (National Committee on Water Engineering, 1997).

- (a) The water engineer should have a sound understanding of the natural sciences which underpin water engineering. These include the sciences of fluid mechanics, hydrology (surface and subsurface), water chemistry and aquatic aspects of the biological sciences. This understanding must stress both process and mathematical description.
- (b) Building on the natural sciences is the need for adequate exposure to the social sciences. Economics, law, ethics, management and the sociology of public and private policy formulation and decision-making present the social framework within which engineers operate, while communication skills provide the vehicle for exchange of ideas and solutions.
- (c) The water engineer should be skilled in the engineering sciences which underpin the practice of water engineering. Skills include the traditional fields of hydrology, hydraulics, water and wastewater treatment technology, and water resource planning and management, and are evolving to include catchment management.
- (d) Water engineers work in a problem-oriented environment seeking to provide practical solutions. At times the challenges they face are without precedent or at the cutting edge of technology and practice. In response to such challenges they need to develop the art of problem-solving as well as holistic or systems thinking skills. Such skills include the ability to systematically and critically analyse problems, to think laterally and independently, and to navigate through the social and technical complexities of modern water engineering infrastructure. Such skills are fundamental to design and to project and resource management.
- (e) A sense of professionalism must be instilled. Engineers must understand their ethical obligations to society, both present and future, and to their clients. Within this framework they must practice in a competent and responsible manner. Moreover, they must recognise that their education never ceases - it is a lifelong experience requiring the ability to learn how to learn. They must undertake continuing education activities throughout their professional lives.

In educating water resources engineers, there is a need to add a social science dimension. This was pointed out by participants in the Conference "The role of social and

behavioural sciences in water resources planning and management' (Baumann and Haines, undated). The supreme goal of water resources planning and management is to provide water of the desired quality and quantity when and where it is needed. The motivation for including institutional and political dimensions in the education of water resources engineers stems primarily from the need to understand the ways and means by which the enhancement of the well-being of the people can be achieved in a fair and equitable process. One problem in evolving broader, more applied curricula is that there is so little experience with truly interdisciplinary planning. The university's role may best be in providing a broad, liberal education of the traditional sort, with more applied work being learned on the job and in special short courses with a mixed agency - university faculty.

A paper by Gully and Dennis (1995) discusses the benefits of the integration of a combination of commercial, public domain and 'in-house' computer software in an undergraduate hydrology and hydraulics course. It describes how the careful implementation of computer-generated solutions has served to enhance the understanding of fundamental concepts. Computer methods are introduced only after underlying principles and manual solutions to problems are addressed and reinforced. As with all learning exercises, the authors have wrestled with the level of complexity students should be exposed to in problem solving. The goal is not to overwhelm the student with the complexities or computational sophistication of the computer programme. The focus should be on the students' interpretation of the results of the analysis and not the level of effort required to produce a solution.

As concerns professional qualifications of water engineers and other professionals, the Council of CIWEM of UK decided to establish two professional Boards to deal with applications for membership of the Institution (CIWEM, 1998a). The Engineering Professional Board will deal with applications from engineers and will incorporate the special requirements of the Engineering Council. The Science and Technology Professional Board will deal with applications from scientists, technologists and others and will cater for any requirements of related professional bodies. The two Boards will also be the centre of focus for professional matters concerning engineering and science and technology.

Structured training of water engineers has continued to gain in popularity (CIWEM, 1998b).

A very thorough handbook on UK Water sector training for developing countries was prepared by WEDC of Loughborough University (WEDC, 1993) under contract to the Overseas Development Administration of the UK. Initially a subject and topic index is offered, which includes the approximate course length and the target study group (that is,

whether high or middle or junior level managers, scientific/design staff, construction staff, technicians, and others). For each programme, the following details are given: title; institution and section; duration; whether UK based or not; whether full or part time; frequency; starting month; objectives; whether specifically designed for developing country participants; organisations using course; target study group; programme format (formal lectures, case studies, training by research, study tours/visits, individual projects, group projects, practical exercises, industrial attachment, and distance learning) and the relative importance of each by time weighting; main/key subjects, the water sector category of each (water resources planning and management; hydrology and meteorology; surface water, flood and hydraulic structures; groundwater; water supply and treatment; water quality and surveillance; sanitation and pollution control; irrigation and agricultural drainage; economics, finance and legislation; and operator training) and the relative importance of each by time weighting; minimum entry requirements (academic, professional/work experience, language proficiency, and other); qualification received; and accrediting body. Also a list of recent non-formal training programmes is given. Finally institutional details are given on: general and training activities; experience of developing countries; the type of support offered to trainees (specialist library; accommodation; personal tutor; equipment; computers; counselling; and language); and type of training (formal, tailor-made, industrial attachments, and research attachments).

In the previous section (2.2.3 on page 21), long-term research and development requirements in civil engineering were considered (Civil Eng. Task Force, 1981). There must be a vast market world-wide for engineering services and equipment related to water resource development and distribution, irrigation and pollution control, since most of the world's population lack a clean water supply and the related facility of hygiene sewage and waste disposal. In the UK, the phase of major construction for initial water development has passed. The future needs are for improved techniques for monitoring in the field the conditions and the performance of existing structures and services, particularly in the development of means of effective major repairs without interruption of use. For new construction the trend will be to making better informed decisions on the economic, environmental and social consequences, requiring fuller and more informative investigations with the systems modelling techniques that should complement them. There is much scope for development of improved treatment of water and of sewage.

2.2.5 Quality assurance

A number of quality checks are imposed on institutions within the higher education sector. These checks are as follows for the case of the UK (British Council, 2000).

A. Institutions' internal quality assurance processes.

B. External quality assurance processes.

- (a) “The Academic Quality Audit” has been carried out since 1997 by the Quality Assurance Agency (QAA). The audit reports deal with the institution’s overall systems, not individual departments or courses.
- (b) The “Quality Assessment” looks at the quality of teaching and learning in specific subjects.
- (c) Where it leads to a professional or vocational qualification, institutional provision for teaching and learning is also subject to separate process generally known as accreditation, carried out by the relevant professional or vocational body. One of the examples is engineering.
- (d) To judge the quality of research, the funding bodies conduct a UK-wide “Research Assessment Exercise” every few years. This Exercise uses a process of “peer reviews”, where distinguished academics (including at least one international academic) in a particular subject review the quality of the work of their fellow researchers.

C. Government authorisation

Authorisation to offer degrees or related qualifications may be granted under Royal Charter or Act of Parliament, or by a special order of the Department for Education and Employment.

D. Institutions in the UK are members of the British Council’s Education Counselling Service. These institutions subscribe to a Code of Professional Standards and Ethics, which gives an additional assurance of quality.

As part of its development of a comprehensive quality assurance process for higher education, the Quality Assurance Agency (QAA) is producing a Code of Practice for Quality Assurance in Higher Education in the form of a series of self-contained sections covering the management of quality and standards in all teaching and learning activities. Also a code of practice for distance learning will be incorporated into the wider QAA Code (QAA, 2001).

2.3 THE WATER AND WASTE-WATER SITUATION IN CYPRUS

2.3.1 Characteristics and needs of Cyprus

Certain characteristics of Cyprus that are related to or affect the situation of water and waste-water engineering of the island should be considered. Such characteristics could include geographic, climatic, geological, and seismic. How these affect the water and waste-water situation could be one of the aims or targets of research to be proposed. These characteristics need to be known to a certain extent, so that courses and research programmes developed, address them. If curricula are developed based on felt or identified

needs of the country, then the author believes that the quality of life would be improved. This belief is based on the axiom that education, training and research should be oriented towards the need for a 'better' society and environment. The needs for personnel skills and know-how in the field of water and waste-water engineering will be assessed based on the development and infrastructure requirements of the country.

Further details are given in section 6.6 (on page 129) on the characteristics and needs of Cyprus in water and waste-water systems. An account of some basic facts and characteristics about Cyprus follows.

The fertile Greek fantasy, wise in its creative conceptions, has chosen Cyprus as the island of the goddess of love and beauty. It is a symbolic recognition of the rich geographic environment of Cyprus. According to Karouzis (1981), many recognised geographers maintained that there is no other place in the world of the same area as Cyprus, that has so abundant a geographic variety. The island is situated in the north-eastern corner of the Mediterranean Sea, 33° east of Greenwich and 35° north of the Equator (Rep. of Cyprus, 1998b) and is the third largest island in this Sea with an area of 9251 square kilometres (Petrides, 1994).

Cyprus is historically an ancient country but geologically it is relatively 'young' (Karouzis, 1981). The geographic area of Cyprus was substantially born 75 million years ago as an island in the place which is known today as the Troodos mountain range.

Cyprus is divided into five morphological districts: the mountain cluster of Troodos (altitude reaching 1952 m) which is the core around which Cyprus was later formed; the mountain range of Pendadactylos (1085 m) in the north; the central plain; the hilly area around Troodos; and the coastal plains. Cyprus is an earthquake-struck place. About 400 earthquakes are recorded in Cyprus each year. Of these, 100 are local. There are 60-70 tectonic faults in Cyprus. They are quite small in area and depth (0-8 kilometres). Many of these are not active (Drousotis, 1995). The enforcement of the seismic code for reinforced concrete structures is compulsory since January 1st 1994.

Cyprus has a characteristically Mediterranean type of climate, the chief features of which are warm and dry summers, and wet and mild winters. The average rainfall is 489 millimetres but it varies considerably (Meteorological Service, 1978). The variation in rainfall is also annual and often two and even three year consecutive droughts are observed (WDD, 1996).

According to the various archaeological findings, the culture of Cyprus extends to a period of about 90 centuries, that is in the Neolithic Epoch (Pavlidis, 1988). The position of Cyprus has affected its geography, history and culture. It is situated amongst three continents: Europe, Asia and Africa. It is the most south-eastern country of Europe.

Cyprus has been an independent state since 1960. The UK continues to maintain military bases in Cyprus which indicates that the island has strategic importance. It is an independent, sovereign Democracy with a presidential system of government. It is a member of the United Nations, the Council of Europe, the Non-Aligned Movement and the Commonwealth and is linked with the European Union through a Customs Union agreement while an application membership was submitted in 1990.

The majority of the population (80%) is Greek of the Greek-Orthodox Christian religion and the Greek language. The minorities include 18% Moslems and 2% Maronites, Armenians and Latins. The population of Cyprus in 1995 was 732 700 (Hellenic Bank, 1996).

The Turkish invasion of 1974 brought about dramatic changes. About 37% of the land and 51.5% of the coasts were captured and are still occupied by the Turkish troops. As a result of the Turkish invasion and occupation, 70% of the economy in 1974 was destroyed, and about 200 000 Greek Cypriots are still refugees and 1619 are missing (P.I.O., 1974). In the attempts of the Government of Turkey to change the demographic composition of the island, 70 000 Turkish settlers were transferred to the occupied part of Cyprus. After the invasion the requirements for reconstruction were tremendous since homes, factories, hotels, hospitals, schools, airports, harbours and roads were lost.

The per capita GNP was CY£6430 in 1996. The rate of inflation was 3,6% in 1997. Unemployment was 3,3% in 1997. The infant mortality was 8 per 1000 live births in 1995. The life expectancy at birth was 75,3 for males and 79,8 years for females in 1994/95 (Rep. of Cyprus, 1998b and Ministry of Finance, 1998).

2.3.2 The water supply situation

Almost all water sources of Cyprus originate from precipitation. Only a small quantity is derived from (desalinated) sea water. The average annual rainfall (including snow-fall) is 500 mm. The water volume that corresponds to the total area of the island is 4600 million m³ but only 20% or 900 million m³ are offered for development. The rest returns to the atmosphere through evapotranspiration (Rep. of Cyprus, 1991). The average annual quantity of 900 million m³ is apportioned to surface flow and groundwater in the proportion of two to one (Petrides, 1994). 270 out of 300 million m³ of groundwater are pumped or overpumped through boreholes or appear in springs. Part of the groundwater finds its way to the sea mainly during winter time (Petrides, 1994). The total surface flow is 600 million m³. 150 million m³ are diverted from the rivers and are used for irrigation during winter and spring. The storage capacity of dams and reservoirs is about 300 million m³ nowadays (Ministry of Agriculture, 1996b). The biggest one is Kouris Dam, its capacity being 115 million m³ (Partasidou, 1987). Cyprus is first in the catalogue of the

International Committee of Large Dams in Europe with 50 large dams every 10000 km² (Kyrou, 1996). The annual amount of water, however, that is provided by the largest dams is only 190 million m³ (according to the use of water too). The rest of the surface flow finds its way to the sea (Petrides, 1994). Water flowing out (total 900 million m³) is apportioned as follows: 37% is lost; pumping and flow from springs 30%; average annual provision from dams 21%; and diversion from rivers for irrigation 17%. These effluences create a small deficit of the order of 5% which is due to the over-pumping of some of the water-bearing layers (Petrides, 1994).

The major water development projects in Cyprus are: the Yermasoyia - Polemidhia Project, the Paphos Irrigation Project, the Pitsilia Integrated Rural Development Project, the Vasilikos-Pendaskinos Project, the Khrysokhou Irrigation Project and the Southern Conveyor Project. The planned projects are: the Kargotis Project, the Northern Conveyor Project, works associated with Dhiarizos and Ezousas rivers and the Domestic Water Supply of Paphos (Ministry of Agriculture, 1996b). 75% of the water resources of Cyprus were developed by the end of 1995 (Min. of Agriculture, 1996a). A sea water desalination plant was put in operation in 1997 with a nominal daily capacity of 20000 m³ (Manoli, 1997) with a prospect of doubling the capacity in 1998. The approved budget for 1998 for governmental Water Development was CY £27 578 500 which was 10,6% of the grand total of the Development budget of the Republic of Cyprus (Rep. of Cyprus, 1998a).

In the field of domestic water supplies more than 99% of the population enjoys a house-to-house connection of good quality water supply (Ministry of Agriculture, 1996b). According to Michaelides (1997), the water demand for domestic needs, tourism, commerce and industry use is about 53 million m³ (25%) and that of agriculture 160 million m³ (75%) annually. In general, water in Cyprus is a scarce resource and demand exceeds supply. It is one of the most important factors affecting the economic development of the country.

2.3.3 Environmental problems

Water is a scarce resource and, therefore, subjected to over-exploitation. Coastal aquifers are subjected to over-pumping which results in sea intrusion. Sewage and industrial effluents are beginning to affect some inland aquifers, whereas fertilisers and agrochemicals are potential pollutants for streams, dams, reservoirs and groundwater.

In particular, the main environmental problems besetting water resources are (Rep. of Cyprus, 1991).

- a) Sea intrusion: Certain areas of coastal aquifers have been affected as a result of over-pumping, and efforts have therefore been made to control pumping through the issue of water use permits and by restricting the drilling of boreholes in the affected areas.

- b) Sewage disposal: The water of certain aquifers has been polluted with nitrates originating from absorption pits of sewage disposal systems. The protection of water resources from nitrates pollution is pursued by promoting, where possible, the installation of sewage treatment plants, or by restricting the depth of absorption pits and wells.
- c) Industrial effluents: Pollution problems of local significance in a limited number of areas have been created by the uncontrolled disposal of untreated industrial effluents. Legislation for the control of industrial pollution has recently been enacted.

2.3.4 Future needs

According to a recent World Bank report the water demand in agriculture will be increased to 200 million m³ annually by the year 2000, whereas for the rest of the uses the needs will reach 95 million m³ by the year 2020 (Michaelides, 1997).

According to the governmental Water Development Department (WDD, 1996), the future water demands will be increased continuously whilst the potential for developing new sources will be decreased. It is estimated that in the year 2010, the needs will be 415 million m³ (320 for agriculture and 95 for other uses). When the government projects that are proposed are realised, it is expected that 95 million m³ annually will be added to the water balance (but needs will be increased by 110 million m³).

2.3.5 The waste-water situation

The towns of Cyprus either possess or are in the stage of designing/building a central system of collection, treatment and re-use of waste-water. The same applies for some rural communities. The rest of the population is served by on-site treatment (septic tanks) and disposal (seepage pits). The access to sanitation was 100% of the population in 1994-95 (World Bank, 1997a).

In some cases, problems exist with industrial and animal farm wastes. A treatment plant has been built for the wastes of the industrial zone of the town of Limassol.

2.3.6 Strategy and difficulties

The thoughts expressed in this section belong to both the author and others (as referenced). The author, however, adapts all opinions expressed in this section.

- a) Cyprus experiences drought events on a regular basis. According to a World Bank report, Cyprus will face serious water deficiencies in at least 10 of the next 25 years. Based on records of previous decades, the Food and Agriculture Organisation of the UN forecasts that in 25 years Cyprus will probably be amongst the countries with the biggest lack of water (Phokaides, 1997). Since 1960, the rainfall has decreased by 12% and the river flow by 30-35%. It has been estimated that the amount of groundwater that is pumped exceeds the amount that is physically recharged by 40 million m³

(Loizidou, 1998). The water resources of an island like Cyprus are fixed and cannot increase substantially.

- b) The Ministry of Agriculture, Natural Resources and the Environment has elaborated a development programme of exploiting all the (so far) undeveloped rivers up to the year 2010. The programme will cost approximately CY£200 million.
- c) The use of alternative sources of water supply should be investigated. Another two desalination plants are being planned by the government of Cyprus but I would consider such a solution as cost-ineffective, the cost being three times that of water from dams (Theopemptou, 1998) and energy consuming, at least for the time being. The use of treated wastewater for irrigation and groundwater recharge should be given even greater emphasis. Decisions on which plants and other considerations, however, should be based on research findings. The wastewater systems of the towns of Cyprus (when completed) can give 30 million m³ of water annually (Petrides, 1994). The approved expenditure for re-use of treated effluent in the 1999 governmental budget is CY £4.750.000 from the sewerage systems of the towns of Paralimni-Ayia Napa, Limassol and Paphos (Perthikis, 1999). Carrying water from other countries is an option that could be used only in extreme cases.
- d) The evaporation of water from dams should be minimised.
- e) There is a need for more protection (of the water quality) measures in the areas of water recharge and storage (Michaelides, 1997). The use of agrochemicals and the discharge of untreated sewage with a danger of spoiling suitable groundwater sources should be controlled (Loizidou, 1998). Instituting environmental impact analysis surveys of all projects affecting the hydrological situation of the island should be a matter of priority. According to Chrysanthou (1996), 1602 samples of drinking water were tested in the laboratory of general tests of the governmental General Chemical Laboratory in 1995. 194 were proved to be not satisfactory (WHO and EU guidelines). 7682 samples of drinking water were tested in the Microbiological Laboratory of the General Chemical Laboratory in 1996 in accordance with EU practice and guidelines. 14% of the samples were unsuitable (since they had more than 10 coliforms per 100ml) whilst 18% had 3-10 coliforms and/or increased bacterial count and/or *Pseudomonas aeruginosa* (Ministry of Health, 1997). Several standards for water quality were issued by the Cyprus Organization for standards and control of quality.
- f) The general water supply system of the country presents leakage of the order of 23% (Michaelides, 1997). This amount is lost before it reaches its destination. (Source: World Bank report mentioned earlier). It should be minimised in water supply and irrigation. The Water Board of Nicosia applies a long-term strategic programme of

locating and minimising invisible leakages since 1985. The result is the reduction of the unaccounted for water from 29% of total demand to 15.5% within 10 years (Theodoulides, 1996).

- g) Saving water and the best possible management of water for irrigation are important requirements. The needs of agriculture and tourist development should be adjusted to the existing water resources. The compulsory use of technology for low consumption of water in houses and agriculture should be enforced by law. Some of the planned irrigation works should be postponed because they are of doubtful benefits for agriculture and they are often a method of converting land into plots for tourist and residential development in rural areas. Private wells should be controlled to avoid wasting water in non-returning and subsidised cultivations. The quantity of water for irrigating citrus trees can be reduced up to 15-20% without affecting production (Loizidou, 1998).
- h) Drinking water should not be used where other water could be used (Pheasas, 1998). Further reference to this matter is given in section 6.6.2 on page 130.
- i) Strategic reserves of water, mainly underground, should be created that would be used only in case of drought events (Stephanou, 1997).
- j) Recently golf courts were created in Cyprus, which need large quantities of water to be maintained. Such needs are impossible and inappropriate to cover by the relatively inadequate natural water reserves. It is noted that a golf court consumes water daily equal to that of the water supply of a town of a population of 9000. According to Stephanou (1996), the construction of golf grounds that use dam water simultaneously with the operation of desalination plants cannot be considered as a healthy policy of water resources management.
- k) Pricing of water should be adjusted so that the price represents a greater proportion its real cost so as to be used effectively. Additionally, prices could vary depending on the use (Theopemptou, 1998 and Loizidou, 1998). For example, water for golf courses should be of a higher price than water for other uses.
- l) The target for greater 'water conscience' by all people has still a long way to follow (Michaelides, 1997).
- m) The 1960 legislation should be updated, unified and harmonised with that of the European Union (Michaelides, 1997).
- n) The governmental services should be unified into an autonomous Water Authority (Michaelides, 1997 and Stephanou, 1997).

The strategic issues and tasks ((a) to (n)) will require professional development of a range of professionals in different disciplines in Cyprus, not just engineers. However, this study focuses on the learning and development needs of engineers.

2.4 HUMAN RESOURCES DEVELOPMENT IN CYPRUS AND OF CYPRIOTS

This section deals with human resources development in general. Human resources development in water and waste-water engineering is considered in Chapter 4.

2.4.1 Education

The literacy rate for persons aged 15 years and over in Cyprus was 94% in 1992 (Rep. of Cyprus, 1998b).

The school system in Cyprus is as follows: Pre-primary education for ages 3 to 6; primary (6 to 12); secondary (12 to 18); and higher (over 18). Compulsory education is for ages of 6 to 15 years old. Secondary education is composed of the secondary general for the first three classes and the options of lyceum, technical and vocational for the last three classes. Also private secondary schools function. The following higher education institutions exist: University of Cyprus; Higher Technical Institute; Higher Hotel Institute; Forestry College; School of Nursing; Mediterranean Institute of Management; Cyprus Police Academy; Public Health Inspectors School; Tourist Guides School; and private local institutions. A number of students study in Universities and other institutions abroad.

Expenditure on all levels of education, both public and private stood at CY £289,9 million of which public expenditure amounted to CY £192,5 million and accounted for 12,9% of the country's budget and 4,5% of the Gross National Product in 1996 (Dept. of Statistics and Research, 1998). Respectively, these percentages are 11,2 and 5,4 in the UK in 1992; 14,3 and 7,6 in Canada in 1992; 10,4 and 5,8 in France in 1993; 14,2 and 6,0 in Australia in 1992; and 9,6 and 4,4 in the Russian Federation in 1993 (UNESCO, 1996).

At all levels of education there were 162 498 full-time pupils/students giving a pupil/teacher ratio of 13,2. Of the total pupils/students 81,0% were enrolled in public schools and 19,0% in private schools. The enrolment of pupils/students by level of education were as follows: pre-primary 16%, primary 40%, secondary 38%, third level 6%, and special education 0,3%. Another 108.091 pupils/trainees were in part-time institutes and other non-formal education. The current cost per pupil/student by level of education was as follows: pre-primary CY £590, primary £894, secondary £1585, third level £2298 and special education £4847. These statistics are for the year 1996-97 (Dept. of Statistics and Research, 1998).

The percentage gross enrolment ratio for third level students was 45 (23 in Cyprus and 22 abroad) in 1996-97 (Rep. of Cyprus, 1998b). This ratio is derived by dividing the total number of students by the population of the age-group for this level. The number of

third level students for 100.000 inhabitants was 1069 in Cyprus in 1993 (3037 for 1996 if the Cypriot students abroad are included) as compared to 6980 in Canada, 5546 in the USA, 3623 in France, 3135 in Australia, 3025 in the Russian Federation, 2788 in the UK and 3026 in Greece in 1993 or 1994 (UNESCO, 1996).

In 1996/97, there was a total enrolment of 9982 third level students in Cyprus. Of the third level students, males accounted for 44,3% of the total and females for 55,7%; 49,9% were enrolled in public institutions. The number of graduates was 2482 in 1995/96, 9% of them being of the engineering field of study. In 1996-97, the third level (non-university) civil engineering students in Cyprus were 178 (149 in public institutions and 29 in private institutions). A number of private colleges have been established which are affiliated with British and American Universities (Dept. of Statistics and Research, 1998).

Cypriot students abroad totalled 9813 (excluding those students not registered with the Ministry of Education for obtaining foreign exchange for their studies) during the academic year 1996/97. The expenditure for students abroad was CY £50,3 million in 1996 (1,2% of the GNP). Their distribution by level of education in 1996/97 was: Undergraduate 69,2%, postgraduate 12,6%, non-university higher 10,2%, vocational 3,3% and preparatory 4,7%. The most popular fields of study were: commercial and business administration, engineering/technology, medicine, social sciences, humanities, mathematics and computer science and fine arts. The proportion for engineering and technology was 12,7%, for education 2%, for natural science 3,4%. As concerns branches of engineering, the proportions were: civil engineering 3.1% (10% of them following postgraduate studies), mechanical engineering 2,42%, chemical engineering 0,7%. The main countries of study were Greece, UK, and USA (Dept. of Statistics and Research, 1998). The proportion of Cypriots studying in the UK was 12% in 1984/85 and 28% in 1996/97 (British Council, 1998). Cyprus is 13th (6th outside the EU) amongst countries contributing students to the UK universities.

According to the 1998 survey on graduating students abroad, 24% of them stay abroad (Dept. of Statistics and Research, 1998).

There is no institution of university level providing education of engineers in Cyprus at present. The University of Cyprus was founded in 1989 (Rep. of Cyprus, 1989). The Schools are the School of Humanities, the School of Economic Sciences and Management, and the School of Pure and Applied Sciences. One of the Departments of the latter is the Engineering one which is not yet functioning since the construction of the new University premises has not been completed. The University of Cyprus and the Scientific and Technical Chamber of Cyprus have been co-operating in promoting the foundation of a Polytechnic School at the University of Cyprus. They are involved in a

study to find out the needs, prospects and benefits of founding such a School (ETEK, 1999a).

There are two tertiary educational institutions offering civil engineering courses for technician engineers, the government-controlled Higher Technical Institute (H.T.I.) since 1968 and the private Frederick Institute of Technology (F.I.T.) since 1977. In both institutions the language of contact is English. HTI was founded jointly by UNESCO and the Ministry of Labour and Social Insurance. It is being involved with educational exchanges. The two-year higher diploma course in Building Technology at FIT has been accredited by the Accreditation Council of Cyprus. Ever since the Cyprus Parliament has voted for the Private Higher Educational Institutions Law in 1987 (Rep. of Cyprus, 1987), the Ministry of Education has initiated a process of evaluation.

The Mediterranean Institute of Management (MIM) was established in 1976 as the international component of the Cyprus Productivity Centre (of the Ministry of Labour and Social Insurance). It offers a one-year (alternatively, two-year part-time) Post-graduate Management Diploma Programme for university graduates (MIM, 1998). The Cyprus International Institute of Management (CIIM) was established by the Cyprus Development Bank and is a postgraduate business school (Cyprus Development Bank, undated). It offers Masters courses and an MBA programme (Cyprus Development Bank, 1998).

Students benefit from various scholarship schemes. The State Scholarship Foundation (formerly, Scholarship Board) is responsible for selecting candidates for scholarships offered by the Cyprus Government or through the Cyprus Government by international organisations, foreign governments and other sources. The fields of study in which scholarships are awarded are set by the Planning Bureau. The Cyprus Government offers scholarships and loans for undergraduate degree studies abroad, and since 1997/98 scholarships are offered also for postgraduate (master) studies abroad. In 1996, the scholarships granted involved an expenditure of CY £350.000 for 144 scholarships. There is also a State Scholarship Programme for the University of Cyprus. The total number of scholarships actually awarded in 1996 was 200 under the Scheme of foreign governments and organisations. Well known schemes include Commonwealth scholarships, the Cambridge Commonwealth Trust, the Cyprus America Scholarship Programme, and so on (Scholarship Board, 1996). A number of British Chevening Scholarships is offered for undergraduate and postgraduate study in Britain. The scheme is funded by the British government and managed by the British Council (British Council, 1998).

As concerns accreditation, the "Council on educational accreditation" and the "Cyprus Council on academic recognition and equivalents of tertiary education degrees" have been established.

The “Council of registration of architects and civil engineers of Cyprus” has accredited 185 university institutions in civil engineering since the Council was founded. These are according to the country: USA 83, UK 28, Russia 12, Germany 12, and so on (Council of Registration of Architects and Civil Engineers, 1996).

University courses in water and waste-water engineering are covered in Chapter Five.

2.4.2 Training

The Industrial Training Authority of Cyprus (ITA) is a semi-government organisation. Its operations commenced in 1979. The Authority consists of the Research and Planning Directorate, the Training Directorate, the Administration and Personnel Service, and the Financial Management Service (ITA, 1998a). The role of ITA is co-ordinating and financing and it has priorities (Constantinou, 1999). It organises accelerated vocational training and retraining courses which are usually subcontracted out to suitable institutions (Dept. of Statistics and Research, 1998). The activities of ITA encompass the following areas: the formulation of an integrated training and human resource development policy; the assessment of the economy’s needs for training; the modernisation of the training system; the distribution of information to enterprises and the public; and the adjustment and convergence to European systems and practices (ITA, 1998a). The programmes available are: In-company training (initial and continuing); training at training institutions (multi-company continuing); and training abroad. Only employees of private or semi-governmental organisations are subsidised (ITA, 1998b). The major criteria for ITA to subsidise the participation of employees in training programmes abroad are: if such programmes cannot be implemented in Cyprus; in areas concerning new technology and technical know-how; for each course only one employee per company per year (Andreou, 1999). The programme organised by MIM (see section 2.4.1 on page 37) is subsidised (trainees’ salaries and participation fees) by ITA. ITA is the national co-ordinating unit for application of the European programme for vocational training “Leonardo Da Vinci”. The major source of income of ITA is the Industrial training levy which is paid by employers (Efstathiades, 1999).

The number of persons that benefited from ITA programmes was 22600 in 1996 (corresponding to 2228 courses). The number of adults was 21910 (97%). Programmes of youth training (3,5%) included training for tertiary students and Higher Technical Institute students practical training. Programmes of further education (94%) included: management training; programmes of ITA and institutions/organisations; programmes of ITA and companies; training abroad (1,6% of total); and training with foreign experts. Special schemes (2,4%) included: training for tertiary third level education graduates (ITA and

MIM); and Cyprus Productivity Centre supervisors (Dept. of Statistics and Research, 1998).

As concerns government staff, the appropriated budget for scholarships and training in Cyprus was CY £ 305.000 in 1998 (compared to 567.500 in 1997) as given by the Ministry of Finance. The appropriated budget for scholarships and training of government staff abroad was CY £450.000 in 1998 (as compared to 350.000 in 1997) as given by the Planning Bureau (Rep. of Cyprus, 1998a).

The Ministry of Finance has a Branch of training of the public sector which is part of the Public Administration and Personnel Service.

The Cyprus Academy of Public Administration of the Ministry of Finance was established in 1991. Its primary aim is to train and enhance the capability of the civil servants in managerial skills. 565 persons participated in these programmes in 1996/97 (Dept. of Statistics and Research, 1998). It organised programmes for civil servants or assisted various ministries in developing training in managerial, technical, professional and EU themes (Ministry of Finance, 1998).

The personnel of the Ministry of Agriculture, Natural Resources and the Environment is taking part in international conferences, educational seminars and workshops; many have offered services as experts in nearby countries. There is a programme of co-operation with the Ministry of Agriculture of Greece for education - training and exchange of experts (Min. of Agriculture, 1996a).

Adult Education Centres and the Cyprus Productivity Centre offer public non-formal education.

The Scientific and Technical Chamber of Cyprus (ETEK) established the Centre of Continuing Education. Its purpose is to upgrade and reinforce the knowledge of Cypriot engineers. Specialised seminars are offered. There is co-operation with Athens Polytechnic. One of the topics was Geographical Information Systems. The engineers are subsidised by ITA (which approved programmes) or ETEK. The EU has approved in 1998 a Leonardo Da Vinci programme by ETEK for training new scientists, with exchange of scientists from Spain, Greece, Italy, and Cyprus (ETEK, 1999b).

The Cyprus Group of Civil and Mechanical Professional Engineers (Cyprus Branch of the I.C.E. and the I. Mech. E. of the UK), in co-operation with H.T.I. organises several education (part-time courses/seminars) programmes. ITA gives allowances to enterprises participating with their employees.

Environmental management services are offered by "Enalion", a subsidiary company of the Cyprus Development Bank, founded in 1992 with the support of Harvard

University of USA and the World Bank. One of its services is environmental training (Cyprus Development Bank, undated).

British Chevening short-term (normally of around 3 months' duration) awards commenced in 1999. These are offered by the British Government's Foreign and Commonwealth Office to help professionals in employment to undertake short-term studies in Britain relevant to the further development of their careers. The Scholarship Board is particularly interested in the nature of the studies and their application to Cyprus (British Council, 1998).

Short-term training awards (3 weeks to 3 months) for professionals in the private and public sectors have been awarded through the Cyprus America Scholarship Programme since 1984. Applicants must apply for fields relevant to their careers. Civil servants must apply for fields approved by the Government of Cyprus Planning Bureau (Scholarship Board, 1996).

2.4.3 Needs in professionals

The unemployment rate in Cyprus is maintained at relatively low levels and it was 3,1% in 1996. 20,7% of the total unemployed persons were third level education graduates (Rep. of Cyprus, 1998b). Some useful unemployment records in Cyprus in October 1998 were: total number 9888; postgraduate degree university graduates 1,8%; bachelor degree university graduates 8,3%; civil engineers 0,4% (35 of them); and chemical engineers 0,03% (3 of them) (Christodoulidou, 1998).

One of the research studies and surveys undertaken by the Industrial Training Authority annually is the labour market (human resources balance) analysis. It records the trends of previous years and forecasts the additional labour supply and demand in all occupations and skills for Cyprus. The findings of the study are very useful in planning appropriate training activities and promoting other actions for the alleviation of problems in the labour market. A restraint was observed in the sector of construction in 1998. It was estimated that surpluses would occur in 1998 in the occupational category (among others) of university and college graduates (800 persons which is 15% of the total surpluses). Shortages in this category would be 107 persons or 2,5% (ITA, 1998a).

Is university education utilised efficiently in the labour market in Cyprus? Do university graduates match to occupations, taking into account their academic qualifications and their vocational training? University graduates constitute 9,1% of the employed workforce in Cyprus, as compared to 27,8% in the USA. A study entitled "The matching of university graduates to occupations in Cyprus" (Demetriades, *et al.*, 1995) examined how the level and subject of study was related to occupation in Cyprus. It was clear that there was a strong association between the level of education attained and the

occupation an individual is likely to end up in. It was found that 63% of university graduates worked in the professional and technical occupational group. Strong subject of study-occupational matching was found in some subjects: medical and health occupations, architecture, religion/theology, mathematics/ computing and engineering. The findings of this study provide useful information regarding the under-utilization of university graduates in the labour market. These findings are very useful to the planning of a more efficient allocation of the available human resources in the country. Is there a need for new educational policies? In general, the Cyprus data do not provide clear evidence of an inefficient allocation of university graduates in the labour market. Therefore, Demetriades, *et al.* (1995) do not believe that either educational or labour market policy needs reformulating on this score.

2.4.4 The Engineering profession

The civil engineering profession in Cyprus has been regulated by law since 1962. Under this law civil engineers and architects had to be registered by a government appointed Registration Council and only those registered could practice and sign building drawings. There was no distinction between the rights of civil engineers and architects. The same Regulation Council also enforced the Disciplinary Code of Deontology.

Since 1992, a new law has been enforced (Act 224/90 and amendments) under which a self-governing Scientific and Technical Chamber (ETEK) was established. Ten professional disciplines come under this law, namely architects including landscape architects; civil engineers; mechanical engineers; electrical engineers; electronic engineers and software engineers; chemical engineers; mining engineers and applied geologists; topographers/land surveyors; quantity surveyors and building surveyors; and town planners. In accordance with this law, no person can practice as a professional engineer unless registered with ETEK in the appropriate discipline. A strict Code of Deontology is enforced on all members by the Disciplinary Board of ETEK. This Code prohibits advertising and any partnership with non-qualified persons. In accordance with this Code, any assignment from a client/employer must be in writing and it should include the fees payable. For an engineer to register with ETEK, he/she must be a holder of a recognised degree that allows its holder to practice as a professional engineer in the country the degree is awarded. As concerns the UK, persons that begin their studies after the year 2000 will need to follow the four-year MEng (Honours) course. Graduates of Cypriot colleges that continue their studies in the UK must complete them with at least two further years in recognised courses (Chrysanthou, 1998). It should be noted that all engineers working in Cyprus have obtained their undergraduate and postgraduate engineering education abroad.

The Council of Registration of Architects and Civil Engineers does not exist any more. Its responsibilities have been taken over by ETEK. The qualifications needed for registration in civil engineering are according to Act 224/90 of ETEK (ETEK, 1997). There are other laws that refer to the practice of civil engineering. The "Roads and Buildings law" requires that the building drawings submitted to the Licensing Authority should be signed by a registered civil engineer or architect. The "Contractors Law" requires that civil engineers or architects should be employed for large building and construction projects. Other laws refer to the manufacture of ready mixed concrete, Government positions, and so on. It is prohibited by law for a civil engineer to practise as both consultant and contractor. The two functions, even for different projects, are classed as incompatible. The submission of construction drawings by registered civil engineers or architects and the submission of structural calculations by civil engineers is mandatory. Since September 1999, supervision of works is mandatory.

As concerns foreign experts, ETEK is against the use of them in Cyprus in an uncontrolled and opaque manner (ETEK, 1996).

Associations of engineers in Cyprus include the Civil Engineers and Architects Association, Association of Civil Engineers (550 members), Association of Mechanical Engineers, Association of Professional Engineers, and so on.

During the 1985-1994 decade, the number of civil engineers that were registered was about 100 per year. The countries of origin of studies of Cypriot civil engineers and architects were the UK, Greece and USA in this order. Other countries follow (Council of Registration of Architects and Civil Engineers, 1996). The number of civil engineers registered with ETEK in 1998 was about 2100 (Savvides, 1998).

2.5 RESEARCH AND DEVELOPMENT IN CYPRUS

This section deals with research in general; research on water and waste-water engineering is dealt with in Chapters 4 and 5.

Unfortunately, the newest comprehensive and thorough statistical work on research and development (R and D) in Cyprus was carried out in 1991 and 1992 (Dept. of Statistics and Research, 1993). There exists no national legislation on R and D policy formulation. The issue is being considered by the Planning Bureau, which is responsible for administering the Development budget under which many R and D activities are funded. No formal, institutionalised system for determining R and D policy has been set up. There exists, however, a number of government departments and semi-government organisations which engage in R and D and influence R and D policy through their proposals for R and D budgetary allocations. There are initiatives at the level of the

Planning Bureau and the Ministry of Commerce and Industry for the setting up of an R and D Council.

Gross expenditure on R and D work carried out in Cyprus in 1992 was estimated to be C £5,6 million (86% of it is current and 14% capital), which is estimated to be 0,2% of the Gross national product (GNP). Expenditure on world R and D forms 2,55% of GNP, while the corresponding figures for the developed and developing countries stand at 2,92% and 0,64% respectively (UNESCO, 1992). In Cyprus the public sector accounted for 84,4% of total R and D expenditure, compared to 15,6% attributed to the private sector. Most of the contribution of the private sector was the result of activities in the manufacturing sector (73%). On a funding basis, 88,6% of R and D expenditure in the public sector was funded through the government budget. Other sources include overseas funds from the European Community, W.H.O. and UNDP. With regard to the private sector, no special funds were raised for R and D activities; instead, nearly all expenditure was funded by the enterprises' own funds. Within the broad public sector, the main contributors to R and D expenditure were shown to come from the Ministry of Agriculture with a share of 60,5% (mainly through the work of the Agricultural Research Institute), the State General Laboratory of the Ministry of Health with 20,3%, the Cyprus Research Centre of the Ministry of Education with 7,3%, and the Industrial Training Authority with 9,0%. Private R and D activities were largely concentrated in the manufacturing sector. Limited R and D activities were performed in the agriculture, mining and services sectors. Where is the money spent? About four-fifths of current expenditure (86% of total) is directed towards wages and salaries, and contributions to the various employment funds. With regard to capital expenditure, 68% forms expenditure on machinery and equipment, and 29% on buildings and other construction work (Dept. of Statistics and Research, 1993).

The number of employees engaged in R and D activities in Cyprus in 1992 was estimated to be 366 persons, an increase of 7,3% over that recorded in 1991. The public sector had the largest share of R and D effort in terms of human resources (85%). The total number of persons engaged represented 0,13% of the total gainfully employed population for the production of GDP. The number of scientists and engineers engaged in R and D formed 40,2% of the total. The Agricultural Research Institute employed 34% and the State General Laboratory 20% of the total personnel (Dept. of Statistics and Research, 1993).

Within the five-year Development Plan and the guidelines prepared by the Planning Bureau (an independent government service), in co-operation with the major R and D centres/institutions, the priorities are set out to be: agricultural produce and live-stock

varieties; transfer of new industrial technologies; energy management and solar energy applications; water utilization and management; and industrial applications of geology.

The Research Promotion Foundation (R.P.F.) was established in 1996 by the government of Cyprus. Its basic aim is to promote scientific and technological research. It is administered by an administrative board which is appointed by the Council of Ministers. It has created (by governmental allowance) a Fund for Scientific Research for financing research programmes. The Planning Bureau's grant for the R.P.F. was CY£150.000 in 1996 (actual expenditure) and £250.000 in 1998 (appropriated budget) (Rep. of Cyprus, 1998a). During the first year of functioning of the Foundation (1997), the main activities included (a) the elaboration of strategy, the basic aims and priorities of it and (b) the organisation of the first programme of financing research proposals and financing twelve such proposals (out of a total of 67). During the second year of its functioning (1998), the R.P.F. has (a) created data bases on the research community of Cyprus, (b) has reinforced the effort of connecting Cyprus with the European Network Supporting Research and Technology "Quantium", and (c) has organised the Second Programme of Financing Research Proposals with an amount of CY£450.000. The programme includes topics in the sector of agriculture, environment, industry, energy, construction, transport, education, health, information, telecommunications, and social and economic sciences. Coordinators of the research proposals should be working in the private sector. The R.P.F. funds up to 80% of the total budget of a proposal, with a maximum limit of £30.000 (R.P.F., 1998).

One of the aims of the Department of Statistics and Research of the Ministry of Finance is to satisfy needs of international organisations, universities, research centres, and so on. It also offers technical consulting services to other Ministries/Departments for carrying out specialised research work and studies (Min. of Finance, 1998). The Department undertakes research to enhance its capability in undertaking its statistical studies (Dept. of Statistics and Research, 1993).

The Agricultural Research Institute (ARI) is a Department of the Ministry of Agriculture, Natural Resources and the Environment and was established in 1962. It is the sole institution engaged in agricultural research and depends almost exclusively on government funding. Its research activities cover the fields of agronomy, horticulture, plant protection, plant pathology and biotechnology, soils and water use, animal production and agricultural economics. The basic objectives of the research (applied and adaptive) are to provide answers to problems facing agriculture and livestock production. The Institute has well equipped laboratories. It is the national CARIS Centre collating information on on-going research (Agricultural Research Institute, 1998a). The ARI is co-operating with organisations of UN that are occupied with agriculture, especially FAO, other international

organisations (ICARDA, ICRISAT), and with research foundations of other countries in the context of bilateral agreements (Min. of Agriculture, 1997a). Several projects were accepted for co-operation with Greek Institutions.

The Geological Survey Department of the Ministry of Agriculture is carrying out research in the fields of hydrogeology, economic geology, engineering geology and seismology.

The State General Laboratory carries out research to improve analytical methodology and systematic quality control programmes, and to study the level of environmental pollution of drinking water supplies from pesticides and other micropollutants, of veterinary drug residues in meat and animal products, and of radioactivity in drinking water and food.

EOTEK in co-operation with the Technical Chamber of Greece applied for participation in the European environmental programme "LIFE" (which is funding organisations). This effort was also supported by the Ministry of Communications and Works. The proposed programme includes environmental training; study of specialised environmental problems in the Mediterranean; and Environmental Impact Assessments (EOTEK, 1996).

Very few individuals and companies within the private sector were found to be engaged in any formal R and D activities (Dept. of Statistics and Research, 1993). It was then believed, however, that the Customs Union Agreement with the EU, which was then due to abolish tariffs progressively over the next ten years, was bound to stir a change in the field and emphasize the need for upgrading the quality of Cyprus products to European requirements. Major R and D activities within the private sector are carried out by manufacturing industries, as well as selected enterprises in the agricultural, mining and services sectors.

Research is one of the environmental management services offered by "Enalion" a subsidiary company of the Cyprus Development Bank (Cyprus Development Bank, undated). The Bank sponsors scientific and medical research (Cyprus Development Bank, 1998).

Among all university activities, it is research which establishes a university internationally, provides new knowledge to science and, consequently to teaching. Simultaneously, research benefits the wider society, as it is ultimately society's needs that determine the direction and scope of research programmes.

A substantial part of the research activity of the University of Cyprus entails the participation of the academic staff in research programmes funded by external institutions, notably by the EU. It currently (1998-99) participates in 25 European programmes and 13

programmes funded by other external (mainly local) sources. The programmes are: International Cooperation with Developing Countries (INCO-DC), COST, ESPRIT, KIT, Raphael, Socrates, Leonardo Da Vinci, Mediterranean Development Agreements (MEDA), and Grecia Venetia. Also funding has been received for the programme of co-operation between the Planning Bureau of the government of Cyprus and the General Secretariat of Research and Technology of Greece. Research cooperation has also been established with many universities, research centres, institutes and organisations worldwide and especially in Europe, the USA and the Mediterranean region. Within the framework of its contribution to society, the University cooperates with various sectors of Cypriot society on research programmes that are almost exclusively aimed at the social needs of Cyprus (University of Cyprus, 1998).

Members of staff of the Higher Technical Institute are involved in long-term research which is mostly related to the conditions of Cyprus. Examples of such research include: steel fibre concrete for rigid pavements of harbours in Cyprus; durability of aggregates; solar energy; cost effectiveness of thermal insulation in buildings; recycling of grey water; hydrological resources in the Mediterranean, and so on (Stavrides, 1993; Dept. of Statistics and Research, 1993). Only 0.64% of the appropriated budget of 1998 was to be spent on the promotion of research at the Institute. It does not, however, include salaries (Rep. of Cyprus, 1998a).

Frederick Research Centre which is affiliated to Frederick Institute of Technology was established in 1995. The Centre has obtained funding through the Bilateral Cyprus-Greece Research Programme, the Research Promotion Foundation of Cyprus, Leonardo Da Vinci (EU), the Bilateral Greece-France Programme, the Cyprus Organisation of Youth, and own funds. The Centre has established collaboration with the National Centre for Research in Physical Sciences of Athens, Aristotle University of Thessaloniki, the Polytechnic School of Athens, Imperial College of London, TEI of Pireaus (Greece), University of Bremen (Germany), and the Joint Research Centre of the EU. The F.R.C. issues the "Cyprus Journal of Science and Technology" (FRC, 1998).

2.6 SUMMARY AND THE STRATEGY

In this Chapter, the background context to water and waste-water, both globally and in Cyprus, was examined.

The global position in the water and sanitation sector was considered emphasizing on the importance of the sector, the water sources and availability, the water use, the dimensions of the problem, the strategies, and the input of education (in achieving the goals). The global needs, strategies and actions for education, training, research and development at university and professional level followed. Even though there were some

references to the global situation and to developing countries, the emphasis in this section was on European (mostly UK) and North American (mostly USA) practices. The reason is that Cyprus, which is the major case study of this Thesis, is part of Europe, is a “high income” country (World Bank, 1997b), and almost all Cypriot professionals study in Europe and/or North America.

Today, engineers must have skills in computer applications, information technology, management, communications and foreign languages, as well as fundamental engineering skills. Courses for professionals are needed to update them with new technology. Engineers must also grasp the political, economic and social implications of projects. Along with such breadth of knowledge, they must have an increased depth of knowledge in specialty areas, and must keep up with technological advances in methods and materials. With an eye toward the future of engineering education and practice, such a level of knowledge requires a master's degree as the first professional degree for the practice of civil engineering at a professional level. [Note: According to ASCE (1998a), the Board of the American Society of Civil Engineers, supports the Master's as the first professional degree]. A longer formal academic experience will not eliminate the need for continued professional growth. The civil engineering profession is complex and ever changing, requiring all engineers to commit to lifelong learning.

In the sections that concentrated on Cyprus, the following themes were considered: the general characteristics and needs of Cyprus; the water and waste-water situation (the water supply situation, the environmental problems, the future water needs, the waste-water situation, and the strategy and difficulties in the water and waste-water sector); the human resources development (education and training) in general (not in water and waste-water engineering) in Cyprus and of Cypriots; the needs in professionals in general; the engineering profession (emphasizing on civil engineers); and research and development in general (not on water and waste-water engineering).

Referring to the objectives of this research work outlined in the “hypotheses” (section 1.1 on page 1) in the introductory chapter, the first objective was to investigate what is needed and how it will be provided in the water and sanitation sector worldwide as far as human resources development and research is concerned in the field of engineering. The identification of the background context and of the requirements was carried out in the section “Global needs, strategies and actions for education, training and research” in this Chapter. The full details of how education is provided currently at Universities and of research in water and waste-water engineering in various countries will be given in Chapter 5. An account of training organisations (other than Universities) will be presented in Chapter 4. The choice of countries will have to be justified. Both undergraduate and

postgraduate courses should be considered. Apart from water and waste-water engineering courses, other related courses, especially environmental engineering will need to be considered. Matters of interest that have to be identified are: where these studies are offered; degrees; mode and type of study; taught/by research; course content; whether industrial training or time abroad is provided; duration of courses; assessment; funding; professional recognition or accreditation; and research topics.

To deal with the objectives concerning Cyprus, the strategy (in the Chapters that follow) is to identify first the current situation as far as human resources development and research in the sector is concerned. The investigation should include: Who are involved? Responsibility and management? Numbers involved? Ways? Level of achievement or involvement? Time factor? Where? Facilities? Relevance to needs? Finance? Priorities? Priority to human resources development? Needs and future plans is the next step. Where do we want to go? Why something needs to be done? What is it to be done? How do we want to get there? What are the options (considering also what others are doing) and what are we going to do? In particular, the needs and plans that should be identified are: (a) as concerns university education: education gaps, branches of knowledge required and also useful postgraduate courses required by graduate professionals to carry out their duties; (b) shorts courses, seminars and workshops for continuing education or training; and (c) academic research, research as part of employment, and suggestions and plans for beneficial research. The needs, gaps of organisation and plans as identified by authorities need also to be investigated. It is very useful to find out what the needs, characteristics and problems in the water and waste-water systems provision (in general) in Cyprus are, so as to aid in reaching the right conclusions about the provision of human resources development.

The last step in the strategy is how to make recommendations to fulfil needs for Cyprus and whether the findings of this work can be applied in other areas of the world. What are the possibilities for human resources development and research in Cyprus and abroad? Which techniques and technologies, especially innovative ones, can help? Can courses be developed and research promoted according to characteristics and needs of a place? These studies and considerations for devising guidelines should be continuous in the future. Recommendations should be offered to do what will not be done (due to limitations and difficulties) in this study.

CHAPTER THREE

METHODOLOGY OF THE RESEARCH

3.1 INTRODUCTION

The purpose of the methodology is to provide means to address specifically each question or hypothesis that was defined; to elaborate methodologies used, and link them to the stated research aims; to justify the research strategies employed to answer the research questions and objectives being investigated; to include details of the sample and how it was selected; and to decide how the data will be processed.

Published information on the subject of education, training and research in water and waste-water engineering in Cyprus or for Cypriots is scarce. There is unpublished information and thus the research was based largely on primary (or empirical sources) rather than on secondary (published sources). The emphasis was, thus, on surveys (questionnaires) and personal communication (interviews and letters).

As concerns current university courses and research in water and waste-water engineering in various countries, an appropriate combination of primary and secondary sources was used so as to obtain data on this subject.

In this Chapter an indication is given of the main methods and established procedures that were followed to carry out the research work. These were: literature survey (especially of documents by organisations); surveys (questionnaires); personal communication (interviews and letters); and case studies. In the sections that follow, for each method, the following matters were addressed: what data was required and why; how the data was collected and why (giving advantages and/or disadvantages of the method); and how the data was managed or analysed.

3.2 EDUCATIONAL RESEARCH

The subject of educational research, development and innovation was considered. The topics regarding educational research that were investigated include : nature, principles, policies, practices, perspectives in education, map of it, resources, philosophy, reporting, role in educational change, planning, methodology, design, new developments, approaches, sampling, sample design in surveys, how to conduct surveys, data collection, data analysis, and practices in case studies. It is noted that a few of the references were published in Cyprus. A standard work on educational research is Borg and Gall (1989) which helps in clarifying the approach. Reference was made to Cohen and Manion (1994) for guidance.

When the term educational research is used, the application of the principles of a science of behaviour (Cohen and Manion, 1994) to the problems of teaching and learning

within the formal educational framework is considered. The particular value of scientific research in education is that it will enable educators to develop the kind of sound knowledge base that characterise other professions and disciplines; and one that will ensure education a maturity and sense of progression.

The relationship between research, policy and practice in education is one of interdependence and interaction. There are many ways in which research can make its contribution. Policy makers and teachers tend to look to research to provide answers to their problems; but research can perform this function only where there is consensus on values, within the framework of accepted policy, or in the context of established practice (Nisbet and Nisbet, 1985). Practical outcomes from educational research should be ensured (Shipman, 1985).

By methods, we mean that range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction (Cohen and Manion, 1994). Kaplan (1973) suggests that the aim of methodology is to help us to understand, in the broadest possible terms, not the products of scientific enquiry but the process itself. In choosing between qualitative and quantitative data, the problem becomes one of determining at which points they should adopt the one, and at which the other, approach.

According to Evans (1984), the types of research are: a survey of literature; a survey of educational practices or opinions; case studies; sociometric study of a group; sociological studies; comparisons of teaching methods; correlational studies; studies of children's thinking; and long-term studies. Cohen and Manion (1994) suggest the following research methods in education: historical research; developmental research; surveys; case studies; correlational research; ex post facto research; experiments, quasi-experiments and single-case research; action research; accounts; triangulation; role-playing; the interview; personal constructs; and multidimensional measurement.

Preliminaries to research include: choosing a field of research; some useful sources of information; background reading; and formulating a title. Planning experimental work involves defining the topic, choosing the method, choosing the subjects, choosing the tests, deciding how to work out the results, statistical techniques, making a pilot study and settling the details. Reporting research involves writing as thesis and articles.

Educational research does not have a long history in Cyprus. Much depends on the initiative of individuals. The contributions in Metzger (1984) showed that the results of the research work included there had a strong and direct relation to educational and paedagogical problems.

3.3 LITERATURE SURVEY

The purpose of the literature survey was to include the essential background reading. It covered both the actual field of research plus the methodological sources. Journals in the field were not neglected because they are more up-to-date than most books. The published references that were used can be categorised as follows.

a) 'Library' books and journals

These books, Conference/Workshop Proceedings, Encyclopaedias, Dictionaries, Handbooks, Directories, Theses and Journals were mostly used as background reading to deal with the global position in water and waste-water; University curriculum development, training and research (in general; in Engineering; in Civil and Environmental Engineering; and in Water and Waste-Water Engineering); educational research methods; university courses and research in water and waste-water engineering; concepts; water and waste-water situation in Cyprus; characteristics of Cyprus; and human resources development and research in Cyprus.

b) University prospectuses and reports

University prospectuses and reports were used to obtain information for university courses and research in water engineering, waste-water engineering and environmental engineering. One question that is raised is how helpful prospectuses are for engineers. One problem with them is that they do not contain details of the syllabuses they offer.

c) Written Documents by organisations

The documents take the form of the latest annual reports/reviews; three-year reports; statements of activities; bulletins; reports on planning, programmes, policies, procedures and services; profiles; catalogues (for example, of standards); the Gazette; legislation; development budgets; and statistics. These could be obtained directly from governmental, semi-governmental and non-governmental organisations. They usually contain information related to these organisations. These contain information on the global position on water and waste-water; human resources development world-wide; characteristics of Cyprus; the water and waste-water situation in Cyprus; human resources development in general and in the sector in Cyprus; needs of professionals; the Engineering profession; research; continuing education and short courses and seminars; and sponsorship.

d) Press reports

The ones used contain information mostly on the water and waste-water situation in Cyprus and world-wide; and on the engineering profession.

e) Use of the Internet.

3.4 SURVEYS (QUESTIONNAIRES)

3.4.1 Purpose and collection of information

Typically, surveys gather data at a particular point in time with the intention of (a) describing the nature of existing conditions, or (b) identifying standards against which existing conditions can be compared, or (c) determining the relationships that exist between specific events. A survey's general purpose must be translated into a specific central aim and also into an identification and itemising of subsidiary topics that relate to its central purpose.

The mail questionnaire (this section) and the interview (section 3.5 on page 59) were the methods of survey employed in this study.

The central aim of the Questionnaires of the author of this Thesis was to design and pilot a 'needs analysis' survey of a range of Cypriot water and waste-water engineering professionals. More specifically, the objectives were to find out what qualifications and experience (education, training, employment and co-operation with foreign experts) the professionals possess and what research they have carried out; what their plans and prospects for the future are; to specify gaps in the education they received; whether they use what they have learned and whether they want/need any other knowledge; and to specify problems faced in the field of water/waste-water in Cyprus and what research in the field is needed so as to obtain benefits for Cyprus.

The chief advantage of the mail questionnaire as compared to interview schedules is cheapness and saving of time. The processing and analysis are usually also simpler and cheaper than in the case of interviews. Another advantage is that often a much larger sample can be covered at a modest increase in cost.

Two main questionnaires were sent to individual professionals working in water and waste-water engineering in Cyprus in 1996 and 1997. Questionnaire I was sent to 151 persons. Questionnaire II was sent to all those persons (63) that answered Questionnaire I. The questionnaires were sent to civil engineers, environmental/public health engineers, hydrologists/hydrogeologists, surveying/agricultural/irrigation engineers, chemical/biochemical engineers/chemists, biologists, and environmental designers.

Questionnaires and introductory (covering) letters (see Tables 1 and 2 of Appendix A on pp. 175 and 176 and Tables 1 and 2 of Appendix B on pp. 182 and 183) were prepared and sent out in either the English or the Greek languages to assist respondents. Stamped self-addressed return envelopes were enclosed to help and encourage people to respond.

3.4.2 Nature and size of sample

In regard to the nature and size of the sample, this can have a bearing on the outcome. The problem is to ensure that the sample is as representative as possible of the target population. If a cook samples the soup without first stirring it up, the spoonful that is tasted may not truly indicate the quality.

The sample was quite representative of the various trends. There were respondents of different ages, sex, geographical location, academic qualifications, professional experience, and type of work involved.

The sample was a targeted selection. Questionnaires were sent to all those people that could be identified that were involved to a certain degree with water and waste-water. No other criterion was used to select them. 71% of the respondents to Questionnaire I were involved in water or waste-water engineering, 25% were involved to some extent, and 2% were just interested. Three-quarters of the respondents to Questionnaire II were fully involved in water/waste-water engineering/management. One-quarter of them was involved to some extent.

Questionnaires were sent to persons working in the governmental Water Development Department (WDD), the governmental Public Works Department (PWD), Town Water Boards, Town Sewerage Boards, Municipalities, the governmental Town Planning and Housing Department, the State General Laboratory, governmental tertiary education and the private sector (consultancy, laboratories, project engineering and educational institutions). Questionnaires were also sent to all Members or Fellows of the Chartered Institution of Water and Environmental Management (CIWEM) of the UK.

The great majority of the persons that answered the questionnaires were civil engineers (70% in Questionnaire I and 72% in Questionnaire II). See Table 3 of Appendix A and Appendix B. 13% of the respondents were members of CIWEM. 63% of all respondents of Questionnaire I worked in the governmental sector and 11% in municipalities and town boards. The majority (51%) was employed in WDD. (See Table 4 of Appendix A). The same result for the WDD applied in Questionnaire II. In this one, 28% were employed or self-employed in the private sector. Most of the projects where the respondents were employed involved water projects (60%) and to a lesser extent waste-water projects (22%). Full lists are given on Tables 3 and 4 of Appendix B.

According to Cohen and Manion (1994), a well-planned postal survey should obtain at least a 40 per cent response rate.

The response rates were 42% for Questionnaire I and 51% for Questionnaire II, which are satisfactory. The rate for Questionnaire II was higher because it was sent to

those persons that answered Questionnaire I. Some people did not answer the questionnaire because they felt it does not concern them because they are not fully involved in the sector.

The response rates were relatively high because the questionnaires looked easy and attractive; the wording was clear and the design was simple; the contents of the questionnaires were arranged in such a way as to maximise co-operation; the practice of subletting questions was used; and a covering letter and a stamped envelope for the respondent's reply were enclosed.

The exact number of professionals involved in water/waste-water in Cyprus is not known. A reasonable estimate could be obtained by considering results of a previous questionnaire of the writer (Michaelides, 1993) involving a sample of 100 civil engineers. In that case, questionnaires were sent to half the members of the Association of Civil Engineers and Architects of Cyprus, and the response rate was 28%. (The procedure of choosing the sample was as follows. The complete list of Members of the Association was obtained; the total number was about 715 that time. Questionnaires were sent randomly to Members till 100 answers were received. Questionnaires were actually sent to half the Members (that is a total of 357) so as to get those 100 answers). Some results follow: only 6% of professionals studied hydraulic engineering or structures at post-graduate level; 17% of academic research related to Cyprus was related to the sector; 9% of interest/planning for future academic research was related to sector; 2% of respondents working for private companies (70% of total) were employed in the sector; 25% of respondents working in non-private jobs (30% of total) were employed in the sector; 15% of respondents needed the subject of public health or environmental engineering and 11% the subject of water resources engineering (among other subjects) to carry out their duties in their present employment; 7% of respondents were interested to study waste-water engineering and 3% water engineering at postgraduate level as it would/could be useful for their work. Based on these results, it is estimated that 9% of civil engineers in Cyprus are involved in the sector. Since there are about 2100 civil engineers (see page 42) nowadays in Cyprus (Savvides, 1998), the number is about 190. If all professionals are considered, then it is estimated that the number of professionals in the sector in Cyprus should not exceed 300. The writer has identified about 150 of them.

3.4.3 Sampling error and sample distribution

It may be assumed that only those persons who were sufficiently keen to do so bothered to send in a completed questionnaire. They could therefore be regarded as 'biased'. However, a sampling error (Berenson, *et al.*, 1988) of less than ± 10 per cent (Table 3.1) was deemed to be acceptable. A sample size of about 75 would be enough. The results of Questionnaire

Table 3.1 Finding sampling error

$$e = \frac{Z_{\alpha/2}}{2 \sqrt{n}} \sqrt{\frac{N - n}{N - 1}}$$

This formula considers maximum error (since no prior idea of results).

e = sampling error

$Z_{\alpha/2}$ = upper alpha half point of the standard normal.

N = population size

n = sample size

In our case,

$Z_{\alpha/2} = 1.96$ since confidence level = 95% (found from table)

$N = 300$

$n_1 = 63$ (for Questionnaire I)

$n_2 = 32$ (for Questionnaire II)

$$\text{Therefore, } e_1 = \pm \frac{1.96}{2 \sqrt{63}} \sqrt{\frac{300 - 63}{300 - 1}} = \pm 10.99\%$$

for Questionnaire I

$$\text{and } e_2 = \pm \frac{1.96}{2 \sqrt{32}} \sqrt{\frac{300 - 32}{300 - 1}} = \pm 16.4\%$$

for Questionnaire II

Thus, the results could be wrong by $\pm 10.99\%$ or 16.4% .

[Note: If $n = 100$, then $e = 8\%$
If $n = 75$, then $e = 9.8\%$]

Note: 95% confidence means that if the study were done 100 times, we expect 95 times to get within intervals of estimates.

Source: Berenson, *et al.*, 1988.

I could be wrong by 11% and those of Questionnaire II by 15% for a confidence level of 95%. Unfortunately the sample size of Questionnaire II was rather small.

The important point about response rates is not the size of the sample, but the possibility of bias. This is because almost invariably the returns are not entirely representative of the original sample drawn; non-response is not a random process; it has its own determinants, which vary from survey to survey. Respondents were, thus, compared with non-respondents on the original sampling list to find out whether and in what way a bias has been introduced.

Oppenheim (1966) makes suggestions to find out whether and in what way a bias has been introduced: by comparing respondents with non-respondents on the original sampling list in terms of geographical location, first letter of family name, sex, type of qualification, and so on.

Taking the first letter of family name, the rate of response of the first five most frequent letters (57% of all first questionnaires and 60% of all second questionnaires sent out) was 27%, 58%, 39%, 53% and 46% for Questionnaire I and 83%, 45%, 29%, 25% and 50% for Questionnaire II. If these are compared to the average response rates (42% and 51% for Questionnaires I and II respectively), then there is some bias perhaps due to the relatively small size. What follows is the percentage proportion of the number of responses for each letter (Questionnaire I) as compared to the total responses, and in the brackets is the proportion of the number of questionnaires sent out for each letter as compared to the total sent out: 9.5 (8.5), 1.6 (2.6), 4.8 (3.9), 0 (2.6), 0 (0), 0 (0.7), 0 (1.3), 4.8 (3.9), 6.3 (5.9), 17.5 (12.4), 3.2 (3.9), 4.8 (5.9), 7.9 (5.9), 0 (0), 0 (0.7), 9.5 (14.4), 0 (0.7), 12.7 (9.8), 4.8 (3.2), 0 (0), 1.6 (2.0), 11.1 (11.8), 0 (0), 0 (0). The proportions do not show significant differences.

A comparison in terms of sex shows that 15.9% of the original sampling list were females and that 17.5% (in Questionnaire I) and 15.6% (in Questionnaire II) of the respondents were females, which is close. 45.8% of females responded as compared to 40.9% of males. Concluding, care will need to be taken on the use of the data (if for example, it is used to design programmes) because of sample size and also 'bias' in those that answered the questionnaires.

3.4.4 Designing the questionnaire

Questionnaires look easy to construct, but they are not. They are even harder to analyse. Methods are only as good as the instrument they produce; there are no easy shortcuts to good, reliable and valid research findings.

A separate introductory letter explaining to the sample the aim and purpose of the questionnaire (and this research study in general) was sent together with each of the mail

questionnaires. The reason is that people to whom the questionnaire was sent would want to know why questions were being asked and what sort of answers were required. They would also wish to know what would be done with their answers and why they were asked the particular questions. Only when they understand the purpose of the questions would it be likely that meaningful answers would be obtained. The 'introductory letters' are shown in Appendices A and B (pages 175 and 182).

Oppenheim (1966) considers that data obtained by means of interviews and questionnaires should always be regarded as confidential, in the sense that no responses or findings should ever be published which could be traced back to particular individuals. Generally some people may become suspicious of the researcher's motives and then give unhelpful answers. In this particular case, however, it is quite unlikely that any of the respondents (or only very few) would be suspicious or consider any of the information as confidential. The prospective respondents were not asked to remain anonymous if they so wished. Even though, it is customary for questionnaires to be answered anonymously, it is more helpful for the researcher to know who the respondents are for further contacts.

Based on the aims of this research study (Chapter 1), a check list of all the points that there was a need to ask questions about was made. When satisfied that everything necessary, and nothing superfluous, was included then the design of the questions themselves began. There was a need to consider not just what was being asked but also what was the most appropriate format for the questions and the most suitable answering procedure.

The researcher was well aware that the actual questions to present to the respondents should be drafted in such a way that they are understood by the respondents; the respondents should interpret the questions to have the same meaning that the researcher considers they have; each question covers precisely one concept; the questions can be answered quickly and simply; the answers can be interpreted and analysed by the researcher quickly and simply; and the format of the questions and answers lends itself to straightforward statistical analysis without tedious extraction of meaning.

An important factor in questionnaire design is the nature of the target population. People fall into two categories in regard to questionnaires, one group being much smaller than the other. The smaller group consists of people who avidly fill in questionnaires with enjoyment. The larger group consists of those who resent being asked and who cannot bear to waste time on irrelevancies and who get impatient with long, seemingly tedious questions. For those people questionnaires have to be made attractive, simple, easy and quick to answer. According to Oppenheim (1966), one cannot be dogmatic about the number of pages that 'cannot' be exceeded. To make it useful it has to be perceived as

useful and not a waste of time. That is why designing questionnaires is as much an art as a science.

Two questionnaires were sent out to avoid a single lengthy one. In addition, one of the questions in Questionnaire I was for the respondents to suggest other professionals involved in the sector. One reason was to increase the sample size. Another reason was in case a person receiving the questionnaire was not the right one.

When the questionnaires had been designed and constructed with the desired design specifications in mind, there was a need to test it out. The draft questionnaire was given to two persons who would form the experimental group to see if they had any difficulty answering it and if the answers they gave to the questions were of the kind expected.

Emphasis was given to questions relevant to the characteristics and needs (context) of Cyprus. The questions were fully related to the context of the subject area of water and waste-water.

One of the problems in the collection of information was the differing interpretation of some definitions. There was the possibility that some respondents could misunderstand the meaning of 'research' and 'training'. In fact it was only the question on 'training' that produced some misunderstandings.

In various questions, the respondents were asked to specify by giving them alternatives plus the option of 'other', for example in Question 2 of Questionnaire I and in Questions 3(b), 4(a), 4(b) and 8(b) of Questionnaire II. In some other questions, options were not specified (for example, Questions 6 and 7 of Questionnaire II) because a) it would make the questionnaire too long, b) it was difficult to prepare such a list of options, and c) respondents could be 'guided'. Respondents were sometimes asked to give priorities (for example, Questions 7 and 8(b) of Questionnaire II).

As concerns the 'employment record' of the respondents, they were asked to give information only for the last five years since (a) it would not be so useful if they gave the full record, and b) it would be too long.

It might be considered desirable to get into detail regarding the content of each subject of the syllabus but that would be far too lengthy to ask in a questionnaire. It was considered to be more useful to obtain details of research required. Questions 2, 3, 4 of Questionnaire II give an indication of how important each subject is (based on the answers given on the nature of their job, the subjects required to carry out their duties, and the postgraduate courses that would/could be useful for their present or future work) but not what the content of each subject should be. How important each subject is can be of practical use since the time allocated for it at University can be estimated and even whether a subject should be included at all.

People were invited to expand NO answers (Questions 4(c), 5(b) and 9 of Questionnaire II) as well as the YES answers. Reasons for not wanting some of the activities that you are investigating could be as (or more) informative than the expanded YES answers. There were no questions about the participation of respondents in seminars/conferences or in committees since this information was obtained through other ways: literature survey; case studies; and contacts with organisations (structured discussions or interviews) or with individuals.

3.4.5 Processing survey data

Once the responses have been received, the task of the researcher is editing and coding (Cohen and Manion, 1994). The questionnaires have to be checked and this is referred to as editing. Errors by respondents have to be identified and eliminated. The central tasks are completeness, accuracy and uniformity. The primary task of data reduction is coding, that is, assigning a code number to each answer to a survey question. Of course, not all answers to survey questions can be reduced to code numbers. For open-ended questions, a coding frame has to be devised after the completion of the questionnaire.

3.5 PERSONAL COMMUNICATION

3.5.1 The interview

The interview as a research technique is normally considered as one of a range of survey methods. In the case of this research study, the interview (or letter writing) has been used as a means of gathering data. Interviews as research tools range from the formal interview (standardised schedule), the less formal interviews, the completely informal interview, and the non-directive interview (Cohen and Manion, 1994). In the latter, the interviewer takes on a subordinate role.

The research interview has been defined (Cannell and Kahn, 1968) as 'a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives of systematic description, prediction or explanation'. There are relative merits of interviewing versus questionnaire. One advantage is that the interview allows for greater depth than is the case with other methods of data collection. A disadvantage, on the other hand, is that it is prone to subjectivity and bias on the part of the interviewer. There are four kinds of interview that may be used specifically as research tools: the structured interview; the unstructured interview; the non-directive interview; and the focused interview.

In the case of this research study, a list of organisations was prepared depending on the information/data to be gathered. For organisations overseas, letters were sent. For

organisations in Cyprus, interviews were arranged with representatives/professionals employed by these organisations by first (in most cases) writing letters to these organisations. See Appendix C on page 193. The letters included brief questionnaires. The interviews were carefully planned as structured discussions or interviews that were based around the letters/questionnaires. Each organisation was asked a number of key issues/points. The questions reflected what the researcher was trying to find. Some organisations answered in writing. Some information was obtained by telephoning.

3.5.2 Organisations

The organisations that were contacted could be grouped as follows:

- a) Academic institutions overseas (South Europe, the UK, the USA, Canada, Australia, some Asian countries) and in Cyprus;
- b) Water and Waste-Water Organisations in Cyprus (Water Development Department, Town Water Boards, Town Sewerage Boards);
- c) Other related (to sector) organisations in Cyprus (Town Planning and Housing Department, Public Works Department, Department of Geological Survey, State General Laboratory, Environment Service of Ministry of Agriculture, the Cyprus Standards and Control of Quality Organisation, Municipalities, District Administrations, Ministry of Finance);
- d) Human Resources development organisations in Cyprus (Industrial Training Authority);
- e) Research establishments in Cyprus other than academic institutions (Agricultural Research Institute, Department of Statistics and Research);
- f) National planners in Cyprus (Planning Bureau);
- g) Funders of education, training, research and development in Cyprus (Research Promotion Foundation, the Scholarship Board, the Cyprus Development Bank, European Union office in Cyprus);
- h) Education organisation in Cyprus (Ministry of Education);
- i) Professional Organisations in Cyprus (Scientific and Technical Chamber of Cyprus, Association of Civil Engineers and Architects of Cyprus, Association of Civil Engineers of Cyprus, etc.);
- j) Private industry (Consultants, Contractors, Laboratories);
- k) Professional institutions/societies overseas (e.g. Chartered Institution of Water and Environmental Management of the UK, American Society for Engineering Education, Engineering Council of UK, Institution of Civil Engineers of UK, American Society of Civil Engineers, Institution of Engineers of Australia); and

- l) Funders of research and development overseas/from overseas (e.g. World Bank, UNDP, UNESCO, WHO, EU, ODA, British Council, Fulbright Commission, International Development Research Centre, UNESCO, International Water and Sanitation Centre (IRC), multi-governmental and foreign institutions in Cyprus).

3.6 CASE STUDIES

Much of this work is a study with particular reference to the situation in Cyprus as concerns education, training and research in water and waste-water engineering.

As concerns current University courses and research in water and waste-water engineering, case studies of other countries have been carried out because all Cypriot professionals obtain their university education in engineering overseas. The intention was to carry out case studies of South European countries (especially Greece), the UK, the USA, Canada, Australia and some Asian countries (Singapore, Malaysia) because: (a) Cypriots study mostly there (UK, USA, Greece); (b) of the language (Greek and English); (c) many Cypriots live there (UK, Greece, USA, Canada, Australia); (d) of cultural and other links with Cyprus (Greece, UK); (e) of climatic and socio-economic similarities with Cyprus (South Europe); (f) of the prospects of Cyprus in joining the European Union (South Europe, UK); (g) of similar development problems (South Europe, Singapore, Malaysia) and so on. Unfortunately, a study for South Europe was not realised since the information collected was incomplete.

As concerns the potential (achievements so far) and the future needs and plans of human resources in water and waste-water engineering in Cyprus, various governmental, semi-governmental and (to a lesser extent) private organisations were contacted to obtain the required information (see section 3.5 on interviews on page 59 and section 3.3 on literature survey on page 51). The survey of professionals (section 3.4 on page 52) was also very useful.

The Water Development Department (WDD) of the Ministry of Agriculture, Natural Resources and the Environment was the organisation selected by the researcher to be the primary case study since it is the biggest employer of professionals involved in the sector. Practices in education, training, and research of the human resources and matters such as funding and facilities provided were examined.

The cases of all towns in Cyprus were investigated. Information was provided through all the Water Boards, all Sewerage Boards, and in some cases the municipalities.

To be exact, what was done was not a full case study; instead, some issues/variables were considered. In other words, it is a study with particular reference to Cyprus, but does not follow a case-study approach.

3.7 SUMMARY

After the subject of educational research, development and innovation was considered in general, the methodologies used to carry out the research work were elaborated. The main methods employed were: literature survey; surveys (questionnaires); personal communication; and case studies. The categories of published references that were used were 'library' books and journals, university prospectuses and reports, documents by organisations, press reports and the Internet. As concerns surveys, two mail questionnaires were sent to individual professionals. Facts about the collection of information, nature and size of sampling, sampling error and sample distribution, designing the questionnaire and processing survey data were given and discussed in this Chapter. Personal communication involved writing letters to organisations and interviewing (in structured discussions) representatives of organisations. The specific case studies that were prepared in this research work were also discussed.

CHAPTER FOUR
POTENTIAL OF HUMAN RESOURCES IN
WATER AND WASTE-WATER
ENGINEERING IN CYPRUS

4.1 INTRODUCTION

This chapter refers to the achievements and involvement so far of professionals (university graduates) in education, training and research working in the field of water and waste-water engineering in Cyprus. General human resources development in Cyprus and of Cypriots concerning education, training and research are considered in sections 2.4 (on page 35) and 2.5 (on page 42). Current university courses and research in water and wastewater engineering are dealt with in Chapter 5.

The information for sections 4.2 to 4.7 was mostly obtained from the Questionnaires for individual professionals (Michaelides, 1998a and Michaelides, 1998b). Facts for the rest of the sections of this chapter were obtained from organisations. A range of organisations (governmental, semi-governmental, industrial, multi-governmental, foreign, training, research, funding agencies, and so on) were contacted to provide information especially on how, why and when they established and fund their training and research facilities. The emphasis was given on the current personnel of institutions: how they manage; the priority they give to education, training and research; numbers; whether sent abroad by water authorities; training budget (priorities; how training prioritised; responsibility and management; funding; funding from overseas); who commissions and funds research; and facilities (for example laboratories) for courses and research.

4.2 NUMBERS OF PROFESSIONALS

Numbers of civil engineers were given in section 2.4.4 (on page 41). There are no statistics of professionals involved in water and waste-water engineering in Cyprus. An earlier study by the researcher (Michaelides, 1993) on civil engineering professionals assisted in making an estimate. The results of surveys employing questionnaires showed the following proportions of water/waste-water engineers to the total number of civil engineers: training courses 11%; postgraduate level courses or research 7%; academic research related to needs and characteristics of Cyprus 17%; interest or planning for future academic research related to needs and characteristics of Cyprus 13%; present employment (branch or subject required to carry out duties) 11-15%; interest for postgraduate courses to follow that would/could be useful for present or future work 10%; and interest to research as part of employment in Cyprus 5%. It is estimated that about 10% of the civil engineers are involved in water and waste-water engineering.

4.3 ACADEMIC QUALIFICATIONS

The information concerning studies includes: what degree professionals possess; where and when it was obtained; whether in progress; the mode of study; the titles of courses if not fully by research; the proportion of research; and sponsoring. The answers are derived from Questionnaire I of individual professionals as carried out by the researcher (Appendix A).

Reference is made to academic qualifications in water/waste-water engineering/management. The proportion of people involved is 44% of the respondents to the Questionnaire. The number of programmes (courses and/or research) is 39.

The degree level of the various programmes is shown on Table 5 of Appendix A on page 179. These results show that about half of the programmes of study were followed at master's level.

About half of these programmes were followed in the UK and one-fifth in the USA. Analytically, these results are shown on Table 5 of Appendix A.

The programmes were followed over the years 1966-1995. 8% of them are in progress.

87% of the programmes were followed on a full-time basis, and 10% on a part-time basis. It is noteworthy that part-time studies is a recent trend. Three-quarters of them are in progress.

Table 5 of Appendix A shows the list of courses attended (only those that were attended 'by course').

The main sponsors of academic studies originate from: own (student's) funds 26% of the total number of programmes, UK 18%, USA 16%, Cyprus 10%. The most important sponsors are: own funds 26%, Fulbright Commission 13%, British Council and British Government 10% and Cyprus government 5%. A wide selection (another 13 of them) of sponsors complete the list. Needs and future plans are considered in section 6.2.

4.4 ACADEMIC RESEARCH

4.4.1 General

Following the analysis of section 4.3, 77% of the programmes involve course/research exclusively on water/waste-water, and 26% involve research only. 21% of the programmes is academic research related to the characteristics and needs of Cyprus (see section that follows). As far as research work is concerned, 63% is concerned with water engineering, 31% with waste-water engineering and 6% with both.

4.4.2 Work related to characteristics and needs of Cyprus

Following the analysis of section 4.4.1, 8 persons (13% of the total number of respondents) are involved with academic research work in the field of water/waste-water

related to the needs and characteristics of Cyprus. As concerns academic programmes, 21% of the total number of academic programmes are related to the characteristics and needs of Cyprus. The degree level is : Post-doctoral 1, Ph. D. 2, M. Phil. 2, M. Sc. 1 and MBA 1. Half of them (on Cyprus) are on a full-time basis, and 38% are still in progress. 63% of the programmes (on Cyprus) involve only research work. The rest involve a general course that includes a thesis related to Cyprus. Half of them (on Cyprus) were/are carried out in British Universities and the rest in Greece, Cyprus, USA and Bulgaria. 10% of the total number of respondents published their work. The list of research projects on Cyprus is shown on Table 6 of Appendix A (page 180). Needs and future plans are considered in section 6.4 (page 120).

4.5 TRAINING

Training is defined here as development of human resources other than formal education (at University). Some of the respondents to the Questionnaire could misunderstand the meaning of 'training'. It is perhaps the only word in the Questionnaire that could create a problem of understanding. The statistics that follow are derived from the answers of individual professionals to Questionnaire II.

Only 19% of the respondents said they had training in the field of water/waste-water. 56% had no training but 28% of these said that training is their employment. No answer was given by 25% of the specimen. 88% stated that the training they had was appropriate to the characteristics and needs of Cyprus. The duration of training varied from 4 weeks to 1 ½ years, and the average duration was 5 months.

Further information on training is given in sections 4.8 to 4.14 on organisations.

4.6 EMPLOYMENT AND RESEARCH AS PART OF IT

Information on the employment of respondents to Questionnaire II is given in section 3.4 (page 53) on methodology.

The engineers/scientists were asked in Questionnaire II whether they were/are doing any research as part of their present/previous job in the field of water/waste-water in Cyprus. A positive answer was given by 34% of the respondents, a negative one by 56%, and no answer at all by 9%. 91% of those that answered positively gave titles of the research work as follows.

- (a) Hydrology of small catchments of different physical and geomorphological characteristics.
- (b) Water policy and groundwater management.
- (c) Leakage control methods.
- (d) Saving water.
- (e) Determination of pesticides in groundwater.

- (f) Effect of discharge of rainwater on beach quality.
- (g) Development of environmental monitoring systems.
- (h) Artificial recharge of ground water.
- (i) Disposal and re-use of treated effluent.
- (j) Solidification of industrial sludges.

This research was/is funded by the government of Cyprus (40% of cases); the European Union (30%); the researcher and the governmental Planning Bureau (10%); Nicosia Water Board (10%); and British Bases (10%).

As far as the duration is concerned, in 55% of the cases it lasted/will last 6 months to 3 years; in 18% of the cases it was open or on going depending on funds; and there was no answer in 27% of the cases.

Results on future plans of researchers are given in section 6.4.2 (page 120). Further information on research is given in sections 4.8 to 4.13 on organisations.

4.7 CO-OPERATION WITH FOREIGN EXPERTS

The respondents to Questionnaire II were asked whether they co-operate with foreign experts on training, research, seminars, design/implementation of projects in the field of water/waste-water in Cyprus. Two-thirds of the respondents answered 'yes', one-fourth answered 'no' and there was no answer by 9%.

Some answers were general in character.

- The government employs experts in various projects.
- Consultants are hired to design and supervise works.
- Most water resources projects are carried out in association with foreign experts.
- Various consulting Engineers that the Water Development Department (WDD) employs.
- European organisations.

Other answers were specific.

- 'Water Training International' of the UK involved in various projects.
- 'Water Training International' of the UK [Project: Borehole design and maintenance].
- Howard Humphreys (UK), RKL (UK), ACER, etc. [Design of projects: Southern Conveyor Project, Vassilikos-Pentaskinos Project, etc.].
- Howard Humphreys (UK). [Project: construction of Arminou Dam].
- Howard Humphreys (UK). [Project: Larnaca Wastewater Disposal system].
- Loughborough University of UK. [Proposals for European Union funding on 'Waste water re-use'].

- Loughborough University of UK. [Project: to develop a water resource management model].
- International Water Quality Association. [Project: Treatment of industrial wastewaters].
- Anglian Water Group, Biwater, etc. [Projects: Dhekelia Desalination Plant; Water Treatment Plant (Limassol), etc.
- US Bureau of Reclamation. [Project: Management of Southern Conveyor Project].
- RIVM Institute of Netherlands ['Life' Programme of European Union: Monitoring of surface water quality].
- WS Atkins, Hansen and Sawyer [various projects].
- Various companies in making proposals [Project: Submerged breakwaters].

If the answer is 'no', the reasons as given by some of the respondents are as follows.

- There is technical knowledge in Cyprus.
- Not relevant to present job.
- Only obtaining information on water/waste-water treatment and management from the UK and other European Universities.

Further information on foreign experts is given also in other sections of this chapter.

4.8 GOVERNMENTAL ORGANISATIONS

4.8.1 General

Table 4.1 shows a Summary Table for organisations and their responsibility.

4.8.2 Water Development Department

The Water Development Department (WDD) was established in 1896. WDD is responsible for implementing the water policy of the Ministry of Agriculture, Natural Resources and Environment with the objective of the rational development and management of the water resources of Cyprus (WDD, 1996).

The Department is staffed by technical officers with wide professional experience, such as civil engineers, topographer irrigation engineers, hydrologists, sanitary engineers, electrical / mechanical engineers, geologists and chemists. It employed 70 professionals (university graduates) in 1994 (Ministry of Agriculture, 1995a) and 71 professionals in 1995 and 1996 (Ministry of Agriculture, 1996a; Ministry of Agriculture, 1997a).

The facilities of the WDD include a Soils, Concrete and Materials Laboratory and a Water Treatment and Hydrology Laboratories (Ministry of Agriculture, 1996a).

Table 4.1 Summary of governmental and semi-governmental organisations in Cyprus

Index: G = Governmental; SG = Semi-governmental

Organisation	G/SG	Responsibility (concerning water/waste-water)
Water Development Department	G	Rational development and management of water resources
Agricultural Research Institute	G	Research on water use in agriculture
Geological Survey Department	G	Identification and rational exploitation of groundwater sources; foundations of water development projects; disposal of waste-water
Branch of Land and Water Use, Department of Agriculture	G	Programmes of irrigation to save water and for rational use of water by farmers
Department of Fisheries	G	Pollution of water (monitoring and prevention)
Information, Natural Resources and Remote sensing Centre	G	Information provided; water resources identified
Branch of Laboratory Analyses, Department of Agriculture	G	Analyses of water samples for rational use of water resources for agricultural purposes
State General Laboratory	G	Monitoring and research on contamination of water
Planning Bureau	G	Evaluating proposals of other Depts. And taking decisions
Organisation for Standards and Control of Quality	G	Standardisation activities
State Scholarships	G	Selection of candidates for scholarships
Water Boards of towns	SG	Controlling water networks in towns
Sewerage Boards of towns	SG	Planning, design and operation of sewers and treatment plants
Industrial Training Authority	SG	Subsidising training programmes
Research Promotion Foundation	SG	Financing research

The WDD has arranged for its personnel training programmes in Cyprus. These are shown on Table 4.2 for 1997 (Socratous, 1997) and on Table 4.3 for 1998 (Socratous, 1998).

It should be noted that 64% of the duration of programmes for which information exists on duration, was spent on computer programmes. The time share allocated for the rest of the programmes was as follows: internet 7%; European Union 6%; telemetry 5 ½ %; G.I.S. 4%; Turkish language 4%; building materials 3%; Q.S. 2 ½ %; human relations 1%; contracts 1%; irrigation 1%; and expropriations 0.3%.

There are, also, cases when WDD professionals offer training programmes/seminars as experts (Kambanellas, 1999).

The WDD is involved with research as follows. The Hydrology Division is involved with the study, interpretation and classifying of hydrological and hydrogeological data for groundwater and surface water (Ministry of Agriculture, 1995b). Research work was in progress (through the State General Laboratory and similar laboratories abroad) to prove non-toxicity of the material to be used in the context of the attempt to decrease evaporation from water dams. A Solar Electric System for the Meteorological station was purchased. The first indications are encouraging (Ministry of Agriculture, 1996a). Research and studies were in progress on hydrology and floods for the Northern Conveyor Project and other basins. The research on methods of artificial recharge through boreholes was completed. The first hydrologic/hydrogeologic and environmental valuation of the Project of re-use of treated effluent of the sewerage system of Limassol – Amathus was carried out using the results of this research work and also the results of the study of the surface artificial recharge (Ministry of Agriculture, 1997a). The Geotechnical Branch of the Department is carrying out research work on geotechnical and concrete matters serving the Department's projects and the private sector (Ministry of Agriculture, 1996a). The Programming Division is concerned with the survey and study of areas that concentrate potential for water development (Ministry of Agriculture, 1995b).

A WDD engineer, Kambanellas, has devised equipment for treating grey water (which is 40% of the total wastewater from houses) that is collected outside houses (Kambanellas, 1999). The water is used for watering gardens and flushing toilets. The purpose is to save water. Ten systems are in operation in houses, pools, and so on at the moment. He has been supported financially by the Department and has obtained a Ph.D. for this research work.

The Consolidated Development Budget of 1998 of the Republic of Cyprus was about C£28716000 for water development (Republic of Cyprus, 1998a). Specifically, it was C£295000 for hydrology and C£223000 for surveys and investigations. The actual

Table 4.2 Training of WDD employees for the year 1997

Code	Programme title	Total number of hours
1	Excel	78
2	Access	54
3	Microstation and siteworks	51
4	Building materials	21
5	Telemetry	20
6	Quantity Surveying	18
7	Contracts	6
8	Irrigation networks and Land consolidation	6
9	Co-operation of colleagues	3
10	Geographical Information Systems (G.I.S.)	2 ½
11	Expropriations and Requisitions	2 ½
12	Contract administration	unknown

Trainers/Instructors	Code
WDD employees	1 to 5, 7 to 9
Land Registry Department staff	10, 11
Land Consolidation Department staff	6
J.R. Knowles (private company)	12

Table 4.3 Training of WDD employees for the year 1998

Programme title	Trainer	Number of Trainees	Total duration (hours)
Access	WDD staff	20-22	39
Management using 'access' data base	'Futurekids' (private)	8	20
Access (advanced) for Managers	'Demstar' (private)	1	
Excel	WDD staff	20-22	69
Excel (advanced)	'Infotronics' (private)	11	20
Corel Draw	WDD staff	6-10	72
Project Planning with Project for windows	'Demstar' (private)	10	48
Word	WDD staff	6	15
Business Organisation with Outlook 98	Demstar		
Internet	WDD staff	6	31
Internet	'Infotronics' (private)	10	16
Internet	CY.T.A.	12	4
Introduction to GIS (ARC/INFO)	S.T.C. of Cyprus	2	30
Telemetry	WDD staff	8	20
Greasing technology	A.M.E. of Cyprus	1	
Welding technology	A.M.E. of Cyprus	1	
Programme of basic training in EU topics	Cyprus Academy	4	45
National Seminar for the UN Agreement For combating desertification		3	
Human relationships in the working Environment	WDD staff	16	4
Turkish Language		12	30

Index:

- CY.T.A. = Cyprus Telecommunications Authority
- S.T.C. = Scientific and Technical Chamber
- A.M.E. = Association of Mechanical Engineers
- Cyprus Academy = Cyprus Academy of Public Administration

expenditure on hydrological observations and research was C£167114 in 1996; the appropriated budget was C£200000 in 1997 and C£220000 in 1998. The appropriated budget for studies for the utilization of treated sewage effluent was C£3000 for 1997 and C£3000 for 1998. The budget for the purchase of machinery and equipment (drilling equipment; laboratory equipment and expenses; and drawing and surveying instruments) was as follows: actual expenditure C£34139 in 1996; and appropriated budget £40000 and £49500 for 1997 and 1998 respectively.

4.8.3 Agricultural Research Institute

The Agricultural Research Institute (ARI) is a Department of the Ministry of Agriculture, Natural Resources and the Environment. Further information on the Institute is given in section 2.5 (page 42). It is organised in eight sections.

One of the fields that the Institute's research activities cover is soils and water use (Dept. of Statistics and Research, 1993). The research work focussed, among other areas, on the reuse of treated effluent for irrigation purposes (Ministry of Agriculture, 1997b). The water (and fertilizer) requirement of the major crops (citrus, olives, deciduous fruits, potatoes and other vegetables and aromatic plants) is the main objective of the Soils and Water Use section. Various methods of irrigation are also tested (Agriculture Research Institute, 1998b). Irrigation experiments concerned the comparison of irrigation methods, the determination of crop irrigation requirements and the testing of irrigation restriction on crop development and yield. Irrigation with borehole or treated sewage water, both supplemented with different levels of nitrogen, was tested with fodder crops, vegetables and flowers. Soil pollution was monitored (Agriculture Research Institute, 1998a).

The agricultural research services have been improved as part of the Pitsilia Integrated Rural Development Project. An Agricultural Research Station has been established for experiments regarding plants, irrigation techniques and water suitability as part of the Vasilikos-Pendaskinos Water Project (WDD, 1996).

The ARI has a Central Chemistry Laboratory and well equipped specialized laboratories. The output of a small solar water distillator, constructed mainly with aluminium and fiber glass insulation, is being recorded daily (Agricultural Research Institute, 1998a). The statistics and computers section of the ARI provides services to scientific members of all other sections (Agricultural Research Institute, 1998b).

Three professionals work in the Soils and Water Use section. Their involvement is as follows: two of them on 'water use' (one on irrigation requirements and management systems, and the other on irrigation requirements and systems); and one of them on the 'use of sewage effluents' (Agricultural Research Institute, 1998b).

The Statistics and Computers section of the ARI provides training to personnel in statistical methods (design and analysis of experimental data) and computer software, such as SAS, Dbase, excel, open-VMS and Pathworks, windows, netscape, mosaic, FTP and E-mail (Ministry of Agriculture, 1997a; Agricultural Research Institute, 1998a).

The ARI organised the workshop 'Use of treated wastewater for irrigation' in May 1997. Contributors involved the WDD, the Sewerage Board of Limassol-Amathus, the ARI, the Department of Agriculture, and professionals from Israel. One of the papers referred also to other Mediterranean and Middle East countries.

Researchers of the ARI published papers in journals, chapters in books and International Conference Proceedings. Some of the titles of 1997 include: 'Water resources and pollution. Case study for Cyprus', 'Use of saline waters for irrigation in Cyprus. New developments and management practices', 'Non conventional water resources. Present situation and perspective use for irrigation', 'Wastewater use for irrigation. Management aspects', and so on (Agricultural Research Institute, 1998a).

The Table of expenditure of the Development Budget (Republic of Cyprus, 1998a) includes (in Cyprus pounds) the following information.

- Soils and water use: 51285 in 1996, 26750 in 1997 and 24350 in 1998.
- Investigation on Calcareous soils under irrigation: 3855 in 1996, 4250 in 1997 and in 1998.
- Water use: 20750 in 1996, 10400 in 1997 and 9000 in 1998.
- Use of treated sewage effluent for irrigation: 3438 in 1996, 5550 in 1997 and 5550 in 1998.
- Improvement of irrigation facilities: 798 in 1996, 4000 in 1997 and 5500 in 1998.
- Special research equipment: 25149 in 1996, 29850 in 1997 and 52300 in 1998.
- Total for ARI: 2724890 in 1996, 3106693 in 1997 and 3161379 in 1998.

It should be noted that the amount for 1996 is the actual expenditure and the amounts for 1997 and 1998 are appropriated amounts.

The break-down of the total finance of the ARI is made up of: personal emoluments 58%; labour and materials 39%; and capital expenditure 3%. In addition to the above, international agencies (ICARDA, IAEA and other donors) provided C£21676 (Agricultural Research Institute, 1998a).

4.8.4 Geological Survey Department

The Geological Survey Department (GSD) is a Department of the Ministry of Agriculture, Natural Resources and the Environment. It consists of eight sections including the Hydrogeology and the Boreholes sections. The facilities of the Department include the Chemical Laboratory, the Engineering Geology Laboratory, and portable equipment. As

far as research equipment is concerned, the facilities of other governmental departments and foreign organisations is also used (Constantinou, 1999). Further information on the Department is given in section 2.5 (page 42).

Generally, the GSD carries out its own research on hydro-geological problems. The Hydrogeology and Boreholes section is occupied with research on locating and rational exploitation of new groundwater sources (Ministry of Agriculture, 1995b); with studies on foundations of water development projects (new water dams, reservoir lakes, tunnels, pipelines) (Ministry of Agriculture, 1995a); and with specialised hydrogeological studies concerning surface and underground disposal of treated waste-water and waste-disposal positions (Ministry of Agriculture, 1997a).

Research had started on developing remote sensing techniques for water (and mineral) exploration (Department of Statistics and Research, 1993). Research on the pollution of groundwater sources in the coastal area of Kokkinochoria with systematic observations, sampling and testing (by the State General Laboratory) started in 1992. The purpose was to determine the degree of pollution due to agricultural and industrial activities and building development. Research on nitro-pollution of groundwater with emphasis on potable water started in 1994. For the purpose, 200 boreholes and springs throughout Cyprus were investigated (Ministry of Agriculture, 1997a). Preliminary results showed that the main sources of pollution are agricultural activities (77%), building development including industrial and tourist (19%) and stock farming (4%) (Avraamides, 1997).

The GSD has developed international relations with other homologous Departments and University Geological Schools (of UK, Greece, Germany, France, USA, Canada, Israel, and so on) to carry out research programmes and to introduce geotechnical knowledge in Cyprus. Some of the programmes are forwarded within the financial framework of the EU (Ministry of Agriculture, 1995b). The most recent programmes are the following.

- (a) A programme entitled 'Vulnerability of groundwater resources to natural radiological hazards in the semi-arid terrains of North Africa and Mediterranean Basin' was carried out in the period 1994-97. Financial support was provided by the EU through the AVICENNE Programme and by the UK Department for International Development. There was professional and technical collaboration between the British Geological Survey, the GSD of Cyprus and the Water Authority of Jordan (Smith, *et al.*, 1997).
- (b) A programme entitled 'Mining waste management in Cyprus: assessment, strategy development and implementation' was carried out in 1995-98. The purpose was to

determine the impact of former large-scale mining and resultant acid mine drainage on the environment, and in particular on the quality of water. It was financed under the LIFE Programme (EU). The contributors were the GSD of Cyprus (beneficiary) in collaboration with the Netherlands Institute of Applied Science, Idrogeo of Italy and the ITC of Netherlands. The State General Laboratory of Cyprus was also involved. The results were disseminated in a workshop held in Nicosia in 1998. It was also attended by people from other Mediterranean countries facing similar problems (Geological Survey Department, 1998).

- (c) The INCO (EU) Programme 'A new integrated geophysical approach for the rational management and exploration of groundwater resources' was carried out in the period 1996-1999. The cost was 806000 ECU and 519000 were contributed by the EU Commission. The coordinator is Rijks Geologische Dienst of the Netherlands. The other partners are the Bureau de Recherches Géologiques et Minières of France; the Natural Environment Research Council, British Geological Survey of the UK; Geoinvest of Cyprus; and the Geophysical Section of the GSD of Cyprus (Geological Survey Department, 1999a).
- (d) The INCO-DC (EU) Programme 'Groundwater recharge in the Eastern Mediterranean – A comparative study on integrated evaluation techniques for groundwater resources along a hydroclimatic gradient' started in 1997 and will be completed in 2000. The cost is 560000 ECU and is contributed by the EU. The partners are the University of Wurzburg (Germany), the University of Thessaloniki (Greece), GSD (Cyprus), Ben Gurion University of the Negev (Israel), and the University of Jordan. A programme of training and exchange of scientists is being carried out with workshops (one in Cyprus on 'Groundwater quality management'), meetings, training (GIS applications and modelling) (Geological Survey Department, 1999b).

The three hydrogeologists of the GSD undergo training twice a year in the context of the research programmes. They also co-operate with the Ministry of Agriculture of Greece exchanging experiences (Constantinou, 1999).

The actual development expenditure of the GSD was C£825866 (82% on drilling and prospecting for groundwater) in 1996. The appropriated budget of the GSD was C£1369810 in 1998, of which 62% was spent on drilling and prospecting for groundwater and 79% was spent on drilling and investigations (Republic of Cyprus, 1998a).

4.8.5 Other Ministry of Agriculture Branches

Initially, some general information regarding activities of the Ministry of Agriculture, Natural Resources and the Environment is given. Staff of the Ministry attend

Conferences, training seminars and workshops. There is a programme of co-operation with the Ministry of Agriculture of Greece on training and exchange of experts (Ministry of Agriculture, 1997a). Various proposals were/are prepared to be submitted to Environmental EU programmes, for example LIFE and METAP. Some were approved and were/are implemented. Participation in these programmes offers the opportunity of cooperation with Universities and other organisations abroad especially in research (Ministry of Agriculture, 1996a).

The Ministry consists of 13 departments, services, centres, institutes and organisations. So far, three of these (that is the Water Development Department, the Agricultural Research Institute and the Geological Survey Department) have been considered in sections 4.8.2, 4.8.3 and 4.8.4. Some of the remaining branches / departments/centres of the Ministry are considered here. These are: the Branch of Land and Water Use of the Department of Agriculture; the Department of Fisheries; the Information, Natural Resources and Remote Sensing Centre; and the Branch of Laboratory Analyses of the Department of Agriculture.

As concerns the Branch of Land and Water Use of the Department of Agriculture, the professional personnel of the branch are trained every year for a few days at the Centres of Agricultural Training of the Department. The branch is not involved with research; findings of research are applied (Motitis, 1999). A study of the use of treated wastewater in agriculture was carried out (Ministry of Agriculture, 1997a).

The European Programme AVICENNE 'Toxic solid wastes, terrestrial and aquatic impact' was completed by the Department of Fisheries in 1996 in cooperation with Universities and Institutions in Greece, Germany, the Netherlands and Israel (Ministry of Agriculture, 1997a).

The Information, Natural Resources and Remote Sensing Centre does not carry research as such but it offers information to other Departments (Siamarias, 1999). It has contributed to hydrogeological research. Ground water reserves were identified in Troodos mountains (Ministry of Agriculture, 1995b). There is cooperation with the Royal Institute of Technology of Sweden on the development of hydrological models (Ministry of Agriculture, 1996a).

One of the facilities is the Branch of Laboratory Analyses of the Department of Agriculture. Samples of water are analysed for the rational utilization of water resources for agricultural purposes (Ministry of Agriculture, 1995a). There is also a laboratory for analysing pig wastewater in the context of the scheme of treating of pig wastewater (Ministry of Agriculture, 1997a).

4.8.6 State General Laboratory

The State General Laboratory (SGL) is a department of the Ministry of Health. Further information on the SGL is given in section 2.5 (page 42). The facilities of the SGL include the Laboratory of general chemical analyses of water, the Laboratory of Environmental Chemistry (I) and Ecotoxicology, the Laboratory of Environmental Chemistry (II) and testing of waste-water and the Laboratory of microbiological testing of water (Ministry of Health, 1997). There is a quality assurance programme: proficiency testing together with valid laboratories of European and other countries (Ministry of Health, 1996).

There is systematic training of the personnel of the SGL in Cyprus and abroad on new methods, on advanced technology equipment and on computer programmes. The personnel is also developed through the participation in European programmes (Ministry of Health, 1997).

An on-going research programme is the Programme of systematic monitoring and research on the contamination of water which started ten years ago (Ministry of Health, 1995 and Christodoulidou, 1999). The European programmes are the following (Michaelidou, 1999 and Ministry of Health, 1997).

- (a) 'Contamination of groundwater'. This was financed by the EU through 'AVICENNE'. It was carried out in cooperation with Fraunhofer Institute of Germany and the Weizmann Institute of Israel and was completed in 1996.
- (b) 'Testing of sub-products of chlorination of domestic wastes'. This was a EU 'AVICENNE' programme also. It was carried out in cooperation with the University of Crete (Greece) and Technion Institute of Israel and it started in 1995.
- (c) 'Integrated testing of surface water of Cyprus'. This was a 'LIFE' programme of the EU financed with 550000 ECUs. It is carried out in cooperation with WDD of Cyprus in the period 1996-2000. They pay consultants plus training.

4.8.7 Planning Bureau

Each governmental department proposes what to do as far as development projects (for example for training) and the Planning Bureau evaluates proposals and takes a decision (Alexandrou, 1998 and Georghiou, 1998). The budget of the Bureau includes scholarships and training of government staff abroad, the grant to the Research Promotion Foundation (see section 4.9.5), participation in programmes and initiatives of the EU, and contribution towards the cost of foreign technical assistance (Republic of Cyprus, 1998a).

4.8.8 Organization for Standards and Control of Quality

The Organization is one of the sections of the Ministry of Commerce, Industry and Tourism. The chemical engineer responsible for water standards recently participated in a

Conference on 'Bottled Drinking Water Standards' by WHO and FAO. The participation was financed by the Ministry (Pythara, 1999).

4.8.9 State Scholarships

Scholarships for education and training are generally dealt with in sections 2.4.1 (page 35) and 2.4.2 (page 38).

Since 1977/98 scholarships are offered to citizens of Cyprus (with the exception of public officers) by the Cyprus government for postgraduate (master) studies abroad. Nine such scholarships were offered in the first academic year but none was on water/waste-water engineering (Savva, 1999). The Cyprus government offered a scholarship for one scholar (public officer of the WDD) in 1996 for a postgraduate course on 'public sector management' for a duration of two years (Scholarship Board, 1996).

4.9 SEMI-GOVERNMENTAL ORGANISATIONS

4.9.1 Introduction

A semi-government organisation is defined as an economic unit with legal entity engaging with one single economic activity which is usually singular in its kind and it is mostly or wholly financed and controlled by government. Also local authorities are covered in this section. Local government authorities are defined as institutional units whose fiscal, legislative and executive authority extends over a small geographical area. These units work in the fields of housing and community development, sanitary and similar services and social welfare services (Department of Statistics and Research, 1996). In this section, all the Water and Sewerage Boards of the towns of Cyprus, other local authorities, the Industrial Training Authority and the Research Promotion Foundation are considered.

4.9.2 Water Boards

Water Boards control the networks in the towns. The Water Board of Nicosia (WBN) employs two civil engineers and one mechanical engineer. The personnel attend seminars and training programmes either in Cyprus or abroad. Programmes are attended in the UK or trainers come from UK organisations (such as Water Training International, Thames International and Hyder). In 1998 a European Union expert gave a seminar in Cyprus on the 'New European Drinking Water Directive'. EU programmes are attended also in Greece (Maimarides, 1999). Locally, various seminars on information technology and personnel development are offered by private organisations. Civil engineers from Greece visited Cyprus through the 'Euroform' programme to share specialised experiences in information technology and on locating unaccounted for water leakages (Water Board of Nicosia, 1997). Training facilities exist at the premises of the WBN (Maimarides, 1999). Also, students from various countries are trained at the WBN. The personnel participate in

international conferences on improving water supply systems; quality control of water; the environment; the relationship with consumers and so on (Water Board of Nicosia, 1997). Studies are being carried by the WBN on improving water supply on extending systems (Water Board of Nicosia, 1996). The Industrial Training Authority of Cyprus funds 70-80% of the training programmes and the Board funds the rest (Maimarides, 1999). In 1996, there was a fivefold increase of the expenditure on training (of all the personnel) as compared to 1995 (Water Board of Nicosia, 1997).

The Water Board of Limassol participated in various international Conferences as follows. The Manager of the Board participated in the International Water Supply Conference in Durban, South Africa in 1995 and in the International Water Supply Congress in Madrid, Spain in 1997. The Head of the Technical Services participated in the Conference in Madrid and in the International Water Supply Conference in Amsterdam, the Netherlands in 1998. The Head of Financial Services participated in the International Water Supply Conference in Amsterdam in 1999. These participations were financed by the Industrial Training Authority of Cyprus and the Board. The Board is being involved in two research programmes: 'Synergy programme network – Urban energetic planning and geographical data buses' financed by the EU; and 'Methods of saving water and applications in the society of Cyprus' financed by the Research Promotion Foundation of Cyprus (Markaris, 1999).

The personnel of the Water Board of Larnaca participate in short-term training. It is financed by the Industrial Training Authority. A seminar on 'unaccounted for water leakages' organised by Water Training International of the UK was attended by all Water Boards of Cyprus in 1996. The Board organised a seminar on 'AutoCAD map' in 1998. The Head of the Technical Services of the Board attended a conference and exhibition on water supply and a seminar on 'desalination' in 1998. The Board is not involved with research as such (Christodoulou, 1998).

4.9.3 Sewerage Boards

The Sewerage Board of Nicosia has cooperated or is cooperating mostly with the World Bank, the European Investment Bank and the World Health Organisation (Yiallourous, 1999). The Engineer of the Board participated in the '16th International ISTT No-dig 98' seminar which was held in June 1998 (Theopemptou, 1999).

The personnel of the Sewerage Board of Limassol-Amathus participated in the following seminars abroad in 1998: 'Quality control of a sewerage system', 'Engineering training course' and 'Liability and damages in international commercial contract'.

The Sewerage Board of Larnaca employ four engineers (two civil, one mechanical and one electrical). The personnel attends seminars in Cyprus, usually once a year per

person. The participation is usually financed in its greatest part by the Industrial Training Authority of Cyprus. Recently, the civil engineers attended computer courses on GIS organised by ETEK. Another seminar was on 'Time management courses' organised by a private consultant (Georghiou, 1999).

The Sewerage Board of Paphos had been founded recently and the human power had been engaged over the last two years. The Board has not organised training seminars and has not participated in any training programmes abroad. It is not engaged in research programmes (Malecides, 1999).

The Chief Engineer of the Sewerage Board of Paralimni attended two 15-day courses by the Water Training International in the UK: 'Design and construction of pumping stations' (1994); and 'Design and construction of sewage treatment plants' (1996). He also attended seminars and an exhibition in Athens in 1995. Funding was provided by the Industrial Training Authority (70%) and the Board (30%). One representative from each Board of Cyprus visited sewage treatment plants in the UK in 1997. These visits were funded by the British High Commission in Cyprus. There is no long-term training for the personnel of the Board. The Board is not involved with research (Sepos, 1999).

The Sewerage Board of Ayia Napa (which has a common sewage treatment plant with the town of Paralimni) employs one civil engineer. He has attended two seminars in Greece: one funded by the Industrial Training Authority and the Board and the other by the Public Sewerage Enterprise of the town where the seminar took place. He attends also some selected seminars in Cyprus which are funded by the Industrial Training Authority of Cyprus and the Board. There was no participation in long-term training abroad or in research. The Board is in contact with some foreign organisations (Charalambous, 1998).

4.9.4 Industrial Training Authority

The status and activities in general of the Industrial Training Authority (ITA) of Cyprus are described in section 2.4.2 (page 38). Table 4.4 shows the training programmes for professionals in water and wastewater engineering subsidised by the ITA in the years 1997 and 1998. A total of 13 programmes was approved: two of these were in-company; six of these were at training institutions; five of these were abroad. All the programmes were short-term. Training in-company or abroad was mostly organised for the personnel of Sewerage Boards (5 cases) and also for a Water Board (one case) and a private company (one case). Half of the programmes involved exclusively waste-water engineering.

As concerns the European programme for vocational training 'Leonardo Da Vinci', no programme was approved in Cyprus (by ITA) that involves water or wastewater engineering (Papachristophorou, 1999).

Table 4.4 Programmes subsidised by the Industrial Training Authority in water and wastewater engineering in 1997 and 1998

Title	Organiser	Year	Type	Duration (days)
Training of engineers of Waste-water Treatment plants	Sewerage Board of Limassol – Amathus	1997	IC	
Leakage management	Water Board, Limassol	1997	IC	8
Methods of treatment of industrial wastes	Association of Water Treatment Scientists	1997	TI	1
Trenchless technology	Congresswise Ltd.	1997	TI	2
Operation and maintenance of small biological treatment plants	Association of Water Treatment Scientists	1997	TI	2
Water treatment and corrosion control in water systems	Tasapro Chemicals Ltd.	1997	A	2
Wastewater treatment technology	Congresswise Ltd.	1998	TI	2
Trenchless technologies	Congresswise Ltd.	1998	TI	2
Wastewater technologies	Congresswise Ltd.	1998	TI	2
Quality control of a sewerage system	Sewerage Board of Limassol – Amathus	1998	A	12
Engineering Training Course (Design of new sewerage and drainage networks)	Sewerage Board of Limassol - Amathus	1998	A	12
16 th International ISTT NO-DIG 98	Sewerage Board of Nicosia	1998	A	4
Liability and damages in international commercial contract	Sewerage Board of Limassol – Amathus	1998	A	3

Type of training:

- IC = in-company
 TI = at training institutions
 A = abroad

References: Andreou, 1999; Efstathiades, 1999; Tofidou, 1999; Mourouzidou, 1999.

4.9.5 Research Promotion Foundation

The status, aims and activities of the Foundation are considered in section 2.5. The sectors to be offered allowances as decided by the administrative board were (among others) water saving (one of four agricultural sectors) and decrease and treatment of wastes and the integrated monitoring to prevent pollution of water and soils (two of three environmental sectors). It was decided to finance these sectors in the budget of the Second Programme of offering allowances for research schemes that was announced in October 1998. One of the twelve proposals that were selected (in early 1998) to be financed by the Foundation according to the First Programme was 'Methods of saving water and their applicability in the Cypriot community', the coordinator being P. Nicolaides (RPF, 1998).

4.10 PRIVATE SECTOR

Various private organisations undertake training (mainly in the form of seminars) of employees of governmental organisations (see section 4.8 on p.67), of semi-governmental organisations (see section 4.9 on p. 78) and of the private sector.

Congresswise Ltd. is one the organisers active in organising short courses/seminars in water and wastewater technologies (see sections 4.9.4 on p.80 and 4.11 on p.82). 'Wastewater treatment technology', 'wastewater technology', 'water treatment' and 'desalination' are some of the titles of programmes organised by them. Very often they cooperate with UMIST of Manchester (Antoniou, 1999).

'Koronida' Research and Development Centre was established in 1997 and its basic aims include the execution of research and experimental work in the field of engineering science and the preparation and delivery of seminars and courses. The centre specialises in Environmental Engineering, Hydraulic Engineering, Health and Safety, Education and four other topics (Koronida, 1998). Long-term (3 hours a week for 5 weeks) seminars for university graduates on 'Hydraulic and wastewater disposal works for buildings' were planned to be delivered towards the end of 1999. These were to be subsidised by the Industrial Training Authority. A research project on 'Water saving' started in 1998 and will last for two years. It is funded by the Research Promotion Foundation and also grants/equipment/personnel time were obtained from private enterprises and the WDD and the Water Boards of Nicosia and Limassol. The Centre also cooperates with foreign consultants (Halcrow Consultants of the UK) on this project (Nicolaides, 1998).

4.11 PROFESSIONAL ASSOCIATIONS

A number of seminars and other meetings on the sector take place in Cyprus. The Scientific and Technical Chamber of Cyprus (ETEK) organised a meeting/seminar on the prospectives of facing the water problem of Cyprus in cooperation with the Ministry of Agriculture and the National Polytechnic of Greece in June 1998. Among the speakers

were academics from McMaster University of Canada and the National Polytechnic of Greece (ETEK, 1999b). ETEK and the Association of Mechanical Engineers of Cyprus participate in the training of WDD employees (see section 4.8.2 on page 67).

The Cyprus Civil Engineers and Architects Association and UMIST (of Manchester) organised a short course on Wastewater treatment technologies in March 1997. The Association of Civil Engineers of Cyprus (ACEC) organised a seminar in 'Water supply network management and identification of unaccounted for water leakages' in early 1997 (ACEC, 1997).

Various Associations organise educational visits. One to the Water Treatment Plant at Tersephanou in November 1999 was organised by ACEC and the Cyprus Group of Civil and Mechanical Professional Engineers.

ACEC participated (as co-ordinator or partner) in the Research Programme 'Thrace-Aegean-Cyprus' to be funded by the Ministry of the Aegean of Greece with the two following proposals: (a) 'Modern methods of management of water resources' (in cooperation with the Technical Chamber of Greece); (b) 'Technical, economic and environmental study of management of rainwater flow in urban areas' in cooperation with the Universities of Thrace and the Aegean (ACEC, 1998). ACEC was also the coordinator (in December 1998) in the research proposal 'Management and utilisation of surface water and groundwater resources in coastal urban areas' to be funded by the Research Promotion Foundation. The partners are the Universities of Thessaloniki and Volos of Greece and the writer of this Thesis (FIT of Cyprus).

4.12 MULTI-GOVERNMENTAL ORGANISATIONS

United Nations (UN) and European Union (EU) organisations are considered here.

One scholar, a public officer of the WDD, was awarded a scholarship in 1996 to attend a one month specialised course in Austria on 'Isotope application for analysis of flow and transport dynamics in hydrological systems'. The awarding authority was IAEA, a UN agency (Scholarship Board, 1996). Further information on scholarships is given in section 2.4.1 (on page 35).

Various opportunities exist for training and research through the 5th Framework Programme for Research and Technological Development (1998-2002) of the EU. Programmes funded by EU in which various organisations of Cyprus participate are considered in sections 4.8 and 4.9.

4.13 FOREIGN INSTITUTIONS IN CYPRUS

The British Council, Fulbright Commission and the British Bases are considered in this section. The British Council's activities in Cyprus are considered in Chapters 2 and 5.

Under the short-term training grants of the Cyprus America Scholarship Program (administered by the Cyprus Fulbright Commission), wastewater management has been one of the issues included within these grants. Under the Hubert H. Humphrey Fellowship program mid-career professionals undertake programs which combine academic and professional development activities directly related to their professional needs and fields of interest. One of the fields is Natural Resources and Environmental Management. The Cyprus Fulbright Commission is planning a number of special bicomunal projects. One of the planned projects is environmental pollution (Fulbright Commission, 1998).

Four water and wastewater engineers work in the British Bases in Cyprus. Also, a mechanical engineer is involved partly on water works. The engineers are trained in the UK by attending courses/seminars four times a year. A recent seminar was on investment appraisals and was funded by the Ministry of Defense of the UK. One of the engineers is carrying out research work on 'Effective management of water resources in the area of the Bases' and this is part of his work. It is funded by the Bases (Pashias, 1998).

4.14 TRAINING ORGANISATIONS ABROAD

'WTI (Water Training International) Training Group' of the UK offer training (among other divisions) on 'Water and the Environment'. This broad area includes courses on 'water science and water resources', 'water distribution', 'sewerage' and 'engineering'. They are involved in open courses, customised courses, training consultancy, training, consultancy and special schemes. They work with clients from over 60 countries. The main clients from Cyprus are the Water and Sewerage Boards and the British MOD and contractors. See also other sections in this Chapter. WTI Training Group staff have been directly involved in the project 'Water distribution and services system training' in Cyprus. WTI has undertaken in-country technical training in Cyprus. The Group itself could not provide total numbers of Cypriot nationals attending their courses (Bird, 1999).

'Construction Technology Transfer Consultancy' of the UK offered a five-day residential course on 'Sewer rehabilitations' in Cyprus in 1996 (Vickridge, 1996).

The 'Centre for Professional Advancement' presents short courses in European locations. Two of the fields are environmental technology and civil engineering.

Numerous organisations in various countries are involved in training. The list is too long to present it here. One of the most well known is the International Water and Sanitation Centre (IRC) which is based in The Hague, The Netherlands. It organises short training courses and briefing programmes. Since 1991, IRC has also been organising courses in collaboration with partner institutes in Africa, Asia and Latin America (IRC, 1997).

Professional organisations offer seminars on a systematic basis.

Apart from education and research (see Chapter 5), universities also organise training in the form of short courses. The Water Engineering and Development Centre of Loughborough University of Technology and other Universities are especially active in training for the needs of less industrialised countries. Some Universities (for example, UMIST of Manchester) are involved in organising short courses in Cyprus.

4.15 SUMMARY

In this Chapter, the potential for human resources in water and wastewater engineering in Cyprus was investigated. Potential of human resources refers to the achievements and involvement so far of university graduate professionals in education, continuing education and training, and research in the field.

Academic qualifications, academic research (in general and work related to the characteristics and needs of Cyprus), training, employment and research as part of it, and cooperation with foreign experts was considered for a representative sample of professionals working in the field in Cyprus. Some worthwhile results follow. Half of the university programmes of study in the field were followed at master's level and half of programmes were followed in the UK. Part-time studies is a recent trend. One-quarter of the programmes involved research only. The academic research work on water engineering had been double that on wastewater engineering. One-fifth of the academic programmes was related to the characteristics and needs of Cyprus. Only one-fifth of the respondents stated that they obtained training but, according to most of them, the type of training they received was appropriate for the country. One-third of the professionals were involved with research as part of their employment and most of it was funded by the government of Cyprus and the EU. Two-thirds of the professionals were cooperating with foreign experts.

Facts for organisations were obtained directly. The range of organisations was governmental, semi-governmental, the private sector, professional associations, multi-governmental, foreign institutions (based in Cyprus) and training organisations abroad. These organisations specialise in the sector of water and/or wastewater engineering/management, in education, in training, in research and development, in planning, in standards and control of quality, in laboratory work and in scholarships. For each of these organisations, some or all of the following information was obtained: the numbers and specialisation of personnel; the facilities (laboratories, equipment, computing, and statistical assistance); training programmes (including also participation in courses, conferences, seminars, workshops, and visits); research programmes; research publications; cooperation with foreign organisations; internal budget (for education, training, research, equipment, and institutional development) and external donors.

Generally, the answers sought were based on the scope, who is doing what, the time frame and the place.

Many of the recent training programmes in Cyprus were spent on information technology. Non-governmental training is funded by the Industrial Training Authority. There is a trend for the research programmes (especially by the Geological Survey Department, the State General Laboratory and the Water Development Department) to be forwarded within the financial framework of the EU.

CHAPTER FIVE

CURRENT UNIVERSITY COURSES AND RESEARCH IN WATER AND WASTE-WATER ENGINEERING

5.1 INTRODUCTION

Global needs, strategies and actions for education, training, research and development are considered in section 2.2 which includes a sub-section (2.2.4 on page 22) on Environmental Engineering and Water and Waste-Water Engineering.

The purpose of this Chapter is to consider current university courses and research, both undergraduate and postgraduate, in the sector of water and waste-water engineering. Specifically, the topics considered are: universities offering courses in the sector; course titles; course content; degrees; duration of courses; mode of study; assessment and degree requirements; accreditation of courses; research topics; and funding and sponsors. The overall picture is given, plus the trends and reasons for the trends. The methodology employed was literature reviews, university prospectuses, personal communication with educationalists, questionnaires, and enquiries with authorities.

University courses in the following countries (other than Cyprus) are included in this Chapter: the U.K., the U.S.A., Canada, Australia, Singapore and Malaysia. These countries have been chosen for the following reasons. The U.K., the U.S.A., Canada and Australia are English speaking countries. Many Cypriots live permanently in these countries. The UK, Canada and Australia are members of the Commonwealth as is Cyprus. The UK is a member of the EU. Cyprus has a customs agreement with the EU and is close to becoming a full member. There are areas of aridity in the USA and Australia and thus there is a similarity with Cyprus which experiences drought events (see section 2.3 on page 28). Also, parts of these two countries have a similar climate to that of Cyprus. A very high proportion of Cypriots study in the UK and the USA. British education is well regarded in Cyprus; historical, cultural, professional and family links between Cyprus and Britain contribute towards ensuring a steady flow of Cypriot students to British institutions. The countries of origin of studies of Cypriot civil engineers and architects were the U.K., Greece and U.S.A. in this order. (See sections 2.4.1 and 2.4.4). According to the results of the Questionnaires (see section 4.3 on page 64), about half of the academic programmes in water/waste-water engineering/management followed by Cypriot professionals were attended in the U.K. and one-fifth in the U.S.A. In the time period 1962-1995, 83 Universities of the USA (first), 28 Universities of the UK (second) and 8 Canadian Universities (fifth) were accredited in Cyprus (Council of Registration of Architects and Civil Engineers, 1996) in civil engineering (see sections 2.4.1 on page 35

and 2.4.4 on page 41). The countries that have been chosen for analysis offer scholarships (see also section 2.4.1). Prospective Cypriot students have easy access for enquiries to the British Council and the Fulbright Commission in Cyprus. Another reason for selecting these countries is that information about studies in these countries is well documented and readily accessible. Singapore and Malaysia are members of the Commonwealth and they are rapidly developing.

Distance (and other modern) learning technologies and techniques are also considered.

5.2 CYPRUS

5.2.1 Introduction

General (not specifically in the sector of Water and Waste-Water Engineering) matters concerning education in Cyprus and research in Cyprus are considered in sections 2.4.1 and 2.5 (on page 42) respectively. Foreign University involvement in Cyprus is mentioned in other sections. For example, the Geological Survey Department co-operates with foreign Universities (section 4.8.4 on page 73).

5.2.2 The University of Cyprus

The Engineering School of the University has not functioned yet (see section 2.4.1).

The University participates in various European Union programmes including the one on International Cooperation with Developing Countries (INCO-DC). One of the research programmes is "A decision support system for the management of Water Resources in the Mediterranean region". The amount obtained is 500000 ECU for all the partners. The overall coordinator is Sunderland University (UK) and the partners are the University of Cyprus (The Department of Computer Science of the Faculty of Pure and Applied Sciences), WDD of Cyprus, The University of Malta, WDD of Malta and a Norwegian company for software. The programme started in 1998 and it will last for 3 years (University of Cyprus, 1996; Keravnou, 1999; Samaras, 1999). The researchers at the University are E. Keravnou and G. Samaras (Computer Science) and T. Christophides (Mathematics).

The Department of Mathematics and Statistics is involved with studies on rainfall, based on data provided by the Cyprus Meteorological Service. The Department of Natural Sciences is involved with studies concerning environmental pollution in Cyprus (University of Cyprus, 1998).

5.2.3 H.T.I.

The government-controlled Higher Technical Institute (H.T.I.) offers 3-year civil (and other) engineering courses for technician engineers (see section 2.4.1 on page 37).

The latest curriculum and syllabus of H.T.I. was issued in 1989 (H.T.I., 1989). According to it, the sector related subjects were Sanitary Engineering (taught in one semester of the second year of studies for 2 hours per week) and Fluid Mechanics (second year; 2 hours per week).

Members of staff of the H.T.I. are involved in research programmes, these include Recycling of grey water and Hydrological resources of the Mediterranean (section 2.5 on page 46). Recently (in 1997), N. Kathijiotis, an Environmental engineer and lecturer at H.T.I. was involved in research work on "Waste-water reuse in Cyprus".

5.2.4 F.I.T.

The private Frederick Institute of Technology (F.I.T.) offers a two-year course in Building Technology and two-year and four-year courses in Civil Engineering (see section 2.4.1 on page 37). Frederick Research Centre (F.R.C.) is affiliated to F.I.T. (see section 2.5 on page 46). Subjects taught at F.I.T. that are related to the sector are: Fluid Mechanics, Hydraulics, Environmental Services and Environmental Engineering (F.I.T., 1999). The writer of this Thesis is an Associate Professor at F.I.T. and is involved with the Water supply in Morphou area. FRC submitted a project titled "Development of an integrated environmental monitoring system in Cyprus" to the EU within the 1998 LIFE Programme, and also submitted a project titled "Study of the trans-boundary transport of pollution at Northern Aegean Sea" to the Greek Ministry of Aegean within the 1998 Thrace-Aegean-Cyprus Programme (FRC, 1998). These proposals did not receive funding. [Only proposals of a cultural nature received funding in the latter case].

5.3 THE U.K.

5.3.1 First degree courses

The water and waste-water engineering content in first-degree courses in the UK is considered in this section. Courses, course content and accreditation of courses are dealt with. Information from several prospectuses of UK Universities and from a publication by the Careers Research and Advisory Centre (CRAC, 1997) was employed by the author to produce the statistics that follow.

Several first-degree courses in Environmental Engineering, Civil and Environmental Engineering and other related areas are offered in U.K. Universities. A list of these courses (titles and universities) is given on Table 1 of Appendix D (on page 196).

The degrees awarded in these courses are: BSc in 34% of the courses; BEng 55%; BSc (Eng) 2%; and MEng 34%. In 25% of the courses it is possible to either receive a BEng or an MEng. The average duration of these courses is 3.6 years. The mode of study is full-time in 93% of the courses and part-time 7%; time abroad is possible in 27% of the courses; and a sandwich mode is available in 43% of the courses. The scheme is modular

in 20% of the courses. The course type is specialised in 70% of the courses and combined in 32% of the courses. Many courses provide a range of opportunities for spending a period of industrial training in the U.K. or abroad, or of study abroad. Time abroad in Europe is possible in 55% of the courses; in North America 27%; in industry 43%; and at an academic institution 41%. A year of industrial experience before the course starts is recommended for students on some non-sandwich courses (9% of the total number of courses) and on some sandwich courses (2%). Students on some non-sandwich courses can take a year out for industrial experience (36%).

It is interesting to compare these statistics with what was offered some years ago. In the academic year 1989/90, Environmental Engineering was offered only at 3 Universities, Civil and Environmental Engineering at 2, Civil, Structural and Environmental Engineering at one, and Building Engineering (Environmental/Building) at one (CRAC, 1989).

The specialised subjects that are related to water/waste-water included in Environmental Engineering and Civil and Environmental Engineering and other related courses are shown on Table 5.1. The table shows, for each year of the course, the subjects that are compulsory or optional. These subjects (related to water/waste-water) is one-third of the total possible specialised (environmental) subjects. It is deduced that these subjects are offered mostly in the intermediate and final years rather than the preliminary year. The compulsory subjects that are most frequently offered are as follows (in order).

1. Water and waste-water treatment.
2. Water supply/resource engineering.
3. Industrial waste-water treatment.
4. Public health engineering.
5. Biological treatment processes.
6. Sludge treatment/disposal.
7. Groundwater contamination.
8. Water quality systems/modelling.

If all the civil engineering courses are considered, some specialised civil engineering subjects are introduced at an early stage, and as the course progresses, they take an increasing proportion of time. By the final year students spend virtually all their time studying specialised courses.

Different courses give different emphasis to topics, which may include, among other subjects, water and waste-water engineering. The requirements for professional recognition mean that many civil engineering courses offer very little choice until the final year, and even then the choice may be fairly limited.

Table 5.1 Course Content in 25 Environmental/Civil and Environmental Engineering First-degree courses in the U.K.

Subject (related to water/waste-water)	Compulsory			Optional			Both
	P	I	F	P	I	F	F
Public Health Engineering	16	36	32	4	4	8	0
Water and waste-water treatment	20	52	48	0	12	24	0
Industrial waste-water treatment	16	40	36	0	8	20	0
Biological treatment processes	8	40	36	0	4	16	0
Sludge treatment/disposal	0	32	36	0	4	8	0
Water quality systems/modelling	8	16	25	0	0	8	4
Water supply/resource engineering	12	48	36	0	0	12	0
Groundwater contamination	0	32	28	0	4	12	0

Notes: P = preliminary year; I = intermediate year; F = final year

Numbers refer to percentages of courses (proportion out of a total of 25 courses for which information is available)

The subject of water/waste-water engineering is offered as a final-year specialisation in 65 courses (39%) out of a total of 167 first-degree Civil Engineering (and related) courses in the U.K. Analytically, these courses (titles and universities) are shown on Table 2 of Appendix D (on page 197).

Courses are accredited by several professional institutions. The Chartered Institution of Water and Environmental Management (CIWEM) is affiliated to the Engineering Council and can register suitably qualified engineers.

5.3.2 Postgraduate courses and research

Postgraduate studies in the UK on water, waste-water and related subjects are considered in this section. In particular, taught courses, related taught courses and research (topics, degrees, funding) are considered. Information from several prospectuses of UK Universities and from CRAC (1998) were used by the author of this Thesis so as to produce the statistics that follow.

a) Taught courses

Thirty-three postgraduate taught courses in the field of water and waste-water were offered in 21 different Universities in the UK in 1998. It is worthwhile to note that only 19 were offered five years earlier (as identified in CRAC, 1992). The details are shown in Table 3 of Appendix D (p.198). The information provided is the title of each course, the university, the degree obtained, the duration of studies, and whether full-time or part-time. The only courses that are offered under the same title in more than one University are: "Water Resources Engineering Management", "Water and Environmental Management", "Water Pollution Control", and "Irrigation Engineering". Each one of these courses is offered in two different Universities. The Universities that offer more than one course in the field of water/waste-water are the following: Cranfield-Silsoe (5 courses), Newcastle (3), Strathclyde (3), Cranfield (2), Glasgow (2), Loughborough (2), and Middlesex (2).

An analysis of the titles shows the following results as far as frequency of words is concerned. The most frequent words are: "water" (67% of courses), "engineering" (42%), "environmental" (27%), "management" (27%), "resources (water)" (18%), "pollution control" (12%), "technology" (12%), "hydrology" (9%), "irrigation" (9%), "coastal" (6%), "groundwater" (6%), "hydraulics" (6%), "hydrogeology" (6%), and "waste-water" (6%).

The following degrees are offered: MSc (in 94% of the courses), MSc (Eng.) in 6% of the courses, MSc (Tech.) in 3% of the courses, PgDip (30%), Dip (36%), and PgCert. (3%).

Full-time courses are more frequent. They are offered in 94% of the cases, whereas part-time study is available in 42% of the cases. Both full-time and part-time study is

available in 36% of the courses, only full-time (58%) and only part-time 6%. The average duration of a full-time course is 12 ½ months, and that of part-time is 2.2 years.

The rest of the information in this section is not shown in Table 3 of Appendix D. Due to the great diversity of courses, it is not practical to include in this report what specifically each course contains. Examples of cooperation include: the course at Middlesex on “Water Pollution Control” is a joint course with Universite de Paris XII Val de Marne; and the course at Oxford Brookes on “Coastal and River Hydraulics” is a joint venture with H. R. Wallingford Ltd, U.K national centre for civil engineering hydraulics.

Some Universities provide core / main / compulsory modules / subjects and optional / elective / support modules / subjects. This is the case in one-third of the courses. The course at Cranfield, Silsoe on “Irrigation Water Management” provides different courses to physical science entrants and to agricultural science entrants in the first term. The course at Bangor on “Water Resources” is a multi-disciplinary one and offers specialisations. The course at Birmingham on “Water Resources Technology and Management” provides in-depth subjects.

The researcher is informed on assessment for about half of the courses. For these courses, written examinations is one of the forms of assessment in 56% of the cases, oral (6%), coursework (19%), integrated study/study assignments (25%), practical exercises (6%), in-company project for part-time study (6%), skill development project and industrial project (6%), major/research/practical-based project (25%), thesis (25%), and dissertation (63%). In seven courses the different requirements for MSc as compared to PgDip and Dip are given. A dissertation is required for an MSc but not for PgDip. or Dip. in five courses. In the remaining two courses (both at Strathclyde) a thesis is required for the MSc and a dissertation for PgDip.

Funding is known to be provided in 58% of the courses. The organisations providing funding are: EPSRC (in 42% of the courses in which funding is provided), NERC (37%), Overseas Development Administration (26%), British Council (16%), European Social Fund (16%), Newcastle University (16%), Strathclyde University (16%), European Development Fund (11%), ESRC (11%), Industry (5%), overseas sources (5%), and training and enterprise councils (5%).

b) Related taught courses

Courses partly involving water and waste/water are presented on Table 4 of Appendix D (p. 200).

c) Research

The information that follows refers to the general area (in alphabetical order), the University, and the details of the research opportunities.

- Biological Sciences (Environmental Biology) at Birmingham: ecophysiology of algae and water management.
- Biological Systems Engineering at Newcastle: application of computer-aided design with GIS for planning drainage, irrigation and waste disposal; and modelling of soil-crop-atmosphere systems with relevance to irrigation, rain water harvesting and intercropping management.
- Building and Environmental Health at Nottingham Trent.
- Civil and Environmental Engineering at Bradford: mathematical modelling of flow and sediment transport in coastal, estuarine and inland waters; knowledge-based systems and modelling for water treatment and quality; flow and disinfection processes in contact tanks; and modelling of groundwater, dual porosity aquifers, and clean-up of organically polluted aquifers.
- Civil and Environmental Engineering at London (UCL): fluid mechanics: structure of turbulence in boundary layers relevant to river, coastal and wind engineering; oscillatory waves and wave current interactions; sediment transport; and wave-loading on off-shore structures; environmental engineering: physical, chemical and microbiological aspects of treatment processes for water supply and sewage disposal.
- Civil and offshore Engineering at Heriot-Watt: water and coastal engineering; fluid loading and instrumentation; and pipeline engineering.
- Civil and Structural Engineering at UMIST: water and groundwater pollution control, infiltration and evaporation of groundwater, water resource planning, water reservoirs, operation and maintenance of water and wastewater plants, social costs of sewer rehabilitation, sewer renovation techniques, and water conservation and re-use.
- Civil and Structural Engineering at Nottingham Trent: water pollution monitoring and purification.
- Civil and Structural Engineering at Sheffield: environmental engineering, and water engineering.
- Civil Engineering at Belfast: environmental hydraulics, salinity and water quality in tidal rivers, assessment techniques for clarification and filtration of water and industrial wastes, and contamination of ground water.
- Civil Engineering at Birmingham: public health engineering: adsorption processes, anaerobic treatment of organic waste-waters; groundwater: regional groundwater flow, pumping test analysis; hydraulics: open channel flow of resistance, dispersion, lateral momentum transfer, sediment transport and turbulence; water

resources: application of computer methods to solution of control problems and to movement of flood waves through reservoirs and open channels.

- Civil Engineering at Brighton: hydraulics and marine technology.
- Civil Engineering at Bristol: earthquake and wind loading on dams; flow in open channel diffusers; behaviour of open channel flow with floodplains; and hydraulic structures.
- Civil Engineering at City: hydraulics, computational fluid dynamics.
- Civil Engineering at Dundee: fluid mechanics; public health engineering.
- Civil Engineering at East London: hydraulics; history of hydraulics.
- Civil Engineering at Edinburgh: storage structures for fluids, hydraulics, water resources, and environmental engineering.
- Civil Engineering at Glasgow: hydraulic engineering.
- Civil Engineering at Greenwich: hydraulics, public health engineering.
- Civil Engineering at Leeds: public health engineering: industrial wastewater treatment, anaerobic digestion; fluid mechanics: ground water, sediment transport, and computational fluid dynamics.
- Civil Engineering at Liverpool: hydraulics.
- Civil Engineering at Liverpool John Moores: hydraulics and hydrology; public health.
- Civil Engineering at London (Imperial): hydraulics: wave mechanics and propagation, water-wave kinematics, dynamics of floating bodies in waves and vibration of hydraulic structures; hydrology: large-scale hydrology for global climate change, rainfall modelling for flood and water resources management, sustainable development of arid zone water resources; environmental engineering: water quality and river basin management.
- Civil Engineering at London (QMW): hydraulics, hydrology, hydrogeology, water resources, and environmental engineering.
- Civil Engineering at Loughborough: water pollution control, biotechnology including microbial engineering, biosensors and networks, expert systems and CAD water treatment plant; stream and river modelling; and water technology for developing countries.
- Civil Engineering at Manchester: hydrodynamics: wide range of shallow water flow problems.
- Civil Engineering at Newcastle: environmental engineering: treatment of water and wastewater; water resources engineering: modelling rainfall, catchments; real-time flood forecasting, control of irrigation canals; flow-transport in unsaturated soil,

- groundwater pollution and geostatistical modelling, fluvial and coastal hydraulics, and hydrogeology.
- Civil Engineering at Nottingham: hydraulics and hydraulic structures, environmental fluid mechanics.
 - Civil Engineering at Portsmouth: hydraulics; public health engineering; and environmental engineering.
 - Civil Engineering at Sheffield Hallam: urban drainage.
 - Civil Engineering at Southampton: hydraulics and maritime; public health engineering: pollution control, reuse technologies, treatment processes, solid wastes, and water quality.
 - Civil Engineering at Strathclyde: environmental health water-borne diseases, water quality and health; water engineering: effluent dispersion modelling, dredging, hydrology and river engineering, and water treatment.
 - Civil Engineering at Surrey: fluid mechanics: wide range of industrial aerodynamics projects.
 - Civil Engineering at Swansea: computational fluid dynamics.
 - Civil Engineering and Building at Coventry: Public health engineering; computational fluid mechanics; and refurbishment of sewers.
 - Civil Engineering and Building at Oxford Brookes: model studies for hydrology purposes; head losses in manholes; expert systems in hydraulics; irrigation and hydrology; stormwater sewer computer design packages; and dewatering potential of sewage sludges.
 - Civil Engineering and Construction at Aston: water resources.
 - Civil, Structural and Environmental Engineering at Paisley: water and public health engineering.
 - Ecological Sciences at Edinburgh: micrometeorology and hydrology.
 - Engineering Geology at London (Imperial): influence of water upon rock strength.
 - Environmental and Evolutionary Biology at Liverpool: freshwater and marine biology, river management, movement of pollutants through aquatic ecosystems.
 - Environmental Biology at Lancaster: aquatic ecology; distribution, survival and activity of bacteria in surface waters and sewage discharges.
 - Environmental Chemistry/Hydrology at Lancaster: environmental pollution; hydrology and water resources: flow forecasting and flood routing, dispersion of pollutants in rivers, use of weather radars for rainfall measurement and forecasting, controls on water, and solute and pollutant movement through soil.
 - Environmental Engineering at Central England.

- Environmental Pollution at Middlesex: water pollutants and their effects in urban areas.
- Environmental Science at Bradford: water pollution; anaerobic digestion of industrial waste-waters.
- Environmental Sciences at East London: water microbiology.
- Environmental Sciences at Exeter: water quality; hydrogeology.
- Environmental Sciences at Hertfordshire: acidification of fresh water lakes; water quality.
- Environmental Science at Lancaster: hydrology, fluid dynamics and water resources.
- Environmental Technology at Brunel: environmental engineering, water/wastewater treatment.
- Environmental Technology at Surrey.
- Irrigation Studies at Southampton: surface and groundwater hydrology, conjunctive use of water resources, and groundwater engineering.
- Soil Science at Aberdeen: catchment studies.
- Soil Science at Newcastle: soil acidity and liming and their effects on soil and water quality.
- Soil Science at Reading: groundwater microbiology; effects of effluents on soils.
- Soil Science at SAC, Edinburgh: modelling and measuring of pollution of ground and surface waters.
- Structural and Civil Engineering at Westminster: sewer systems.
- Urban Drainage at Sheffield Hallam: urban drainage modelling and pollution impact assessment; computer information systems for urban drainage data management; field testing of combined sewer overflows and screens; knowledge-based systems for sewer defect recognition and repair; physical modelling of hydraulic structures and fittings; and development and analysis of jacking pipe couplings.
- Water and Wastewater Treatment at Cranfield.

The degrees that can be obtained follow. In 88% of the research programmes, an MPhil. or Ph.D. could be received; an MPhil./MSc/Ph.D. in 3% of the cases; a DIC/MPhil./Ph.D. in 3% of the cases; an MPhil./MSc (Eng.)/Ph.D. in 2% of the cases; and an EngD in 3% of the cases.

Funding is provided by the following organisations (percentages for the cases for which funding is known to be available): EPSRC 79%, NERC 41%, BBSRC 21%, British

Council 10%, Overseas Development Administration 10%, EU 7%, Foreign and Commonwealth Office 7%, Ministry of Agriculture, Fisheries and Food 7%, and others.

5.4 THE USA

Graduate programmes and research in Water Resources Engineering and Environmental Engineering in the USA are considered in this section. Courses (including part-time ones), degrees, research, and financial aid are considered for Water Resources Engineering. Information from several prospectuses of Universities of the USA and from Peterson (1998) was used by the author to produce the statistics that follow.

5.4.1 Water Resources Engineering

Twenty-eight American Universities offered graduate programmes in Water Resources Engineering in 1998. A full list is shown on Table 5 of Appendix D (p. 201). For each course, the Table shows the University, the Faculty/College, the Department, the title of the course (with options) and the degree obtained.

The programmes offered are as follows: Environmental / Water Resources Engineering in 29% of the cases; Water Resources Engineering 21%; Water Resources 18%; Water Resource Systems Engineering 4%; Water Resource Systems 4%; Hydrologic Science and Engineering 4%; Hydrology and Hydraulic Engineering 4%; Hydraulics / Hydrology 4%; Irrigation Engineering 4%; and Environmental Engineering with one of options in Water Quality Engineering and Science 4%.

The following degrees may be obtained: MS in 82% of the programmes; Ph.D. 71%; MEng. 18%; DEng. 7%; MCE 7%; DE 4%; ME 4%; MSCE 4%; and MSWREE 4%.

The following Universities offer part-time programmes: Auburn, Colorado State, Louisiana State, New Mexico Institute of Mining and Technology, Ohio, Oregon State, Pennsylvania State, State University of New York at Buffalo, Texas A and M, California (Irvine), Colorado at Boulder, Delaware, Maryland (College Park), Memphis, Missouri - Columbia, Missouri - Rolla, Southern California, Virginia, Utah State and Villanova. These constitute 71% of the Universities. Additionally, the State University of New York at Buffalo offers post baccalaureate distance learning programmes. Villanova University also offers evening/weekend programmes.

Examples of research in some of the American Universities follow:

- Colorado State: Flood prediction, stochastic hydrology, drought analysis, and watershed modeling.

Total annual research expenditures: \$400,000

- Oregon State: Water resources; waste management.

- Texas A and M: Water resources development, planning and management; Water resources system engineering, hydrology and hydraulics; and Groundwater systems analysis.
- California, Irvine: Environmental air and water chemistry, environmental microbiology.
- Delaware: Computer programme for groundwater modeling, in situ stress determination by microhydraulic fracturing, stochastic groundwater flow modeling, and poroelasticity in rock mechanics.
- Maryland, College Park: Mathematical and computer modeling and use of such technologies as geographic information systems to access hydrologic and water quality responses of mixed land use watersheds.
- Utah State: Surge flow, on-farm water management, crop-water yield modeling, drainage, and groundwater modeling.
- Villanova: Photocatalytic decontamination and/disinfection of water; urban storm water wetlands; removal and destruction of organic acids in water; and sludge treatment.

It is known that financial aid is available in the following 11 American Universities: Colorado State, Louisiana State, Princeton, Texas A and M, California (Berkeley), California (Irvine), Delaware, Maryland (College Park), Southern California, Utah State, and Villanova.

The following forms of financial aid are available in these Universities: Fellowships in 91% of these Universities; Research assistantships 91%; Teaching assistantships 91%; Institutionally sponsored loans 27%; Federal work-study 27%; for part-time students 27%; Career-related internships or fieldwork 18%; Full and partial tuition waivers 18%; Partial tuition waivers 9%; and Scholarships 9%.

5.4.2 Environmental Engineering

Graduate programmes in Environmental Engineering are offered in 135 American Universities. See Table 6 of Appendix D (page 203).

5.5 CANADA

Postgraduate programmes and research in Water Resources Engineering, Environmental Engineering and other related areas are considered in this section. In particular, courses (titles, degrees, duration, degree requirements, mode of study), research topics and financial aid are considered. Information from several prospectuses of Canadian Universities and from Peterson (1998) was employed by the author to produce the statistics that follow.

5.5.1 Programmes of study

Ten Canadian Universities offered fourteen postgraduate programmes in Environmental Engineering, Water Resources Engineering and other related areas in 1998. A full list of courses is shown on Table 7 of Appendix D (p.205). For each course, the Table shows the University, the Faculty/College, the Department, the title, the degree obtained, the average duration, the degree requirements (number of courses, project, thesis, dissertation, examination), and whether part-time available. The programmes offered are as follows: Environmental Engineering 42% of the cases; Water resources engineering 17%; Environmental Engineering and water resources management 8%; Regional Environmental systems engineering 8%; Fluid mechanics and hydraulic engineering 8%; Geoenvironmental engineering 8%; and Environment 8%. The following degrees may be obtained: Ph.D. in 93% of the programmes; MEng 86%; MSc 57%; MaSc 14%; MASc 7%; MScA 7%; MScE 7%; MEnv 7%; and Diploma 21%. For cases where information is available, the average duration of a Master's degree is two years and for a doctorate is 4.5 years. In half of the programmes of study, the Universities state that part-time study is possible.

5.5.2 Research

The following research work is carried out in four of the Universities of Canada.

a) University of Alberta

The total annual research expenditure is \$2.5 million.

- i. Water Resources Engineering: Hydrologic modelling; remote sensing; evapotranspiration; snow hydrology; hydrometeorology; water resources engineering; river and river ice engineering; flood routing; compound channel flows; numerical methods; environmental fluid mechanics; hydraulics of fishways; urban hydraulics; debris flows; outfalls in rivers; erosion and stratified flows; computational methods in hydraulics; flow in curved channels; and unsteady and nonuniform flow experimental methods, including laser Doppler anemometry.
- ii. Environmental Engineering: Municipal and industrial wastewater treatment, reaction kinetics, modeling, reactor development, peroxidase enzyme - catalyzed aromatic compound removal; Disinfection of water and wastewater, including Giardia and Cryptosporidium; environmental microbiology; water quality deterioration in distribution systems; appropriate technology for water and sanitation; Exposure assessment, indoor/outdoor air pollution relationships, personal exposure monitoring, risk assessment; Ozone water and wastewater treatment; advanced wastewater treatment; land application of wastewater; solid - waste management; low - temperature, dilute wastewater treatment; water treatment and water quality studies;

Combining both hydraulics (mass transport) processes and reaction kinetics for various environmental applications, which include water and wastewater treatment unit processes and contaminant fate in natural waters; and Solid - and hazardous - waste management, environmental impact and risk assessment and management, environmental engineering economics, and systems and decision analysis.

b) McGill University

- i Hydrology and Water Resources Engineering: Stochastic modelling and analysis of precipitations and floods; rainfall-runoff relations for urban and small watersheds, and optimisation of water resources systems.
- ii Fluid Mechanics and Hydraulic Engineering: Turbulent transport processes in natural environments; mixing, internal hydraulics, and frontal phenomena in stratified flows; turbulent jets and plumes; quasi-two-dimensional turbulence; and computation and mathematical modelling of turbulent flows.
- iii Environmental Engineering: Physicochemical and biological treatment processes for water and sewage treatment; methods for examining polyelectrolyte breakdown, measuring trace concentration and toxicity; removal of trihalomethane precursors; wastewater disinfection; Biochemical treatment processes for the precipitation of aromatic compounds from industrial waste-waters, development of measurement protocols for odorous emissions from stationary sources, and application of dispersion models to assess odor impact on surrounding communities. University of Regina
Flood control; waste management and treatment; and ground water flow.

d) University of Windsor

Water resources.

5.5.3 Financial aid

Table 8 of Appendix D (page 207) shows details on the financial aid in Graduate studies in Environmental/Water Engineering programmes that was given to students by four Canadian Universities in 1996-97. For each University, the information given is the number of students receiving aid, and the number and amount of research assistantships, fellowships, scholarships and teaching assistantships. Aid is normally available to students who are already in the programme.

5.6 AUSTRALIA

Education in water engineering in Australia is considered in this section. Information from several prospectuses of Australian Universities, a publication by the National Committee on Water Engineering (1997) and a publication by Magabook (1997) was used.

5.6.1 Undergraduate Degrees

In Australia the education of water engineers has primarily been through formal bachelor degrees in civil engineering accredited by the Institution of Engineers, Australia. More recently, a number of universities are offering bachelor degrees in environmental engineering. A proportion of graduates from these programmes practise in the area of water engineering.

Currently there are 23 universities in Australia which offer bachelor degrees in civil engineering and 12 which offer bachelor degrees in environmental engineering. In addition the University of New England is unique in offering a bachelor degree in natural resource engineering which has a strong emphasis on the management of water and soil resources.

All of these undergraduate degrees require four years of full-time study or an equivalent amount of part-time study. Some institutions offer a bachelor degree in civil or environmental engineering by off-campus study (for example, civil engineering at the University of Southern Queensland and environmental engineering at Deakin University).

All civil engineering students in Australia study some hydraulics and/or fluid mechanics as well as hydrology. Most study aspects of public health and environmental engineering. Some courses also contain studies in water resources management and planning.

Virtually all environmental engineering courses contain studies in environmental fluid mechanics, hydraulics and hydrology. They also contain significant studies in water quality, water and wastewater treatment, groundwater contamination and natural resources management.

5.6.2 Professional Recognition

The Institution of Engineers of Australia views undergraduate engineering education as the first step towards attaining the status of a professional engineer. The graduate engineer must serve something akin to an apprenticeship and face further assessment before being eligible to be admitted as a Chartered Professional Engineer (CPEng) of the Institution and a member of the College of Civil Engineers.

The engineering profession under the auspices of the Institution provides another link in the education partnership. Engineering graduates must typically obtain at least three years of approved engineering experience working under the supervision of an experienced engineer. At least one year of this experience must be in design or planning and at least one year in construction or manufacturing.

Chartered members can apply for registration as a professional engineer. The National Professional Engineers Register Section 3 (NPER-3) is restricted to current

practising engineers who have maintained an average of at least 50 weighted hours of continuing professional development activities over a rolling period of three years. Professional development activities include formal postgraduate training, attending conferences or short courses as well as self-directed reading.

5.6.3 Postgraduate Education

At the postgraduate level, a number of universities now offer specialist studies in water-related areas. Formal postgraduate coursework qualifications recognised by the Commonwealth Department of Employment, Education and Training include the graduate certificate (1 semester of full-time study), graduate diploma (2 semesters of full-time study) and masters degree (1 to 2 years of full-time study). Examples of postgraduate coursework programmes in the area of water engineering are given on Table 9 of Appendix D (page 208). For each course, the title, the degrees obtained and the University are given.

Postgraduate masters degrees by coursework often involve a research component. This may be as high as 50% of the total work for the degree. The topic studied in a research degree is an individual matter which is decided jointly by the student and the supervisor.

All departments (or schools) of civil (or civil and environmental) engineering offer postgraduate research degrees in water or environmental engineering. These include the master of engineering (or engineering science) and the doctor of philosophy (PhD). A masters degree by research requires 1 to 2 years of full-time study while a PhD requires 2 to 4 years. Engineering graduates are often accepted as Masters and PhD students in science faculties of Australian universities. Postgraduate qualifications may also be taken in an off-campus mode.

5.6.4 Co-operative Research Centres

The Commonwealth Government's co-operative research centre (CRC) programme has funded three centres which have ties with water engineering. These are the Centre for Catchment Hydrology (involving the CSIRO Division of Water Resources, Monash University and the University of Melbourne), the Centre for Waste Management and Pollution Control (involving the University of New South Wales and several others) and the Centre for Water Treatment and Water Quality (involving SA Water, the University of South Australia, the University of Adelaide, RMIT, Monash University and CSIRO). In addition, a number of other research centres exist including the Australian Centre for Water Research (University of Western Australia) and two Centres for Groundwater Research based at the University of Technology, Sydney and at the CSIRO Division of Water Resources in Adelaide and Perth.

The CRCs are aimed at promoting co-operative research with industry and have a number of industrial partners. They also promote postgraduate research and training.

5.6.5 Continuing Education

Universities and other professional bodies offer a wide range of seminars and short courses for practising water engineers to maintain and enhance their professional knowledge. These courses may vary in length from a one-hour seminar to a short course run over one to two weeks.

Short courses and seminars in water engineering are organised by the state water panels of the Institution of Engineers of Australia, the Hydrological Societies of South Australia and Canberra, the Australian Water and Wastewater Association (AWWA), the Australian National Committee on Large Dams (ANCOLD), the Australian Chapter of the International Association of Hydrogeologists (IAH) and the Stormwater Industry Association. The topics covered embrace the full range of water engineering and are usually strongly focused on a particular area, for example, municipal water treatment, time series modelling in hydrology, design of wetlands, groundwater modelling, water reuse, and urban drainage design.

Individual subjects from an undergraduate degree or postgraduate qualification are also available at most universities.

A wide range of conferences in water engineering are offered in Australia. The National Committee on Water Engineering of the Institution organises the following conferences: the Hydrology and Water Resources Symposium series (18-month cycle), the Hydraulics in Civil Engineering series (triennially), the Stormwater Management Series (triennially) and the Watercomp series (at irregular intervals in conjunction with the Australian Computer-Aided Design Society).

The AWWA has an annual convention as does the IAH. Other conferences are organised on an irregular basis by ANCOLD and other bodies.

5.7 SOME ASIAN COUNTRIES

5.7.1 Singapore

a) Introduction

Environmental engineering education in Singapore is considered in this section. The information was obtained from Jern (1997) and Koe (1995). In the early 1970s, the focus of environmental education was to ensure sufficient exposure and competence of civil engineering graduates in the relevant fields of water supply and pollution control. This strategy had served the nation well as the development of Singapore was then mainly conceived with the provision of water supply, waste facilities and associated sanitary works. The current 'buzz' words are now resource recovery, recycling and reuse.

Environmental assessment is now a norm for large development projects and 'sustainable development' is now feverishly pursued in all corners of the world.

b) Present Status

Tertiary education institutions include the National University of Singapore, the Nanyang Technological University and various polytechnics.

At the university degree level, environmental engineering education is incorporated into the existing civil engineering and chemical engineering courses. Optional courses to address emerging environmental topics (such as advanced waste treatment processes, separation technologies, environmental impact assessments and toxic and hazardous waste treatment) are regularly upgraded and offered to students. Additional postgraduate courses are also initiated whenever manpower resources are available and a sufficient number of students show interest.

Realising the significance and usefulness of a broad-based technical background to enable students to understand the new advanced topics of environmental engineering, the undergraduate subjects offered to the early years of the engineering degree courses were revamped to address the basic sciences and fundamental engineering principles. More emphasis is now placed on environmental chemistry and biochemistry. Topics on microbiology and basic chemistry of environmental pollutants are now a prerequisite before students are allowed to proceed further in the engineering degree courses.

The 'Environmental Technology-Wastewater Biotreatment Group' of the National University of Singapore carries out research and development work, serves as a resource group and trains professional manpower in environmental engineering. The research is on biotechnologies as applied to wastewater treatment. The courses offered to undergraduate and graduate students are: Basic Environmental Science and Engineering, Water and Wastewater Engineering, Advanced Wastewater Treatment, Air Pollution, Environmental Modelling, Environmental Planning and Management, Sludge Management, Solid Wastes Management, Water Quality Management, Environmental Health Engineering, Industrial Wastewater Control, Urban Environmental Management, and Toxic and Hazardous Waste Management.

c) Future Demands

The present state of affairs in environmental engineering education at the university is, however, not ideal. It is seriously hampered by the overriding need to be in balance with the wide range of courses offered to civil engineering students. While there appears to be a general appreciation of the need to place more emphasis on environmental engineering education (given the growing international momentum on environmental issues), there is a limitation on manpower resources and market opportunities for graduates

in environmental engineering in Singapore. The traditional civil engineering emphasis on structures and geotechnical subjects as well as other civil engineering fields, remains important and of great significance in an urban country like Singapore. As long as environmental education in Singapore remains within the existing curricula of the civil or chemical engineering degree courses, its coverage and emphasis will be constrained and unable to keep pace with the upsurge of environmental issues that need to be addressed.

In recognition of the need to overcome this constraint, staff from the engineering and science faculties of the university have come together to consider the possibility of initiating a Diploma/MSc degree in environmental engineering. The purpose of the proposed Diploma/MSc degrees is to prepare individuals with advanced engineering capabilities in the management and control of the environment, for the protection of human health and nature's ecosystem, for conducting industrial and other human activities without adverse consequences, and for the enhancement of the quality of life. Special emphasis will be placed on developing competence in certain areas of environmental technology that have special relevance to Singapore's industrial development and manufacturing economy.

The proposed programme will be established by combining and expanding the existing educational activities concerning environmental science, environmental engineering and public health of various academic departments in the university. Basic modules that are considered necessary to courses that cover the basic science and engineering science principles upon which the practice of environmental engineering is based have been identified as: environmental chemistry; environmental microbiology; physical principles of environmental engineering; chemical and biochemical reaction engineering; mathematical methods for environmental engineering; and instrumental methods and process control.

Advanced modules are proposed to cover selected specialised fields of environmental engineering, such as topics on various environmental technologies, environmental management, environmental health and environmental processes and systems.

5.7.2 Malaysia

Environmental Engineering education in Malaysia is considered in this section. The ultimate goal for Malaysia is to have rapid economic development without environmental degradation. This goal can most probably be realised through modification of the present engineering education system. This is because engineers are directly involved in creating facilities and utilities for industrialisation, transportation and communications. Most of these engineering activities have created wealth, but at the same

time have resulted in massive ecological problems in the form of deforestation, atmospheric pollution, surface and ground water pollution and soil erosion (Aziz, 1990).

In recent years the government of Malaysia has included environmental education at all levels of the education system. These environmental education programmes are aimed at creating general awareness and a sense of responsibility towards the environment among the educated.

At the tertiary level, the objective of environmental engineering education is to produce professionals who are well-versed in the sciences, engineering and management of the environment. In the last decade, considerable progress has been made in this area. Many courses were added to the curriculum of undergraduate programmes in civil and chemical engineering. Master degree programmes were also introduced in some universities, such as the National University of Malaysia and the University of Science Malaysia (Hashim, 1995).

In the civil engineering undergraduate curriculum, an introductory course on environmental studies is offered in the first year. This course deals with the concept of basic ecology, man and the ecosystem, natural resources and their utilisation and the technology-society-environment interface (Abllah, 1988). The impacts of human activities on the environment and the control and legislative issues for environmental protection in Malaysia are major components of this course. Ecological principles in terms of biogeochemical cycles are also included. The course on 'Engineer in Society' in the second year civil engineering undergraduate programme deals with human relations, economic requirements and social environmental and political factors. In the third year, conservation issues are highlighted and the importance of harmony between technology and the environment is stressed. The course on conservation also deals with the natural equilibrium in different ecosystems and the interference by human activities on the ecological equilibrium. Traditional courses in civil engineering such as public health engineering, hydraulics and water resource engineering are offered in the third and fourth year. Optional courses in environmental engineering include advanced hydraulics, water resources management and advanced hydrology. These are advanced courses that deal with unit operations and processes for water, wastewater and solid waste treatment and management. In addition to treatment technology, effluent reuse and reclamation aspects are also covered. Environmental management is another important area of specialization in the undergraduate civil engineering curriculum. In this course, technologies related to clean water, fertile land, clean air, modern housing and healthy life are emphasised.

The chemical engineering undergraduate programme includes a course on industrial wastewater treatment using physical, chemical and biological methods.

Biological waste treatment technology is also emphasised in the optional biochemical engineering course. Traditional courses in chemical engineering (such as heat and mass transfer, transport phenomena, process control, reactor design and separation processes) are directly relevant to the technical aspects of environmental engineering. Some of these courses are being modified to stress their relevance to environmental engineering. Basic science subjects, such as analytical chemistry, ecology and microbiology, and environmental subjects like pollution prevention, waste minimisation, low waste or no-waste technologies, environmental impact assessment, environmental audit, risk and hazard analysis and disaster management, are being developed into optional courses in the chemical engineering undergraduate curriculum (Sulaiman, 1990). Ideally, these subjects should be included in a comprehensive environmental engineering programme. Unfortunately, the present chemical engineering curriculum is not able to accommodate all these courses because the programme is already overloaded with compulsory courses. Perhaps the time has arrived for the engineering community in Malaysia to consider environmental engineering as a separate undergraduate discipline.

Postgraduate programmes in environmental science and engineering are being offered by different universities in Malaysia. These programmes include basic science courses such as environmental chemistry, biology, microbiology and ecology, engineering courses such as industrial waste treatment, air pollution control, solid waste management, water and waste-water engineering, and management courses such as environmental management, disaster management and resource management. The aim of these programmes is to train engineers and scientists and to give them the specialised knowledge and skills to solve environmental problems (Hashim, 1995).

The latest development in environmental engineering education in Malaysia is that private organisations, such as the Environmental Management and Research Association of Malaysia (ENSEARCH), are conducting Master of Environmental Management (MEM) programmes in collaboration with foreign universities. ENSEARCH has developed the programme as part of its contribution to the nation's technological development in environmental protection and enhancement. These programmes offer opportunities to practising professions to upgrade their environmental knowledge, skills and capabilities. The main objective of the programmes is to lay the foundation for training professionals who will have the technical knowledge and capability to protect and enhance the environment (Hashim, 1995).

In conclusion, both public education organisations and private professional bodies in Malaysia are making serious efforts to equip new and practising engineers with

environmental knowledge and skills, as the activities of this group of professionals have the greatest influence on the environment.

5.8 MODERN TECHNIQUES AND TECHNOLOGIES

Distance education is the enrollment and study with an educational institution which provides lesson materials prepared in a sequential and logical order for study by students on their own.

Distance learning courses can be provided using computer aided, multi-media packages. These opportunities exist through computer and telecommunications technologies including the Internet, the World Wide Web, videoconferencing, and so on.

The distance learning options are: (a) live, interactive class sessions delivered via videoconferencing; (b) specially designed world wide web sites with all course materials, e-mail, threaded discussion lists, and hot links to related web sites; (c) professionally produced videotapes; (d) textbooks, course notes, readings and other printed materials.

An Internet web site may contain a syllabus with class assignments, e-mail chat capability, and student generated materials from several case histories. An example is the 'Science, Technology and Culture-Link' electronic archive at the University of Colorado at Denver (Tang and Johnson, 1999). Participating universities could develop a common course. There is a need to eventually project this teaching tool in terms of a nationally and globally networked programme.

The Distance Education and Training Council (DETC) is a non profit educational association located in the USA. It serves as a cleaninghouse of information about the distance study/correspondence field and sponsors a nationally recognized accrediting agency called the "Accrediting Commission of the Distance Education and Training Council". Today, more than 2.5 million Americans are enrolled in DETC – accredited institutions (DETC, 2001). Another organisation is the International Centre for Distance Learning (ICDL) which is an information service in support of distance learning worldwide.

An example of a new-age electronic textbook is 'Fluid Mechanics: An interactive text' by the ASCE (ASCE, 1998b). It is a fully-integrated multimedia CD-ROM packed with computational tools. The difficulties with fluid mechanics stem from the abstract and nonlinear nature of the subject matter. The creators of the CD-ROM have tried to alleviate such problems by introducing an interactive text that uses hypertext features, animation, video sequences, dynamic graphs and computational facilities that permit students to break away from the static graphs and tables found in conventional textbooks. Another example of software on CD-ROM is 'Computer applications in hydraulic engineering' by Haestad Press (Civil engineering software). It can be used a lot for projects and assignments.

The ASCE's Continuing Education Department offers videotape and audiotape and correspondence self-study programmes or courses (ASCE, 1999a).

An innovative idea is a four-year engineering (Eng. D.) programme, as opposed to the traditional Ph. D. It is run by the Centre for Innovative Construction Engineering at Loughborough University. This degree will require candidates to spend at least 75% of their time performing research directly for a firm (ASCE, 1999b).

The Department of Civil and Environmental Engineering at Worcester Polytechnic Institute, USA, implemented a graduate-level course entitled 'Integration of Design and Construction'. The goal is to provide a project-based, practice-oriented opportunity for teams of students to deal with the problem of functional integration. The course involved a mix of class discussion, laboratory, and lecture activities. Faculty relied on industrial participation to present the real-world projects to the students (Albano and Salazar, 1998).

Hydraulic engineering is a course typically taught in a lecture-based format. Two teaching techniques, Problem-based learning and Cooperative learning, can be used to enhance learning in the course. The goals of Problem-based learning are to provide the student with an active role in learning and to allow the student to take responsibility for learning. The goals of Cooperative learning are to have students work in teams, thereby learning from both each other and the instructor and to teach students to work together cooperatively in small groups (Johnson, 1999).

Competitions or student paper contests can be an element of a course. An example is Padnos competition (Plotkowski, 1998). It is a means for creating a structure for courses with a project component, and generating excitement among young students by addressing environmental issues. The competition is an annual one which recognizes innovative student projects in engineering which are environmentally responsible. The intent of the contest is to be compatible with any engineering course that includes a project component. To be considered, a project must have a major focus on an innovative engineering approach to solving a problem in an environmentally responsible manner. The particular environmental problem for the project must be addressed in the report.

5.9 SUMMARY

A database of the institutions that are currently used for training Cypriots in Cyprus and in several countries overseas in the sector of water and waste-water engineering has been established and is mostly presented in Appendix D. Relevant undergraduate and especially postgraduate courses on Water and Waste-Water Engineering and other related areas (for example, Environmental/Civil/Water resources/ Pollution control/Irrigation Engineering/Management/Technology) were collected, analysed and synthesised. Thus, a comparative international survey and curriculum analysis of existing Water and Waste-

Water engineering (taught and research; full-time, part-time and long distance) degrees was conducted. The information collected includes institutions, courses (titles, degrees, content, duration, assessment, requirements, accreditation, mode of study), research topics, funding and sponsors.

The countries for which courses have been considered in this study include Cyprus, the UK, the USA, Canada, Australia, Singapore and Malaysia. The reasons for the choice of these countries were explained.

As concerns Cyprus, the Engineering School of the University has not functioned yet. Other Departments are involved in research in this sector. The other institutions in Cyprus offer non-University level education or are not accredited yet. They are, however, involved in research.

As was identified, the international trend is for a considerable increase in the number of courses offered nowadays in the sector (Water and Waste-Water Engineering; Environmental Engineering) as compared to courses 5 and 10 years ago. It is also interesting to note that an increasing number of Civil and Environmental Engineering Departments have been founded. In the USA, for example, 43% of the postgraduate programmes in Water Resources Engineering were offered (in 1998) by Departments bearing the title 'Civil and Environmental Engineering Department'. The greater emphasis in environmental engineering is explained by the fact that there is a growing international momentum on environmental issues. In particular, resource recovery and reuse, environmental assessment for large development projects, sustainable development and other topics are increasingly becoming more important.

Modern learning techniques and technologies are very promising.

CHAPTER SIX

NEEDS AND FUTURE PLANS FOR CYPRUS AND CYPRIOT WATER AND WASTE-WATER ENGINEERS

6.1 INTRODUCTION

It is important to assess the training needs of graduate engineers working in Cyprus. In this Chapter, the needs of and future plans for personnel and infrastructure in the field of water and waste-water are assessed. The questions that need to be answered are:

- (a) What is provided now and to whom? Who provides/meets needs now? And whose?
- (b) Is this appropriate now? Will it be appropriate in the future?
- (c) What are current and future needs? What are the priorities?
- (d) What are the gaps between current provision and needs?
- (e) What are the plans/intentions/interests/proposals and who decides?

Question (a) was dealt with in Chapter 4. The rest of the questions are the subject of this Chapter. These questions need to/will be applied to education, training and research and to different branches of knowledge related to water/wastewater management. The in-country and overseas dimensions need to be addressed.

It is interesting to note that only 2% of the professionals (when asked, in the Questionnaire, "Which are the basic problems faced in the field of water/waste-water in Cyprus") consider research and training as problems by stating 'no research' and 'lack of training'. (see section 6.6.2 on page 130).

6.2 UNIVERSITY EDUCATION

The facts given in this section are derived from the responses of professionals to Questionnaire II (see Table 2 of Appendix B on page 183).

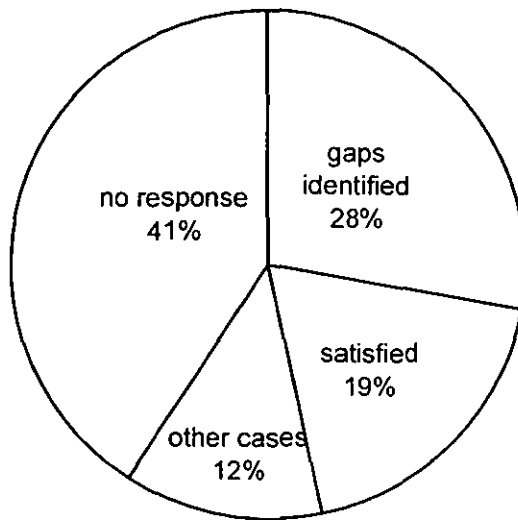
6.2.1 Branches of knowledge

In Question 3(a) of Questionnaire II, the engineers/scientists were given a list of 23 branches of knowledge (in water/waste-water engineering) and they were asked to specify which of them are required to carry out their present duties in the field of water/waste-water. They could specify as many branches as they thought necessary. They could, also, specify other branches not in the list provided by the researcher. The subjects that were specified by more than half of the respondents are as follows (in order of frequency): water storage; theory of hydraulics; water quality; water demand; transmission and distribution of water. The results are shown in detail in Table 5 of Appendix B (on p.188). There was no answer in 3 out of 32 cases. One person (out of 32) suggested only some other subject (not in the list provided), and none of those in the list provided.

6.2.2 Education gaps

Question 3(b) of Questionnaire II was to specify gaps in the education they received at University so that (if the gaps were not there) they would be in a better position to carry out their present duties in the field of water/waste-water. 41% of the respondents did not give an answer, 19% (which is 32% of those that gave an answer) were quite satisfied, and 28% (47% of those that answered) indicated some specific gaps. 13% were other cases: a) wrong choice at University; b) specialisation is needed now; c) graduation a long time ago, whereas new technology is introduced now; and d) education in another branch. See Fig. 6.1.

Fig. 6.1 University education gaps (identified by professionals)



Those persons that indicated some gaps, offered the following suggestions for the University curriculum: Hydraulic design and dynamic forces of moving water; Design of water retaining structures; Water quality; Water quality and the relationship with the environment; Training in execution and maintenance of waste-water projects; Toxic waste treatment; Information systems; Industrial visits; and Industrial training. These gaps are directly linked to the requirements of the occupation of each respondent, with the exception of the suggestions for industrial training/visits which could apply to anybody.

6.2.3 Useful postgraduate university courses

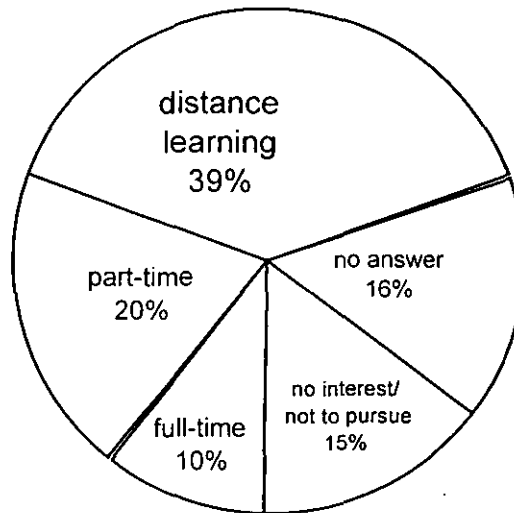
In Question 4(a) of Questionnaire II the engineers/scientists were given a list of 14 titles of postgraduate university courses and they were asked to specify which of them they would follow now (even if they already possess a postgraduate degree) that would/could be useful for their present or future work. They could specify as many courses as they wished. They could, also, indicate other courses not in the list provided by the researcher.

[Note: Suggestions for courses not in the list were considered for statistical analysis]. The five most popular courses (in order of preference) are as follows: Environmental Engineering; Water and Environmental Engineering; Environmental Civil Engineering; Environmental Design and Engineering; and Hydraulic Engineering. Details are given in Table 6 of Appendix B (p.189). There was no suggestion in 22% of the cases. 13% of the respondents suggested only courses that are not in the list provided.

Two-thirds of the respondents are willing to follow such studies; there was no answer by 16%; 9% are not interested (even though one person appreciates the usefulness of such courses); one person (3%) will not pursue such studies even though interested; and one person would surely follow a course if it was 5-10 years ago.

If the people that are interested are considered, only 14% would follow a full-time course. The rest would follow a part-time course (24%) or a distance learning course (52%) or either of the two (10%). These answers were given for Question 4(b) of Questionnaire II. See Fig. 6.2.

Fig. 6.2 Useful postgraduate university courses (intentions of professionals)



72% of the total number of respondents are prepared to follow such a course if offered in Cyprus. One person, however, stated that the answer is positive depending on its standard. 9% answered negatively because of lack of time and other duties and interests; and there was no answer at all by 19%. These answers were given for Question 4(c) of Questionnaire II.

Many mid-career professionals are already learning by distance learning methods. Given that it would be difficult for many mid-career engineers in Cyprus to take up a higher education course full-time in another country, distance learning needs to be considered as an important option. In fact, it would be a better option than taught courses.

These programmes are of particular interest to people that are unable to take time away from their work (losing also income, experience or seniority) or leave home to undertake a full-time residential course, or if they and their employers (or sponsors) wish to save on the cost of travelling and living at a University. Also, tuition fees are less. It is the form of education that has the advantages of flexibility of place, time, content of studies, and of pace. In other words, distance learning offers the learner more control over what he or she learns, and where and how he or she learns it. Distance learning methods are very often very effective. On the question of education effectiveness, numerous individual testimonials have been offered over the years attesting to the benefits of distance education (DETC, 2001). A disadvantage of distance learning is that it would be a difficult method for gaining practical skills. Information on the methodology of distance learning is given in section 5.8 on p. 109.

6.3 SHORT COURSES, SEMINARS AND WORKSHOPS

The objective in this section was to see what the interest (in terms of topics, form and duration) professionals had in continuing education/training short courses, seminars and workshops. For achievements so far, see Chapter 4. See section 6.5 for governmental/semi- governmental organisations. In Question 8(a) of Questionnaire II, the professionals were asked to propose topics that they would be interested to attend in seminars/workshops/courses in the field of water/waste-water. Twenty persons (63%) suggested 35 topics (32 different ones). There was no answer by 34% of the respondents.

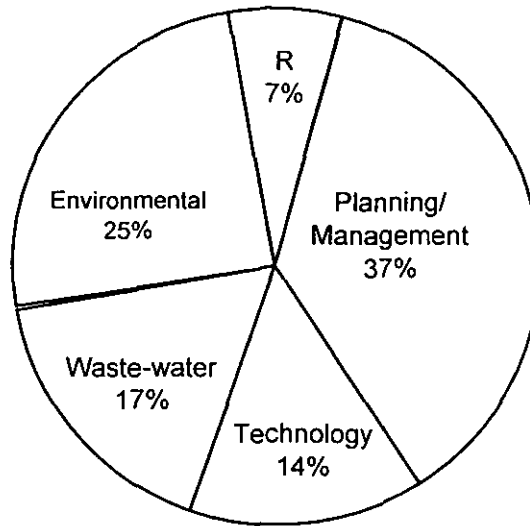
If the topics are arranged into groups, the results are as shown on Fig. 6.3 (p. 116).

The five groupings are explained on Table 6.1. The same broad groupings are used for topics identified by workers in the field for research (see section 6.4 on p. 120) and for problems faced in the field of water/waste-water in Cyprus (see section 6.6 on p. 129). Based on the various topics suggested by respondents, similar topics were grouped to arrive at broad groupings. In the summary, the groupings identified will be linked to see if there is correlation between training/seminar demands and research topics.

The topics that were actually suggested for seminars/workshops/courses are as shown on Table 6.2. These courses/topics are mostly directly linked to the jobs of the respondents.

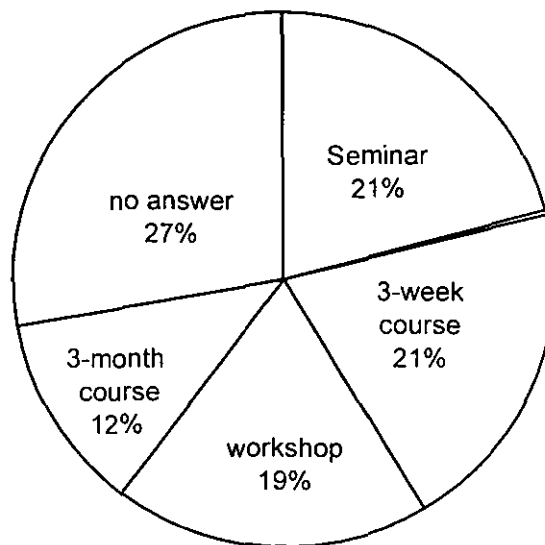
In Question 8(b) of the Questionnaire, the respondents were asked how the seminars/workshops/courses should be delivered. They were asked to give in order of priority whether it should be a seminar, a workshop, a 3-week course, or a 3-month course. The method of scoring that was used is as follows: If the order of preference is first place then the score is 4 units; if second the score is 3; if third the score is two; and if fourth the score is one unit. The order of popularity is shown on Fig. 6.4 on page 116.

Fig. 6.3 Topics (broad areas) to attend in seminars, workshops and courses as proposed by professionals



R = Water Resources

Fig. 6.4 Mode of continuing education/training proposed by professionals



The result shows that the majority do not prefer long courses because most probably they do not have the time, or the circumstances do not allow them to attend.

Table 6.1 Content of groupings of topics suggested by professionals for training, research and problems in water/waste-water in Cyprus

A. Water Resources

Water resources / inadequacy of water resources / hydrology / new sources / droughts / larger demand than availability / development of resources / losses in dams.

B. Planning and Management

Planning / Design / Management / Policies / Co-ordination / Criteria on decisions / priorities / political motivation / sustainability / post-evaluation / conservation / saving / optimisation / water conscience / operation / productivity / losses and monitoring systems / no research / lack of funds / lack of training / information systems.

C. Technology

Water treatment / desalination / engineering / rainwater disposal.

D. Waste-water

Systems / management / treatment / maintenance / re-use / sludge management / recharge of ground water.

E. Environmental

Water quality / water pollution / toxic wastes / environmental effects due to large projects (including environmental impact assessment) / environment and management.

Table 6.2 Topics suggested by professionals for seminars, workshops and coursesWater Resources

- Water resources
- Water resources of Cyprus

Planning and Management

- Design and planning of water resource developments
- Optimisation of water resources
- Water resources management (3 cases)
- Water resources management of an area
- Water management
- Water conservation
- Water saving
- Lessening of invisible losses in the water supply networks
- Water conscience
- Information systems

Technology

- Desalination
- Desalination plants
- Process design of reverse osmosis plant
- Technology in water sector
- Disinfection of potable water supplies

Waste-water

- Management of large central sewage projects
- Waste-water treatment
- Economical waste-water treatment
- Maintenance of waste-water projects
- Pumping of sewage
- Sludge management

Environmental

- Environment and management of water resources
- Water quality for engineers
- Environmental civil engineering of water development works
- Environmental themes related to water projects

(continued)

Table 6.2 (continued)

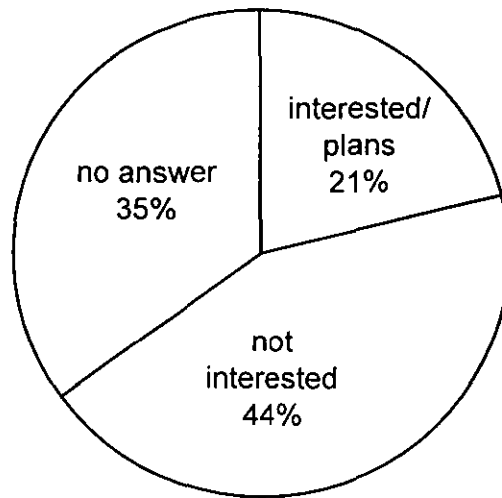
- Environmental impact assessment on water projects (2 cases)
- Principles of Environmental Engineering
- Environmental impact assessment
- Toxic wastes management

6.4 RESEARCH

6.4.1 Academic research

It is noteworthy that 21% of respondents to Questionnaire I (see Table 2 of Appendix A) are interested or plan to carry out academic research work in the field of water/waste-water related to the characteristics and needs of Cyprus in the future. If this proportion is compared to 13% that were involved in the past (see section 4.4), then it may be deduced that there is a trend for greater interest in research work in the future. 44% of the respondents are not interested and 35% did not give an answer. See Fig. 6.5.

Fig. 6.5 Academic research: interest by professionals



Almost all (92%) of those that gave a positive answer suggested a specific area for research work. Only 15% knew or secured sponsorship for their future work. The sponsors are the European Union (EU) and the Planning Bureau of the Cyprus Government. The topics are shown on Table 6.3.

The most popular broad areas for research are shown on Fig. 6.6 on p. 122.

6.4.2 Research as part of employment

In Question 5(b) of Questionnaire II, the professionals were asked whether they would be interested to carry out some research as part of their job in the sector, irrespective of whether they were or were not involved with research. The response is shown on Figure 6.7.

The research proposals are shown on Table 6.4 on p. 123.

Table 6.3 Topics suggested by professionals for academic research work (related to the characteristics and needs of Cyprus)

Planning and management

- Modelling of water resources for optimal (sustainable) development
- Water saving

Waste-water

- Groundwater recharge with treated effluent
- Collection and treatment of waste-water in small communities
- Composting of domestic sludge and animal wastes
- Sludge management
- Use of treated waste-water for preservation of ecosystems (Acrotiri – Paphos – Larnaca areas)

Environmental

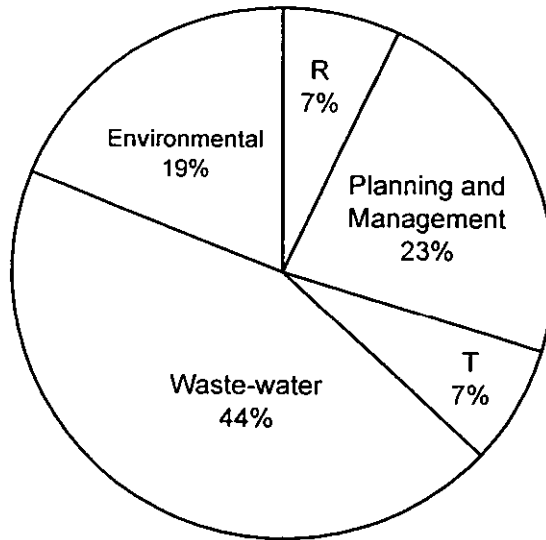
- Underground water pollution in Cyprus
- Water quality in coastal water

Various

- Water supply development in Morphou area
- Water development in rural areas

Water supply; irrigation; waste-water systems

Fig. 6.6

Academic Research areas proposed by professionals

R = Water resources

T = Technology

Fig. 6.7

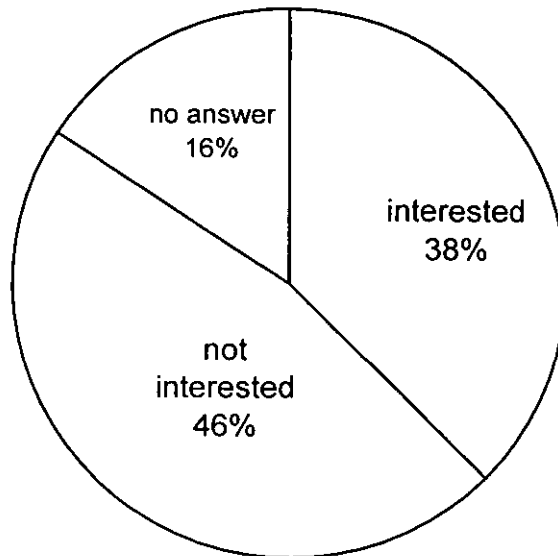
Research as part of employment: interest by professionals to carry out

Table 6.4 Research as part of employment: topics proposed by professionalsWater resources

- Water resources in Cyprus

Planning and Management

- Water policy and groundwater management
- Systems optimisation (of water)
- Water saving
- Post-evaluation of water projects
- Water supply management in Morphou area

Technology

- Hydraulics/coastal engineering
- Water engineering

Waste-water

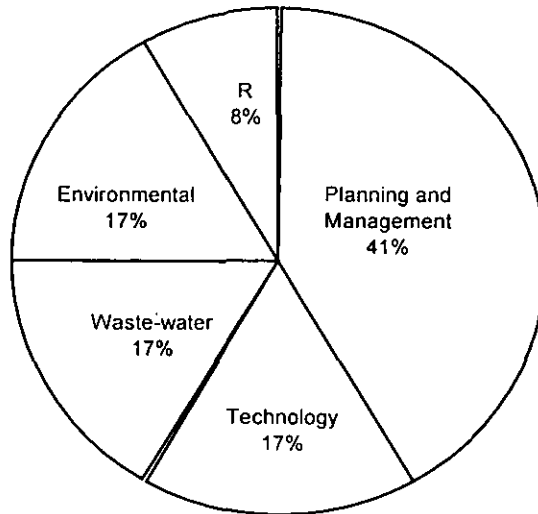
- Soil aquifer treatment (SAT) applications as an alternative option for waste-water treatment
- Waste-water management

Environmental

- Environment and management of water resources
- Groundwater effect from re-use of treated effluent

The broad areas of the research proposals are shown on Fig. 6.8.

Fig. 6.8 Research as part of employment: broad areas proposed by professionals



R = Water Resources

The research work that is proposed will be funded by the government of Cyprus (42%); in 8% of the cases governmental subsidy will be sought; in 33% of the cases it was not known who could fund it; and in 17% of the cases, there was no answer by the respondents.

In the case of a negative answer (that is, if there was no interest to carry such work), then they were asked why they were not interested. The results were as follows: lack of time 33%; retiring soon/research is for young people 13%; no professional motives/opportunities/presuppositions 13%; other priorities/interests 7%; and no answer 33%.

6.4.3 Suggestions and plans for beneficial research

In Question 6 of Questionnaire II they were asked to indicate what research (according to their experience) is needed in the field of water/waste-water so as to obtain benefits for the country and people of Cyprus. Twenty-three persons (72% of respondents) suggested 33 areas of research; 25% gave no answer and 3% suggested the use of technical knowledge from abroad. The proposed topics are shown on Table 6.5.

If the topics are broadly grouped, then the results are as shown on Fig. 6.9. (page 127).

If the topics are analytically grouped, then the results are as shown on Table 7 of Appendix B (page 190).

Table 6.5 Beneficial research: topics proposed by professionalsWater Resources

- Exact definition of available water sources and water demand
- Finding new water sources
- Hydrology of small catchments of different physical and geomorphological characteristics

Planning and Management

- Utilisation and management of water sources of economic cost (not the over-simplified solution of desalination)
- Optimisation of water resources
- Sustainable management of water resources in arid regions
- Post-evaluation of water projects
- Project operation under conditions of lack of water
- Water conservation
- Water saving
- Research and methods of saving of water consumption by the consumers (water amount is limited)
- Leakage of dams and water supply network

Technology

- Ground water engineering
- Rainwater collection and use
- Desalination

Waste-water

- Infrastructure for waste-water works
- Design parameters for waste-water treatment
- Treatment of waste-water and re-use of treated waste-water
- Industrial and waste-water treatment and re-use
- Sludge management
- Waste-water re-use
- Re-use of treated waste-water and mud
- Use of waste-water for irrigation
- Artificial recharging of aquifers using secondary effluent and re-use for irrigation
- Education of farmers to re-use treated effluents for irrigation

(continued)

Table 6.5 (continued)

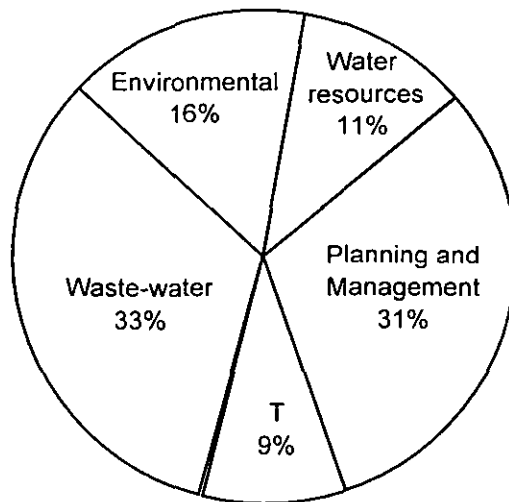
Environmental

- Extent and sources of water pollution
- Effect of pesticides and fertilisers on ground water systems
- Bathing water quality
- Environmental control
- Toxic wastes management

Various

- Water sources, utilisation and distribution for various uses (domestic, irrigation, tourism)
- Water/waste-water management

Fig. 6.9

Beneficial research: broad areas suggested by professionals

T = Technology

6.5 ORGANISATION BY THE AUTHORITIES

6.5.1 Needs as identified by authorities

Unfortunately not enough information is available to the author to deal adequately with the topic of “organization by the authorities”. The reasons are: some organisations have not undertaken needs identification studies (one reason being that some organisations, like Sewerage Boards, were recently founded); other organisations (that possibly carry out needs assessments) do not notify such information to a third party as they consider it as an internal matter. Further details on the general matter of obtaining information from organisations are given in section 7.2 (page 141).

The Scientific and Technical Chamber of Cyprus supports the view that university education and research in engineering is needed for Cypriots based in Cyprus. The reasons and arguments for it are (ETEK, 1999a and ETEK, 1999b): (a) to assist in the protection of the physical environment and the cultural heritage with the provision of scientifically determined guidelines of the rational development of the built environment; (b) to increase the margins of research fields; (c) to offer the University and other institutions the opportunity to take part actively in the large number of research programmes in the context of the EU which will improve their image abroad and will assist in the import of high technology in Cyprus; (d) to assist in the development of technology and the support of the industry; (e) to contribute in the development of engineering and in consequence the

development of the country since the planning of the public works will be improved and the averting of employment of an excessively large number of foreigners in Cyprus; (f) to stop or minimise the flight of capable professionals to other countries; (g) to constitute the base to improve the sector of services in Cyprus so as to contribute to the export of services by Cypriot engineers abroad; and (h) to bring about immediate economic benefits since the export of student exchange will be decreased.

The Sewerage Board of Larnaca admits that it falls short in training (Georghiou, 1999).

The author believes that one of the needs in the civil service is professionals to prepare and enforce standards on water and waste-water.

6.5.2 Appropriateness and gaps of organisation

One of the questions to be answered is whether there is a problem with leaders and planners and at which level. One-quarter of the respondents (to Questionnaire II) believe that (when asked which are the basic problems faced in the field of water/waste-water in Cyprus) it is a problem of planning/management/motivation (they refer generally to water/waste-water systems and not necessarily to education, training and research specifically). See section 6.6.2 (page 130) for further details.

6.5.3 Plans

The researcher managed to obtain some short-term plans for continuing education for the personnel of governmental and semi-governmental organisations.

Training programmes for W.D.D. personnel are prepared six-monthly. The author obtained the plan for 1997-98 (see section 4.8.2 on p. 67). The plans were implemented. They were written by G. Socratous, a W.D.D. officer responsible for training.

The future plan of the Water Board of Limassol, as given by its manager, is the participation in international conferences on water supply themes (Markaris, 1999).

The Water Board of Larnaca and the Sewerage Board of Larnaca wish to be further involved in continuing education for their personnel and to co-operate with training organisations (Christodoulou, 1998; Georghiou, 1999).

The Sewerage Board of Paphos has been founded recently and manned over the last two years and has no plans for training its professional personnel (Malekides, 1999).

The Planning Bureau is the national planners of Cyprus. See section 4.8.7 (p. 77) for its work. Unfortunately, the new Strategic Development Plan (for the five-year period 1999-2003) which is prepared by the Planning Bureau will be published in the year 2000, too late to be considered for this Thesis. As concerns the previous Strategic Development Plan of 1994-1998 (Planning Bureau, 1994), one of the main objectives of the Plan was the improvement of the quality of the labour force. The policy measures proposed were the

investigation of the possibilities of utilising EU programmes (with emphasis on training issues); the recognition of degrees and training certificates; aligning and co-ordinating educational policy and occupational training; and the training programmes of the Cyprus Training Authority should be intensified and expanded. According to this document, Cyprus was clearly lagging behind most EU countries in the sectors of technology and research. It is worth pointing out that the amount spent in Cyprus on research accounted for only 0.2% of the GDP, and this is for all research, not just for water. [Note: Other details about research statistics of 1992 - which is the latest year for which official thorough statistics exist - are given in section 2.5 on p. 42. According to preliminary, unpublished statistics by the Department of Statistics and Research, it is estimated that the research expenditure in Cyprus is 0.25% of the GDP nowadays (the amount, in monetary terms, has been doubled since 1992) compared to an average of 2% in EU countries. The amount in Cyprus will be increased in the near future due to EU Programmes (Kathis, 2000)]. The promotion of research activity in Cyprus constituted one of the basic strategic objectives of that plan. Some of the measures proposed were: co-operation would be promoted between the University of Cyprus and other Cyprus research institutions with universities and other research institutions in EU countries, as well as the utilisation of the research results from community programmes and the encouragement of training and mobility of Cypriot researchers; promotion of the participation of Cyprus in the 'COST' programme which constitutes the framework for co-operation between European countries in research and technology issues; specialisation of the policy regarding technology on the sectoral level, with emphasis on sectors where Cyprus may acquire comparative advantages or which have strategic importance for Cyprus, for example water resources; upgrading the equipment of the various training institutions (for example, the Higher Technical Institute) with the Industrial Training Authority participating in its financing; and establishing an Institution for the promotion of research in order to encourage scientific research in Cyprus, with an emphasis on applied research. The latter was realised as stated in section 2.5. The new Plan (of 1999-2003) will include a review of progress of the previous Plan (of 1994-1998). When the review is published, we will know how much of the previous Plan was realised.

6.6 CHARACTERISTICS AND NEEDS OF CYPRUS IN WATER AND WASTE WATER SYSTEMS

6.6.1 General

The general water and waste-water situation in Cyprus is analyzed in section 2.3 (p. 28). Also, the general characteristics and needs of Cyprus are described in that section.

The ultimate aim is to identify needs in education, training and research bearing in mind: (a) the characteristics and needs in Cyprus; and (b) the constraints faced by water/waste-water systems in Cyprus.

The problems, as identified by workers in the field, are considered in section 6.6.2 that follows.

6.6.2 Problems

The author referred earlier (in section 1.1) to the WEDC acronym SCHTEFIE (Social, Cultural, Health, Technical, Economic, Financial, Institutional and Educational/Environmental aspects) about the needs for multi (and inter) disciplinary action for development to be both appropriate and sustainable.

In this section, the problems in water/waste-water systems are identified as indicated by workers in the field. J. Pheas, a chemical engineer, believes that the problem is complicated and is neither only technical nor does it need a one-dimensional approach. A summary of his views (Pheas, 1998) on the management of water resources in Cyprus follows in this paragraph. It seems that not all the available knowledge is utilised for the preparation of an integrated strategic plan to face water shortages. There is no lack of technology or technical solutions. Everything, however has its cost; both what we do that we should not (for example, the use of potable water where other water could be used) and what we do not do that we should (for example, the selective return of treated waste-water in positions where it can be used). The problem is the lack of capability to manage the various qualities of water separately according to the quality needs of each use. We have not exhausted all the possibilities for the re-use of water and we do not apply closed systems in many agricultural cultivations. We do not carry out studies on the use of water. We can achieve impressive results with knowledge and wisdom and some courage to go on with applications.

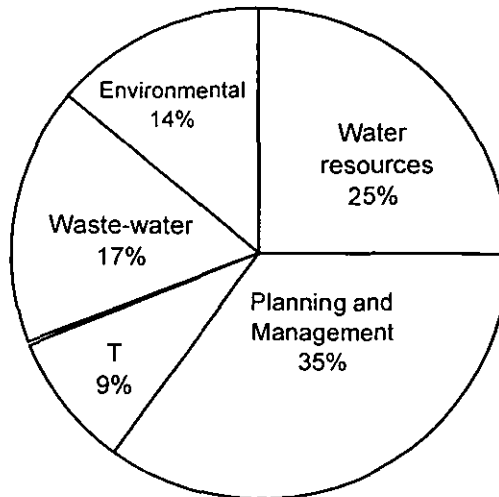
When the Scientific and Technical Chamber of Cyprus (ETEK) presented recently its views before the Environmental Committee of the Parliament, the major theme was desalination. In particular, one issue was the installation and the operation of desalination plants and their effect on the environment. Another issue was the need to install desalination plants for hotels and other units that consume large quantities of water (ETEK, 1999b). There is a debate in Cyprus as concerns desalination. The official governmental position is that it is the solution to obtain the additional water quantities that Cyprus needs. For others, including environmentalists, the use of desalination is problematic because it is cost-ineffective (see section 2.3.6), energy consuming (since imported non-renewable energy is used for the generation of electricity required), and it is causing environmental problems. The opposers to desalination believe that it can be used after all other

alternative sources of water supply are fully exploited and after more effective water management/planning/coordination policies/techniques are fully utilised/in operation.

In Question 7 of Questionnaire II, the professionals were asked to indicate three basic problems (in order of priority) faced in the field of water/waste-water in Cyprus. Twenty-six persons (81% of respondents) suggested 68 problems. The list of problems were grouped by the researcher. Each suggested problem was given 3 units if placed by a respondent in the first place, 2 units if in the second place and one unit if in the third place. When the problems are grouped, the results obtained are shown on Table 8 of Appendix B.

If the problems are broadly grouped, the results are shown on Fig. 6.10.

Fig 6.10 Problems in water/waste-water systems as indicated by professionals:
Groupings



T = Technology

A full analysis of the problems as indicated by the respondents is shown on Table 6.6.

6.7 SUMMARY

In this Chapter, the needs and future plans for education, training and research in the field of water and waste-water engineering in Cyprus were assessed.

The facts given for university education were derived from the responses of professionals to the Questionnaire. The subjects/branches of knowledge that are needed to carry out their duties (as specified by themselves) are, in order of frequency: water storage; theory of hydraulics; water quality; water demand; and transmission and distribution of water. Half of those that answered the question on gaps in the education they received,

Table 6.6 Problems in water/waste-water systems in Cyprus as indicated by professionals

Water resources (26% of total units)

Inadequacy of water resources / lack of water / limitations of the water resources availability / shortage of potable water and water for irrigation / droughts / lack of water due to droughts / low rainfall / decrease in rainfall and runoff and long drought years / use (demand) of water being larger than available water resources/large losses in water dams.

Planning and Management (36% of total units)

- Water/water resources management (8 units)
- Lack of long-term policy for water resources management (2 units)
- Lack of water policy and wrong priorities of use (3 units)
- Lack of political motivation to tackle the issues of water scarcity (1 unit)
- Scientific approach in policy of exploitation - management of water resources/management according to technical rather than political criteria/project implementation and water works construction often depend on political rather than technical decisions (7 units)
- Strategic planning for exploitation of available water resources (3 units)
- Long-term planning of efficient and effective procurement and utilisation of 'water' resources (1 unit)
- Timely planning, design and construction of water projects (1 unit)
- Exploiting first the available low-cost water sources and then other sources (2 units)
- Fragmented industry/lack of integrated policy (lack of 'Water Authority')/lack of coordination between relevant departments/No coordination between government departments (7 units)
- Low productivity (1 unit)
- No data available to private sector from government (1 unit)
- Large losses in water supply systems in towns (2 units)
- Inadequate monitoring systems (3 units)
- Creating water conscience/lack of water conscience (4 units)
- No research (1% of total units)
- Lack of funds (1% of total units)
- Lack of training (1% of total units)

(continued)

Table 6.6. (continued)

Technology (7% of total units)

- Proper treatment (3 units)
- Economics of treatment (2 units)
- Long-term consideration about treatment viability (1 unit)
- Treatment of 'water' in general in its broadest sense (2 units)
- Rainwater disposal: construction and maintenance (1% of total units)

Waste-water (18% of total units)

- Waste-water systems (2 units)
- Lack of waste-water systems (in most areas; in towns and villages)/lack of infrastructure works for waste-water systems (8 units)
- Sewerage management/Lack of experience on waste-water management/Lack of administration on a national level (waste-water) (7 units)
- Disposal of treated waste-water (2 units)
- Not using waste-water and disposing to sea (2 units)
- Re-use of effluent (1 unit)
- The application of economic solutions for treating waste-water for new use (1 unit)
- Lack of education of farmers on benefits by reusing treated effluent for irrigation/not informing people properly for the reuse of treated waste-water (3 units)

Environmental (14% of total units)

- Quality trends in surface and groundwater (2 units)
- Water quality of drinking water through pipe network (3 units)
- Long term effects of use of treated water (2 units)
- Water pollution/ Environmental burdening (pollution of water sources) (4 units)
- Not enough concern on environmental effects (projects)/Environmental percussion of construction of large projects/Environmental protection/Respecting environment (projects) (9 units)

indicated some gaps and one-third were quite satisfied. Those persons that indicated some gaps, offered various suggestions for the curriculum. Another theme was postgraduate courses that would/could be useful for their present or future work. Two thirds are willing to follow such studies (even if they already possess such degrees). This shows the high proportion of people wishing to improve their qualifications. The most popular courses in order of preference would be: environmental engineering; water and environmental engineering; environmental civil engineering; environmental design and engineering; and hydraulic engineering. The preference in environmental engineering is evident. 86% would follow a part-time or a distance learning course; and 72% are prepared to follow such a course if offered in Cyprus. These high proportions are explained by the fact that professionals are not willing to abandon their jobs and families in Cyprus.

Needs and plans for continuing education/training (in the form of short courses, seminars and workshops) were investigated for professionals through the Questionnaire. The majority do not prefer long courses because most probably they do not have the time, or the circumstances do not allow them to attend. In fact, 29% prefer seminars, 29% three-week courses, 26% workshops, and only 17% three-month courses.

It may be deduced (from the results of the Questionnaire) that there is a trend for greater interest in academic research work in the future. 21% of respondents are interested or plan to carry such work related to the characteristics and needs of Cyprus in the future, compared to 13% that were involved in the past. 44% are not interested. Only 15% knew about or secured sponsorship. This shows that sponsorship is a problem in Cyprus. As concerns research as part of employment, 38% answered positively and 47% negatively. A large proportion of the research work that is proposed would be funded by the government of Cyprus (42%); and in 33% of the cases it is not known who could fund it. In the cases when there is no interest to carry out such work the reasons are: lack of time 33%; retiring soon 13%; no professional motives 13%; other priorities 7%; and no answer 33%. The professionals were also asked to indicate what research is needed so as to obtain benefits for the country and people of Cyprus. 72% suggested areas for research.

Information on the needs as identified by authorities, appropriateness and gaps of organisation was scarce. The researcher managed to obtain some short-term plans (if any) for continuing education for the personnel of governmental and semi-governmental organisations. Some semi-governmental organisations are willing to intensify and expand training. The (new) Strategic national development plan for the next five years will be published soon, but not soon enough to be considered in this Thesis. The previous one emphasised the need to expand training and research activities in general.

In this Chapter, also the problems on water/waste-water systems in general (not specifically education, training and research) were identified as indicated by workers in the field. The reason for this discussion is to identify needs in education, training and research bearing in mind the constraints faced in water/waste-water systems in Cyprus and the characteristics and needs of Cyprus. Only 2% consider training and research as problems by stating 'no research' and 'lack of training'.

Five broad groupings of topics (from those suggested by the professionals) were formed by the author for the investigations on continuing education/training, academic research, research as part of employment, beneficial research, and problems faced in Cyprus in water/waste-water systems. These groupings are: Water resources; Planning and Management; Technology; Waste-water; and Environmental. The degree of interest expressed or needs and plans identified by professionals in the field of water/waste-water engineering in Cyprus are shown on Table 6.7. Is there any correlation between training demands and research topics? [There is an attempt here to link the five groupings but caution is needed since the size of sample was relatively small for the cases of academic research and research as part of employment. Additionally, the case of academic research was considered in Questionnaire I and the rest of the cases in Questionnaire II]. On average, the most popular areas of concern are: Planning and Management 34%; Waste-water 26%; Environmental 18%; Water resources 12%; and Technology 11% (see Table 6.7). If the results for each grouping are analysed and explained, 'Planning and Management' is more important in real practice as can be seen from the relatively low score in the interest (or plans for) academic research. People are not involved so much with 'Water resources' but it is a very important problem (as indeed recognised by the findings through the Questionnaire) for Cyprus. 'Waste-water' is important for research (especially some kinds of it) since there is a lot of interest for re-use (explained by the fact that water is a scarce resource in Cyprus) and since lately many waste-water projects are realised. There is a higher interest for continuing education in 'Environmental' matters since there is a trend for environmental concerns over the last decade. As expected, since 'Technology' is more practical than academic, there is relatively higher interest for it in training and in research as part of employment. If Training, Research and Problems are considered, then the analysis is as follows. The interest in 'Continuing education/training' is greater in Planning and Management, and Environmental matters. The interest in or plans for 'Academic research' are greater for Waste-water (by far) and for Planning and Management. The interest in 'Research as part of employment' is greater (by far) in Planning and Management. The needs in 'Beneficial research' are greater in Waste- Water

Table 6.7 Interest/needs/plans of professionals in water/waste-water engineering in Cyprus: proportions

Grouping	Interest in Continuing Education/Training	Interest in / Plans for Academic research (in context of Cyprus)	Interest in Research as part of employment	Needs in Beneficial research	Problems faced in Cyprus in the sector	Average
Water resources	6%	7%	8%	11%	26%	12%
Planning and Management	37%	23%	42%	31%	36%	34%
Technology	14%	7%	17%	9%	7%	11%
Waste-water	17%	44%	17%	33%	18%	26%
Environmental	25%	19%	17%	16%	14%	18%

and in Planning and Management. The biggest problems faced in water/waste-water systems in Cyprus (as identified by the professionals) are in the Planning and Management and the Water Resources areas.

If the data is analysed to see if there was any correlation between the answers and the occupation of the respondents, then it was found out that there was a direct link, for example in the cases of the education gaps and of the training/continuing education.

CHAPTER SEVEN

DISCUSSIONS AND RECOMMENDATIONS

7.1 DISCUSSION

7.1.1 Hypotheses

In this section, the hypotheses of section 1.1 are considered - whether they have been proved, and what can be implied, concluded and recommended.

It is reminded that the basic hypothesis was that the level of professionals in the sector of water and waste-water engineering should improve so as to close the gap of needs in Cyprus. In other words, the current infrastructure in education, training and research was considered to be insufficient. The needs were identified in this Thesis. What remains is to identify what has to be done to remedy the situation so as to allow effective water and waste-water management in a sustainable manner.

The basic aims of this research work (as outlined in Chapter One) can be divided into two major parts: (A) the existing situation (potential, achievements, needs and plans); and (B) the recommendations. The specific objectives in part (A) were (a) to examine the current university courses and research in the sector of water and waste-water engineering worldwide (done in Chapter Five); and (b) to investigate the current potential and the achievements so far (done in Chapter Four) as well as the needs and future plans (done in Chapter Six) for Cyprus and for professionals working in Cyprus in education, training and research in the sector of water and waste-water engineering.

Based on this discussion here, the recommendations of sections 7.3 on p. 143 (how to fulfil needs for Cyprus), 7.4 on p. 151 (wider application of results of study) and 7.5 on p. 151 (recommendations for further enquiry) follow.

The findings, conclusions and implications will be related to the selected parts of the literature review, highlighting contradictions, new findings and potential implications for further/future research.

7.1.2 Background, methodology and limitations

Initially, the background context globally and in Cyprus was investigated in this Thesis (see Chapter 2).

The research design of this work was outlined in Chapter 3. Does this study contribute to new methodology in the field in Cyprus or elsewhere? The contribution of this study is that it is the first one on the subject in Cyprus.

The researcher faced various problems in his investigations. These limitations and difficulties are analysed in this final Chapter (section 7.2 on p.141).

7.1.3 Findings

The most important findings of the researcher follow.

As was identified in Chapter Five, the international trend is for a considerable increase in the number of courses offered nowadays in the sector as compared to courses five and ten years ago. An increasing number of Civil and Environmental Engineering Departments have been founded. The greater emphasis in environmental engineering is explained by the fact that there is a growing international momentum on environmental issues.

The achievements and involvement so far of university graduate professionals in education, continuing education and training, and research in the field of water and wastewater engineering were considered by the researcher for a representative sample of professionals working in the field in Cyprus. See Chapter Four for the details. Some of the findings follow. Half of the university programmes of study in the field were followed at master's level and half of programmes were followed in the UK. Part-time studies are a recent trend. One-quarter of the programmes involved research only. The academic research work on water engineering had been double that on wastewater engineering. One-fifth of the academic programmes was related to the characteristics and needs of Cyprus. Only one-fifth of the respondents stated that they obtained training but, according to most of them, the type of training they received was appropriate for the country. One-third of the professionals were involved with research as part of their employment and most of it was funded by the government of Cyprus and the EU. Two-thirds of the professionals were cooperating with foreign experts. An investigation was also carried out at the organisational level. Many of the recent training programmes in Cyprus were spent on information technology. Non-governmental training is funded by the Industrial Training Authority of Cyprus. There is a trend for the research programmes of governmental departments to be forwarded within the financial framework of the EU.

The needs and future plans for education, training and research in water and wastewater engineering in Cyprus were assessed in Chapter Six. Most of the facts were derived from the responses of professionals to the Questionnaire of the author. The branches of knowledge that are needed to carry out their duties are, in order of frequency: water storage; theory of hydraulics; water quality; water demand; and transmission and distribution of water. Half of those that answered the question on gaps in the education they received, indicated some gaps and one-third were quite satisfied. Another theme was postgraduate courses that would/could be useful for their present or future work. Two-thirds are willing to follow such studies (even if they already possess such degrees). This shows the high proportion of people wishing to improve their qualifications. The most

popular courses in order of preference would be: environmental engineering; water and environmental engineering; environmental civil engineering; environmental design and engineering; and hydraulic engineering. The preference in environmental engineering is evident. 86% would follow a part-time or a distance learning course; 72% are prepared to follow such a course if offered in Cyprus. These high proportions are explained by the fact that professionals are not willing to abandon their jobs and families in Cyprus.

As concerns needs and plans for continuing education/training (in the form of short courses, seminars and workshops), it was found that 37% of the professionals are interested in planning/management, 25% in environmental themes, 17% in waste-water, 14% in technology, and 7% in water resources. (Note: These topics are in the context of water and waste-water engineering). The majority does not prefer long courses because most probably they do not have the time or the circumstances do not allow them to attend. In fact, 29% prefer seminars, 29% three-week courses, 26% workshops, and only 17% three-month courses.

There is a trend for greater interest in academic research work in the future. 21% of respondents are interested or plan to carry such work related to the characteristics and needs of Cyprus in the future, compared to 13% that were involved in the past. 44% are not interested. The most popular topics are waste-water (44%), planning/management 23%, environmental (19%), and so on. Only 15% knew about or secured sponsorship. This shows that sponsoring is a problem in Cyprus. As concerns research as part of employment, 38% answered positively and 47% negatively. The broad areas suggested were planning/management (41%), environmental (17%), waste-water (17%), technology (17%), and so on. A large proportion of the research work that is proposed would be funded by the government of Cyprus (42%); in 33% of the cases it is not known who could fund it. In the cases when there is no interest to carry out such work the reasons are: lack of time 33%; retiring soon 13%; no professional motives 13%; other priorities 7%; and no answer 33%. The professionals were also asked to indicate what research is needed so as to obtain benefits for the country and people of Cyprus. 72% suggested the following (broadly grouped) areas for research: waste-water 33%; planning/management 31%; environmental 16%; and so on; one-quarter gave no answer.

As concerns organisations, some semi-governmental organisations are willing to intensify and expand training.

Also the problems on water/waste-water systems in general (not specifically education, training and research) were identified as indicated by workers in the field. About one-third of the respondents believe that the most important problem in the sector in Cyprus is planning and management; one-quarter that it is a problem of water resources

and one-fifth that waste-water systems and re-use is an important problem to tackle. Other problems are: environmental 14% and technology 9%. Only 2% consider training and research as problems by stating 'no research' and 'lack of training'.

7.1.4 Recommendations

Returning to the aims and objectives of this work, the specific objective in Part (B) is for the researcher to offer recommendations (in the sections that follow in this Chapter) of (a) how to fulfil needs for Cyprus; (b) to consider the prospects for wider application of the results of the study in other countries; and (c) to recommend further enquiries. These recommendations form the action plan.

7.2 LIMITATIONS AND DIFFICULTIES OF THE STUDY

7.2.1 Introduction

Some difficulties were faced by the researcher in the following cases: the possibility of bias in the Questionnaires for individual professionals; in obtaining information from some governmental and semi-governmental organisations in Cyprus and from some individuals or organisations from abroad; in obtaining numbers of students in each course; in completing case studies on university education and research in southern European countries; and in estimating comparative costs of the status quo and any options proposed by the researcher. These limitations and difficulties are analysed in detail in sections 7.2.2 to 7.2.6 that follow. To overcome these problems, recommendations for further enquiry are given in section 7.5 on page 151.

The limitations affect interpretation/analysis of the data as well as its application.

7.2.2 Questionnaires

Are the sample sizes for Questionnaires, surveys and interviews carried out by the researcher in Cyprus large enough?

For organisations in Cyprus, the sample was almost full.

A sampling error (for Questionnaires for individual professionals) of less than ± 10 per cent was deemed to be acceptable. See section 3.4.3 on page 54. The results of Questionnaire I could be wrong by 11% and those of Questionnaire II by 15% for a confidence level of 95%. Unfortunately, the sample size of Questionnaire II was rather small. The important point about response rates is not the size of the sample, but the possibility of bias. An analysis was carried out on whether a bias has been introduced by comparing respondents with non-respondents on the original sampling list. It was found out that there was some bias but not to a significant extent.

A problem with questionnaires is time since things change. Questionnaires should be carried out on a regular basis to see changes/trends.

7.2.3 Information from organisations in Cyprus

Several organisations in Cyprus responded positively to the request of the author for information support: some answered in writing; others gave written authorization to the author to obtain information from their library and the archives of officers (for example, the Agricultural Research Institute); and others provided the information through oral communication.

But, some problems were faced with the responses of some governmental and semi-governmental organisations in Cyprus. Some had no time to respond; some were not willing; some were not in a position to help (did not possess the information); others had no power (authorization) to help. The Sewerage Board of Limassol – Amathus, the Environment Service, and the Department of Town Planning and Housing gave no official answer. The official answer by the acting director of the State General Laboratory was that due to lack of administrative officers, it was difficult to give me the information I asked for. Even so, some information was given by individual professionals. The official answer of the Sewerage Board of Nicosia was that the information asked for had to do with internal matters of the Board and could not be notified to a third party. The only exception was the question on co-operation with foreign institutions. Some of the personnel of the Water Development Department (when approached individually) stated that they could only give information if authorized. The authorisation was obtained. In any case, the researcher managed to get the required information (for potential) through various methods. See Chapter 3. Unfortunately, the information was not adequate on the subject of needs and future plans as identified by authorities. See section 6.5 on page 127. Only some short-term plans for some organisations were obtained. One reason was that some organisations (for example, Sewerage Boards) were recently founded. Others simply had no plans. A very important limitation was that the New Strategic Development Plan (1999-2003) of the government of Cyprus is not yet published. The lack of adequate information on needs and plans proved to be a big gap. The absence of needs identification by the authorities is a problem for determining what is feasible in implementation - without their commitment any change is very limited (other than that financed from outside Cyprus - and even this needs agreement internally).

The author should use phrases like ‘I would be very grateful..’ instead of ‘please give’ (see p.193) in future requests (letters) to organisations for information support. Moreover, the author could promise to give a copy of his findings to these organisations. These statements constitute self-criticism.

7.2.4 Information from abroad

The information obtained from organisations from various countries was often too general, that is, it was generally on water/waste-water, and not specific on education, training and research. Very often, individuals were unable to help since they had no information on the subject. These difficulties had an effect on the study concerning training organisations in the sector in various countries.

7.2.5 University studies

The case study of university education and research in South Europe was not realised since the information collected was incomplete or not thorough enough. The author was unable to obtain the number of students in each course (in Chapter 5) or other similar statistics, for example: a comparison of the number of courses and of the students in a country with demand for graduates in each engineering discipline; relationship of scholarships to either fees and/or average cost of living/salaries; and the proportion of students receiving aid. These considerations will be useful/applicable when university courses will be offered in Cyprus. The author believes that statistics about numbers are not important for Cypriots studying abroad: what they need to know is not the numbers of students on a course abroad but what is on offer (for example, the quality and content of studies).

7.2.6 Costs of proposals

Comparative costs of the status quo and any options suggested by the researcher were not carried out.

7.3 HOW TO FULFIL NEEDS FOR CYPRUS

7.3.1 Introduction

The sector of water and waste-water engineering (and consequently education, training and research in the sector) should be given even greater importance in Cyprus for the following reasons: (a) Water shortage is the second most important problem in Cyprus (the political problem of the country being the first one); (b) Waste-water sewerage, treatment and reuse programmes are in progress in all towns of Cyprus; (c) the country faces various environmental problems (examples are given in section 2.3.3 on page 31); (d) Cyprus will join the EU in the near future and thus environmental policies and their application will become more important. Moreover, there are no university courses offered in the sector in Cyprus at the moment.

7.3.2 Global provision and trends and their relationship to the needs of Cyprus

In this section, links (or comparisons) are established between the overall picture of what is on offer plus the trends (as concerns university courses around the world - see

Chapter Five) with the needs and trends in Cyprus (that is, what happens in Cyprus and the outcomes of questionnaires - see Chapter Six).

There is a great demand for postgraduate courses. Two-thirds of Cypriot professionals are willing to follow such studies in the sector (even if they already possess such degrees). The topics they prefer are: environmental engineering; water and environmental engineering; environmental civil engineering; environmental design and engineering; and hydraulic engineering. The preference in environmental engineering is evident. This can be matched with the international trend for a considerable increase in the number of courses in environmental engineering over the 1990s.

An analysis of the titles of postgraduate taught courses in the field of water and waste-water in the UK in 1998 showed that the frequency of words (in the courses that Cypriots show interest) is as follows: 'water' (67%), 'engineering' (42%), 'environmental' (27%), and so on. In the USA, graduate programmes in environmental engineering are offered in 135 universities. Twenty-eight American Universities offered graduate programmes in Water Resources Engineering in 1998. Of these, the most frequent programme is Environmental/Water resources engineering. Ten Canadian Universities offered fourteen postgraduate programmes in Environmental Engineering, Water Resources Engineering and other related areas in 1998. The most frequent programmes offered are: Environmental Engineering 42% of the cases; Water Resources Engineering 17%; and so on. Concluding, what is on offer in courses around the world matches (ties) with the needs of Cypriot professionals.

As was found out by the author, 86% of Cypriot professionals would follow a part-time or distance learning course. Part-time study is available in 42% of the postgraduate taught courses in the sector in the UK. Part-time postgraduate programmes in Water Resources Engineering are offered by 28 (71%) of the Universities in the USA. There are also distance learning possibilities. In half of the postgraduate programmes in the sector in Canada, part-time study is possible. Postgraduate qualifications in the field may also be taken in an off-campus mode in Australia.

There is a trend for greater interest (by Cypriot professionals in the field) in academic research work in the future. There is a wide variety of research topics and opportunities in various Universities around the world.

A high proportion (72%) of Cypriot professionals is prepared to follow courses whilst in Cyprus. For these people, part-time and distance learning studies and also modern techniques and technologies (see section 5.8 on p. 109) would be the best options.

7.3.3 Studying, training, researching overseas

There are many possibilities for Cypriots to study, train or undertake research abroad in the fields of water and waste-water engineering. The current university courses and research programmes in the field in various countries are dealt with in Chapter Five. Also, overseas agencies currently used for training Cypriots are considered in section 4.14.

There are also some other possibilities. One is organising customized programmes (as distinguished from scheduled courses) for Cypriots. This is an area to study more (see section 7.5 on p. 151). Another is following courses partly in Cyprus and partly overseas. (see section 7.3.6 on p. 149).

Students or professionals should be careful to attend accredited courses. Accreditation of university courses was considered in sections 2.2 (p.10), 5.3.1 (p.89) and 5.6 (p.101) (in other countries) and in section 2.4.1 (in Cyprus).

7.3.4 Need to increase possibilities in Cyprus

All Cypriot engineers (including water and waste-water engineers) obtain their university education abroad. (see section 2.4.1 on p. 35). The School of Engineering of the University of Cyprus was founded recently and has not functioned yet.

Is there a need to offer (or increase) education, training and research programmes in water and waste-water engineering in Cyprus itself? The arguments for university education and research in engineering to be offered in Cyprus (as supported by the Scientific and Technical Chamber of Cyprus) were analysed in section 6.5.1 (p.127). Some of these reasons and arguments are (if summarised): to provide scientifically determined guidelines of the development of the built environment; to increase the margins of research; to assist in the development of technology and the support of the industry; to improve planning of the public works; to minimise the flight of capable professionals to other countries; to contribute to the export of services; and to decrease the export of student exchange. The author would add that the amount of research work related to the characteristics and needs of Cyprus will increase.

In the Questionnaire of the author, the professionals were asked whether they would follow a useful postgraduate university course in Cyprus (if offered). 72% of the total number of respondents are prepared to follow such a course if offered in Cyprus (see section 6.2.3 on page 113).

7.3.5 Guidelines for developing courses and research in Cyprus

Which are the researcher's guidelines for education, training and research for Cypriots in water and waste-water engineering?

In general, the scope of education, training and research is to follow changes in economy, technological developments, and modern requirements of society. The purpose

of the University and other institutions of Cyprus is to meet the needs and requirements of a modern Cypriot economy and rational development that will serve the quality of life and the interests of the citizens.

Engineering is an evolving profession that adapts to suit its context and the needs of the community. A new educational approach is needed to meet these changing requirements. See section 2.2.2 (page 12) and especially the work by Beder (1999).

What skills engineers should have was considered in sections 2.2 (p.10) and 2.6 (p.46). Summarising, engineers must have skills covering fundamental engineering topics, and increased depth of knowledge in specialty areas, must keep up with technological advances, and have skills in computer applications, information technology, management, communications, and foreign languages. Engineers must also grasp the political, economic and social implications of projects. The minimum academic degree required should be a master's degree. Engineers, however, should commit to lifelong learning. These skills should also drive the course design.

In the author's opinion, the factors, or even values, that should be considered when developing the curriculum or research areas to be investigated at university level, include the following: (a) the development/infrastructure needs of Cyprus for personnel skills and know-how; (b) climatic, geographical, geological and other characteristics of Cyprus that affect the design of projects; (c) wise exploitation of natural resources, for example promoting the use of renewable sources of energy; (d) preservation of the natural environment and the historical, cultural and architectural heritage; (e) aiming at realising projects so as to be cost-effective and safe and according to accepted standards of quality for materials and practices; (f) realising projects for satisfying human needs; and (g) practices and experiences of Universities of other countries.

Generally speaking, there was no programme of what individual Cypriot engineers should study (abroad), especially in postgraduate courses and research, that would be related to the needs in know-how and skills in Cyprus and the characteristics of the country. The question of whether there is a need, in Cyprus, to formulate policies to produce a tighter fit between the education system and the labour market (the matching of university graduates to occupations in Cyprus in the sector) should be addressed. A 1995 study (see section 2.4.3 on p.40), however, showed that in highly vocational subjects, such as engineering, the matching is relatively high.

Do global trends and provision help in anyway Cyprus? A new trend is the integration of water and waste-water management. It is fortunate that this Thesis does deal with both of them. Some important global problems include arid land and growing populations. The latter is not a problem in Cyprus. Cyprus, however, experiences drought

events on a regular basis (see section 2.3 on p.28) and thus, since also other countries (see section 5.1) face similar problems, their experiences (in educating and training engineers and their research programmes) to tackle these problems could be useful for Cyprus.

Generally, in looking at training options elsewhere, there should be correlation between these and the manpower needs in those countries if you are to use those types of data in relating courses to needs in Cyprus.

Objectives are needed to design a course. Goals and broad targets are derived from a needs analysis. Commonly, curriculum discussion is about the content of syllabuses and methods of teaching. The really important questions are about objectives and this component of the curriculum is the logical starting point, although one could break into the cycle of interrelated parts at any point (Hooper, 1971). For the purposes of curriculum design and planning, it is imperative that the objectives should be identified first, as we cannot, or should not, decide 'what' or 'how' to teach in any situation until we know 'why' we are doing it. Another question is 'for whom'.

Having established what is done where (courses around the world in Chapter Five) and what would be particularly relevant to Cyprus (Chapter Six), particular people/institutions world-wide that would be best disposed to advise on curricula in Cyprus should be identified. Alternatively, or in addition, institutions which could be approached to validate appropriate courses should be suggested.

Courses should be validated. In doing so, guidelines for courses should be decided. Professional bodies should put constraints including grants and fellowships. Programmes should be evaluated. How is progress of a young engineer measured? Also, monitoring is required, that is evaluating if everything is working. There is a need to bring in new components. Courses should be accredited. These matters were considered in section 2.2 (in general) and in section 2.4 (for Cyprus). There is no history of provision of university education in Cyprus. Appropriateness of university education (abroad) and training received was the subject of questions in the author's Questionnaire II for professionals.

A study about the demand for a course (finding about numbers) is required. Can students be attracted from other countries also? What is an optimum number to run a course? To run a Master's course (taught and a dissertation), a minimum number of 12 persons is required at WEDC of Loughborough University (Ince, 1996). This number, however, is not to be taken as standard; it relates to cost recovery for WEDC. The possibility of a joint course, that is a link with a University abroad should be considered: if for example there is not sufficient demand to set up in Cyprus, the taught part could be offered in another country and the research project in Cyprus.

One very important aspect of supply and demand is availability of funding (for institutional development, for studentships, for research programmes, and so on) and competition with similar countries. The cost of the proposals is as important as other aspects (like scope, timeframe, human resources, content of programmes, facilities). For Cyprus, this would involve, as one component, the comparative costs of the status quo and any options being suggested. The sponsors of education, training and research should be established. Another question is what constitutes an efficient allocation of resources within the university budget. Expenditure on education and scholarships schemes in Cyprus were considered in various sections (especially 2.4.1, 2.4.2 and 4.8.9). Financing of training for Cypriots was considered in various sections (especially 2.4.2 and 4.9.4). Expenditure and sponsors of research in Cyprus in general are dealt with in section 2.5. The Questionnaire (for professionals) of the author dealt with sponsors of university studies, of training and of research as part of employment in the sector. For university studies, a quarter is from own funds and the rest from UK, USA and Cyprus. Research as part of employment is mostly funded by the government of Cyprus (half of it) and the EU (one-third). Expenditure by various organisations is considered in sections 4.8 to 4.13. Concerning needs and future plans of professionals in the field, the Questionnaire dealt with sponsors of academic research work in the context of Cyprus (only 15% knew about or secured sponsorship and the sponsors were the EU and the government of Cyprus); and research as part of employment (half of them secured funding, that is, the government of Cyprus). In general, sponsoring of research is a problem in Cyprus.

The specific calculation for the cost-benefit of proposals of how to fulfil needs for Cyprus is a suggestion (by the author) for further enquiry. See section 7.5 on page 151.

The ultimate aim is to offer an effective (in the context of the country) curriculum that would solve the water and waste-water engineering problems of the country. The researcher has carried out needs assessments in education, training and research. See Chapter Six for the details. According to the findings of the author (Chapters Four and Six), the following points should be considered when deciding priorities/emphasis in recommendations for Cyprus:

- (a) Cypriots prefer university programmes at master's level;
- (b) there is a trend for part-time studies (especially by professionals);
- (c) there is a trend for research programmes to be forwarded within the EU framework;
- (d) changes in university curriculum are needed since gaps were identified; the most popular branches of knowledge needed are water storage, theory of hydraulics, water quality, water demand, transmission and distribution of water;

- (e) two-thirds of professionals are willing to follow postgraduate courses (even if they already possess such degrees); according to the needs, the most popular courses would be environmental engineering, water and environmental engineering, environmental civil engineering, environmental design and engineering, hydraulic engineering; almost all would follow a part-time or a distance learning course; two-thirds are prepared to follow such a course if offered in Cyprus;
- (f) as concerns training/continuing education programmes, the majority prefers short courses; some semi-governmental organisations are willing to intensify training; and
- (g) there is a trend for greater interest in academic research work in the future; the most popular topics are water resources/supply, reuse of waste-water, and water quality/pollution; sponsorship is a problem; and motives and time are needed.

One question is whether the identified and designed training programmes will be realised by the authorities. Various specific possibilities for Cyprus are given in the section that follows.

7.3.6 Possibilities in Cyprus

The needs in education, training and research in water and waste-water engineering for Cypriots can be fulfilled in Cyprus in the following ways: (a) Studying or researching at the University of Cyprus; (b) studying or researching or being trained at other institutions in Cyprus; (c) attending courses, seminars and workshops in Cyprus; and (d) following courses or research programmes through overseas institutions whilst in Cyprus. Also, various useful modern techniques and technologies available (distance learning options and learning techniques) are considered towards the end of this section.

(a) University of Cyprus

The Polytechnic School was recently founded. The Department of Civil and Environmental Engineering will most probably offer relevant courses. Research in the sector is already being carried by some Departments and Units (see section 5.2.2 on p.88).

(b) Other institutions in Cyprus

The Higher Technical Institute offers only education for technician engineers. Training for professionals is offered in the form of short-courses. Research in the sector is carried out by members of staff (see section 5.2.3 on p.88). The private Frederick Institute of Technology offers a B.Sc. degree in Civil Engineering but it is not accredited yet. The affiliated Frederick Research Centre is involved with research in the sector (see section 5.2.4 on p.89).

(c) Training in Cyprus

Training is available through various short courses, seminars and workshops. The needs for such courses were investigated by the author in section 6.3 on p.115. These findings can be used in planning such courses.

(d) Overseas institutions

Students and professionals can follow various studies or carry out research through overseas institutions whilst in Cyprus. There are various alternatives: part-time, distance learning, courses of overseas institutions offered in Cyprus, and so on. Examples of universities and course details are given in Chapter Five.

A possibility is transfer of programmes. This means a course of say a University of the UK to be offered in Cyprus. An example of this option is a course by Loughborough University that is offered in Sri Lanka with funding by the British Council (Ince, 1998).

There are various models of how the opportunity for an overseas engineering education can be made available to students in Cyprus: twinning; articulation; and credit transfer. Twinning is where a college in Cyprus can offer courses almost identical to those of a specific overseas university. Quality control is required and it involves a contractual relationship. Articulation is where a college in Cyprus can offer courses that will be accepted as equivalent at an overseas university (through an agreement on transferring tertiary credits). Credit transfer is similar to articulation, but there is no written agreement on equivalent courses. [The exact credits will be determined after acceptance]. An existing case of these models is Malaysian colleges linked to USA universities (Stevens, 1999). The maximum coursework toward an engineering degree that can be completed in Malaysia is usually about 50%, because of ABET accreditation requirements of the US university.

Cyprus will become a member of the European Union, hopefully in the year 2003. This means that European (especially British) Universities will be free to function in Cyprus. Thus, it is expected that in the next few years, some European universities will offer their programmes in Cyprus, either directly or in co-operation with local institutions.

The author believes that there is a need for one or more postgraduate courses in the sector in Cyprus. More than two-thirds of the professionals are willing to follow such a course. The most popular courses would be environmental/water engineering. See section 6.2.3 on page 113. Such a course (or courses) could be staffed by academics from abroad and from Cyprus.

(e) Techniques and technologies

There are various useful modern techniques and technologies available. The distance learning options are: videoconferencing, Internet web sites, videotapes, audiotapes, and printed materials. Learning techniques that can bring about worthwhile

results include problem-based learning, cooperative learning, project components and competitions. Details about these techniques and technologies are given in section 5.8.

7.4 WIDER APPLICATION OF RESULTS OF STUDY

Can the results of this study be applied to other countries?

Much of the work done in this research study is not specific for Cyprus and could be directly useful for any researcher on the subject of education, training and research in water and waste-water engineering. This work includes: (a) Concepts (see 'Glossary' on p.156); (b) the background context: the global position in water and waste-water (see section 2.1 on p.7 of this Thesis); (c) the background context: global needs, strategies and actions for education, training, research and development in university curriculum, in engineering, in civil engineering, in environmental engineering and water and waste-water engineering (see section 2.2 on p.10); (d) elaboration of the methodologies used to carry out this research work (see Chapter Three); (e) current university courses and research in water and waste-water engineering in various countries: the UK, the USA, Canada, Australia, Singapore and Malaysia (see Chapter Five); (f) training organisations in the sector worldwide (see section 4.14 on p.84).

Cyprus is the basic case study of this work. Other researchers in the sector (for another country) could find it useful to consider the methodology and results of the case study of Cyprus (in their concern to develop courses according to the characteristics and needs of a place). This work is particularly useful to countries with climatic, hydrologic, environmental, economic and sociocultural similarities with Cyprus.

7.5 RECOMMENDATIONS FOR FURTHER ENQUIRY

In the hypotheses section (section 1.1), the aims and objectives of this study were given. They were restated at the start of this Chapter. Recommendations should be offered to do what has not been done (due to limitations and difficulties - see section 7.2 on p.141) in this study. This section includes ideas for further research and also modifications that would be made before using this design again. These recommendations follow.

- (a) Studies on University education and research in water and waste-water engineering in South European countries (for example, Greece, Italy, Spain, Malta) should be carried out since these countries have climatic and socio-economic similarities with Cyprus. Additionally, Cyprus has strong cultural and educational links with Greece. Also other countries could be considered due to their proximity and relations with Cyprus (Middle Eastern and Eastern European) or due to climatic similarities (Mediterranean countries).
- (b) The possibility of organising customized programmes by overseas universities (for Cyprus) should be considered.

- (c) As concerns training, some work has been done, but further work should be done on training organisations in the sector in various countries, since the coverage of this section has not been adequate in this Thesis.
- (d) Further work is needed on needs and future plans for Cyprus and Cypriot water and waste-water engineers at the organisational (governmental and semi-governmental) level. In particular, what needs to be tackled are the needs as identified by authorities, the appropriateness and gaps of organisation, and plans (see section 6.5 on page 127).
- (e) Actual syllabuses for education and training can be developed based on the country's requirements. These needs can be identified based on suggestions by the authorities and the outcomes of questionnaires (like the author's).
- (f) Studies are required on the cost and funding of my proposals of how to fulfil needs for Cyprus (see section 7.3 on p. 143).
- (g) The wider application of the results of this study (see section 7.4 on page 151) should be considered more specifically.

7.6 SUMMARY

7.6.1 Introduction

In this summary, for each objective of this research work, (a) the basic findings are given; (b) it is stated what was not done due to limitations and difficulties; and (c) needs for further enquiries are outlined.

Finally, recommendations are given of (a) how to fulfil needs for Cyprus; and (b) whether the results of the study can be of wider application.

7.6.2 Objectives, findings, limitations and further enquiries

- (a) Current university courses and research in water and waste-water engineering worldwide were examined. The international trend is for a considerable increase in the number of courses offered in the 1990s. [Note: But, the viability, in terms of numbers, cost and so on, of such courses may be such that they cannot/should not be offered in all countries]. Statistics on the number of students in each course should be obtained in the future. A full case for Southern European educational and research institutions has not been completed. It is proposed that university education and research in the sector should be considered in the future for Southern European, Mediterranean, Middle Eastern and Eastern European countries. The possibility of organising customized programmes for Cypriots by overseas institutions should be examined. Considering training organisations (other than universities) in the sector worldwide had not been a primary objective of this

Thesis but some work on the topic has been carried out. Further enquiries are needed.

- (b) The current potential and the achievements in education, training and research of individual professionals working in Cyprus in water and waste-water engineering were investigated for a representative sample of professionals. There was a limitation concerning the Questionnaires: it was found out that there was some bias but not to a considerable extent. Similar questionnaire surveys should be carried out in the future so as to keep up with changes. An important finding is that part-time study is identified as a recent trend. Despite the difficulties, the researcher managed to do also a study of the current potential of human resources at the organisational level.
- (c) The needs and future plans for Cyprus and professionals working in Cyprus in education, training and research in the field of water and waste-water engineering were examined. It was found out that changes in university curricula are needed since gaps were identified. The most popular branches of knowledge needed are water storage, theory of hydraulics, water quality, water demand, transmission and distribution of water. Two-thirds of professionals are willing to follow postgraduate courses (even if they already possess such degrees). According to the needs, the most popular postgraduate courses would be environmental engineering, water and environmental engineering, environmental civil engineering, environmental design and engineering, and hydraulic engineering. Almost all would follow a part-time or distance learning course. Two-thirds are prepared to follow such a course if offered in Cyprus. There is a need to investigate distance learning as a possible way forward in terms of opening up course options for engineers extending their expertise in the water field in Cyprus. As concerns training/continuing education programmes, the majority prefers short courses; some semi-governmental organisations are willing to intensify training. There is a trend for greater interest in academic research work in the future. The most popular themes are waste-water, planning/management (in the sector), and environmental themes. Sponsorship is a problem. Motivation and time are needed. Unfortunately, the information was not adequate on the subject of needs and future plans as identified by authorities. Only some short-term plans for some organisations (that devised plans) were obtained. Further work is needed on this topic.

7.6.3 Fulfilling needs for Cyprus and wider application

The action plan, as proposed by the researcher, of how to fulfil needs for Cyprus in education, training and research in the sector of water and waste-water engineering is as follows.

- (a) Opportunities overseas are given in detail in Chapter Five and section 4.14 (page 84). Other options are (i) customized programmes for Cypriots, and (ii) studies partly in Cyprus and partly overseas.
- (b) Guidelines for courses and research in Cyprus were developed. The aim is to serve the quality of life, the interests of the citizens, the economy and development requirements. The characteristics and needs of the country, and also practices and experiences of other countries, should be considered. The important values, that professionals should aim at in realising projects, are the preservation of the natural environment and the heritage of the country, the wise exploitation of natural resources, cost-effectiveness, safety, and quality standards. The skills engineers must have are considered in section 7.3.5 (page 145). Water engineering and waste-water engineering should be integrated (as is the international trend). Actual syllabuses for education and training can be developed. Part-time studies (especially for professionals) at master's level should be promoted. The same applies for short courses. Motives and increased funding are required to promote research. Performing research for firms is a field to consider in the future. Programmes should be validated, accredited and evaluated. Studies on the demand for courses should be undertaken. One possibility could be joint courses with foreign (especially European Union) universities. Assessments on costs, benefits and sponsorship are needed. Cost-benefit studies of the proposals of the author were not carried out and thus, further enquiries are required.
- (c) The needs can be fulfilled in Cyprus through various ways: (i) The Polytechnic School of the University of Cyprus will function in the near future. Research in the sector is already being carried out by some Departments. (ii) Training and research is offered by other institutions in Cyprus but university studies are not accredited yet. (iii) There are good prospects for continuing education in the form of short courses. (iv) Students and professionals can follow studies or carry out research through overseas institutions whilst in Cyprus. The alternatives are: part-time, distance learning, and transfer of programmes. (v) There are various useful modern learning techniques and technologies available that can bring about worthwhile results.

- (d) On the basis of the work undertaken in this study, and within certain constraints (professionals are facing), the following recommendation is put. It must be stressed once more that there should be (i) development of access to distance learning, and (ii) establishment of a part-time postgraduate course in the sector (for professionals based in Cyprus). These developments can be undertaken by local or overseas Universities.

What are the prospects of wider application of the results of this study? Much of this research work is not specific for Cyprus. Even for work that is specific for Cyprus, other researchers could find it useful. The same applies for organisations or individuals that are involved with education, training and research in countries with similar characteristics as Cyprus. Further enquiries, however, are needed.

GLOSSARY

Civil Engineering

Scott (1980), in his dictionary of Civil Engineering, points out that Civil Engineering, was originally the whole of non-military engineering at the time of the founding of the Institution of Civil Engineers of the UK. The sense has now become limited to that part of engineering which is neither mechanical nor electrical. Civil engineering includes buildings, land drainage, water supply, rivers, canals, dams, reservoirs, harbours, docks, marine construction, water power, sewage disposal, sewerage, bridges, tunnels, railways, roads, traffic engineering, foundations, airports, municipal engineering, soil mechanics, structural design, town planning, and transportation engineering. The field is so wide that it is difficult for any engineer to specialise in more than two of the subjects mentioned. The work of a civil engineer consists in preparing plans after surveying a site, letting contracts, supervising construction, and so on. The Massachusetts Institute of Technology recognises five areas of specialisation, namely structures, materials, hydrodynamics, soils and systems (with special stress on systems which affect the other four, for example water-resources systems, transport systems, environmental-control systems, information systems).

Employers of civil engineers include engineering consultants and contractors, central and local government, transport providers, the water industry, oil companies and large organisations with plant and other facilities to be built and maintained (CRAC, 1997).

Municipal engineers deal specifically with the requirements and problems associated with areas of population. They need to know about building, water treatment and distribution, and public health engineering. They also have to be sensitive to a wide range of environmental issues.

The Scientific and Technical Chamber of Cyprus (1997) has defined the term civil engineering, has regulated the competencies of civil engineering branches, and has defined the specialisms and works within civil engineering. The specialisms related to water and waste-water engineering are: water supply works; water dams, water reservoirs, water towers; engineering hydrology; waste-water engineering works; drainage of rain water; irrigation works; land drainage and recovery.

Curriculum and Syllabuses

The curriculum means all the dimensions of the educational process: the content of education, the courses of study, educational experiences, subjects to be studied, subject

matter and educational activities. Syllabuses mean the subjects or topics offered in undergraduate and postgraduate taught courses and which form the basis of qualifying examinations.

Curriculum development at university level is dealt with in detail in section 2.2 (p.10).

Engineering

Engineer is one who contrives, designs or constructs electrical or mechanical plant, public works or mining work (Scott, 1980).

The term 'engineer' is used in different senses. In this study an 'engineer' means a graduate, professional engineer, a technological decision-maker, working primarily with his brain and by means of drawings and reports, often prepared with the assistance of a computer.

At the inaugural meeting of the foundation of the Institution of Civil Engineers (UK) which was held in 1818, H. Palmer gave a definition of an engineer (Thorburn, 1993): 'The Engineer is a mediator between the philosopher and the working mechanic and like an interpreter between two foreigners, must understand the language of both, hence the absolute necessity of possessing both practical and theoretical knowledge'. Thorburn concludes that it is the proper balance between scientific and practical knowledge which makes the complete engineer.

Sutton (1984) examined the roots of the word 'engineer'. He concludes that an engineer need not have anything to do with engines or machines, but is really a creative thinker who uses mental abilities to solve real problems and to achieve difficult objectives. We also need to find better ways than we have done up to now to promote the engineer as the ingenious designer rather than as the minder of the engine if we are to upgrade the status of the professional engineer.

Engineering is the re-shaping of the environment and resources to human needs, a remarkably varied, fulfilling and challenging activity ranging from the planning of urban communities to the development of aids for the disabled. It is easy to distinguish engineering from science, which is the search for physical knowledge without concern for its implications. Engineering is the finding of answers to urgent problems, taking into account all implications. The engineer does not have the freedom of the scientist to exclude from a problem any aspects which are inconvenient. Engineering is thus much more than just applied science; science is only one of the ingredients, often not the major one. The engineer must often consider ease of manufacture or construction, cost and appearance. Indeed, engineering demands the assessment of possible alternative solutions and supplies the best compromise between conflicting requirements.

Environmental Engineering

According to Scott (1980), environmental engineering has two senses in USA: (a) sewage treatment, sewer networks, and prevention of pollution by gases, dust or noise or other 'insult to the environment'; (b) all the engineering work concerned with central heating and air conditioning - the improvement of the enclosed environment. In Britain in 1979 it had begun to have the sense of (a) only.

Peavy, *et al.* (1986) have defined environmental engineering 'as the branch of engineering that is concerned with the protection of the environment from potentially deleterious effects of human activity, protecting human populations from the effects of adverse environmental factors, and improving environmental quality for human health and well-being'.

Environmental engineering is a modern discipline and the term has only found its way into general usage in the past few decades. Environmental engineering is closely associated with other branches of engineering, including civil, chemical, material and mechanical engineering, and draws on chemistry, physics and biology (CRAC, 1997).

Research

The purpose of research is to extend knowledge - not the knowledge of any particular individual or group, but the pool of existing knowledge available to anyone with the equipment to use it (Evans, 1984).

The nature of research is defined by Mouly (1978) as follows. Research is best conceived as the process of arriving at dependable solutions to problems through the planned and systematic collection, analysis and interpretation of data. It is a most important tool for advancing knowledge, for promoting progress, and for enabling human beings to relate more effectively to their environment, to accomplish their purposes, and to resolve their conflicts.

Academic research programmes, or units, means research carried out by members of staff and postgraduate research students (at various levels) and associates at a University institution. Undergraduate project work is not excluded.

One of the problems is the differing interpretation of the definition for research and development activities. According to the "Frascati Manual" (OECD, 1981), research and experimental development may be defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge of humans, culture and society and the use of this stock of knowledge to devise new applications. The criterion for distinguishing research and development from non-research and development activities is the presence or absence of an appreciable element of novelty. The Frascati manual identifies three types of research and development work.

- a. “Basic research”: original investigation undertaken in order to gain new knowledge and understanding. It is not primarily directed towards any specific practical aim or application, but may be oriented towards an area of interest to the performing organisation.
- b. “Applied research”: original investigation in order to gain new knowledge. It is, however, directed primarily towards practical aims or objectives.
- c. “Experimental development”: the use of existing knowledge in order to produce new or substantially improved materials, devices, products, processes, systems or services. This includes the design, construction and operation of prototypes and pilot plants.

The following related activities should be excluded from the measurement of research and development (Dept. of Statistics and Research of Cyprus, 1993): education; scientific and technical information services; general-purpose data collection; testing and standardisation; feasibility studies for engineering projects.

The subject of educational research which is related to the methodology used in this study is considered in detail in section 3.2 (page 49).

Sustainability

Sustainability is the ability of a system to survive and function for some specified (finite) time. A sustainable system is one that attains its full expected lifetime. Sustainable development is forms of economic growth and activities that do not deplete or degrade natural resources upon which present and future economic growth and life depend (Miller, 1996). Similarly, sustainable development is defined in the Brundtland Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. (World Commission on Environment and Development, 1987). Sustainable development emphasizes the need for a balanced relationship between environmental, social and economic factors (Taylor, *et al.*, 1994).

Training

According to the Concise Oxford Dictionary of Current English (Allen, 1990), training means the act or process of teaching or learning a skill, discipline, and so on.

Waste-water engineering

Domestic or sanitary waste water refers to liquid discharge from residences, business buildings, and institutions. Industrial waste is discharged from manufacturing plants. Municipal waste-water is the general term applied to the liquid collected in sanitary sewers and treated in a municipal plant. In addition, interceptor sewers direct dry weather flow from combined sewers to treatment, and unwanted infiltration and inflow enters the collector pipes. Storm runoff water in most communities is collected in a separate storm sewer system, with no known domestic or industrial connections, and is conveyed to the

nearest watercourse for discharge without treatment. Several large cities have a combined sewer system where both storm water and sanitary wastes are collected in the same piping (Hammer, 1977).

Sewerage refers to the system of sewers and associated structures and treatment works built to collect, convey, treat and dispose of waste-water (Barnes, *et al.*, 1981).

Water supply and water engineering

Water supply is the impounding, treatment, pumping and piping of drinking water for customers by a public authority (Scott, 1980).

City and municipal water supplies may be used for domestic, commercial, industrial, agricultural and public purposes. Water supply for domestic and industrial purposes may be but one component of a major water resources project in which a large storage or a series of linked storages, will serve multiple purposes such as flood control, river flow regulation, irrigation and hydro-electric power generation (Barnes, *et al.*, 1981).

Water Engineering is the field of engineering that is concerned with the utilisation, control, treatment, protection and management of water for the sustainable benefit of humankind and the environment. It includes the following activities: water supply, sewerage, drainage, irrigation, flood control, erosion control, water and waste treatment, water pollution control, hydro-electric generation and water resources management (National Committee on Water Engineering, 1997). It is practised primarily by civil or environmental engineers, but usually involves inputs from other sub-disciplines of engineering and other professions, including: chemical, mechanical, electrical and agricultural engineers, chemists, biologists, geologists, economists, lawyers and social scientists.

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APPENDIX A
QUESTIONNAIRE I

Table 1. Introductory Letter

Dr. George Michaelides
11 Avlonos Street
Peristerona
Nicosia District
Tel: 822499

September 25th, 1996

QUESTIONNAIRE

Dear colleague,

I am enclosing a questionnaire for you to answer.

I am a civil engineer and I am carrying out research on 'water and waste-water engineering syllabuses and research in university education in the context of the characteristics and needs of Cyprus' in co-operation with Loughborough University of the UK.

I would be grateful if you answer the questionnaire I enclose. You may send it back to me using the enclosed stamped envelope addressed to myself. If you get two questionnaires, one in English and one in Greek, you may answer in only one of the languages; anyone you prefer.

Even if none of the questions apply to you, please send the questionnaire back to myself.

Yours sincerely

George Michaelides

Table 2. QUESTIONNAIRE I

1. Name:.....
 Address:.....
 Tel.: Fax:
2. Are you a civil engineer / mechanical eng. / chemical eng. / chemist / microbiologist / other?
3. Specify all academic qualifications in water/waste-water engineering / management you possess or studies you are following now:
 - (a) B.Sc./Post. Dip./M.Sc./M.Phil./Ph.D./other:
 Country:
 Year obtained:
 Title of course (if not fully by research) :

 Title of research Thesis:
 Part-time/full-time:
 - (b) B.Sc./Post. Dip./M.Sc./M.Phil./Ph.D./other:
 Country:
 Year obtained:
 Title of course (if not fully by research) :

 Title of research Thesis:
 Part-time/full-time:
4. Who sponsored your studies?
 - (a)
 - (b)
5. If you have carried out academic research work in the field of water/waste-water related to the characteristics and needs of Cyprus (and you have not referred to it in section 3), give:

B.Sc./Post. Dip./M.Sc./M.Phil./Ph.D./other:

Country:

Year obtained:

Title of course (if not fully by research) :

Title of research study:

(continued)

Table 2. (continued)

- Was study the main thesis/a project?
6. Are you interested/do you plan to carry out academic research work in the field of water/waste-water related to the characteristics and needs of Cyprus in the future?
 YES/NO :
- If yes, which topic or topics?
-
- Who will sponsor it?
7. If any of your research work in the field of water/waste-water related to the needs and characteristics of Cyprus, was published, give details of publication if in journal:
 title of article:
- title of journal :.....
- number and volume of issue:
- year:
- publisher and place of publication:
- Please specify 'yes' if you have more than one publication:
8. Give the names and addresses (or telephone numbers) of any scientists or engineers you know are involved with water/waste-water:
-
-

Table 3. Profession (Question 2)

Profession	Percentage of respondents
Civil Engineers	70
Environmental/Public Health Engineers	5
Hydrologists/Hydrogeologists	5
Surveying/Agricultural/Irrigation Engineers	5
Chemical/Biochemical Engineers/Chemists	8
Biologists	2
Architect/Environmental Design and Engineering	2
No Answer	5

Table 4. Employer

Employer	Percentage of respondents
Water Development Department	51
Public Works Department	6
Town Sewerage Boards	5
Town Water Boards	3
Municipalities	3
Town Planning and Housing Department	3
Governmental General Chemical Laboratory	2
Tertiary education (governmental)	2
Private sector/other/unknown	25

Table 5: Academic programmes by course/degree level/country

Title of course	Percentage of courses
Civil Engineering	14
Environmental Engineering	11
Public Health Engineering	11
Water Engineering	7
Water Resources	7
Engineering Hydrology/Hydrology	7
Hydrogeology/Hydrogeology and Eng. Geology	7
Irrigation Engineering	7
Engineering	4
Civil and Environmental Engineering	4
Water Management	4
Waste-water engineering for developing countries	4
Irrigation and Water Engineering	4
Hydraulics Engineering	4
Engineering Geology and Geotechnics	4
Business Administration	4

Degree Level

B.Sc./B.Sc. (Hons) 18% of total number of programmes; Post-graduate Diploma 5%; M.Sc./M.Eng. 46%, MBA 5%; M.Phil. 5%; Ph.D. 13%; post-doctoral 3%; and unknown level 5%.

Country where programmes followed

UK 49% of total number of programmes; USA 21%; Greece 5%; Netherlands 5%; Yugoslavia 5%; Cyprus 3%; Malta 3%; Canada 3%; Bulgaria 3%; Germany 3%; and Israel 3%.

Table 6: Academic research work in the sector related to Cyprus

Title	By research only / project (part of course)
Groundwater investigation in Paphos region	Research only
Evolution of water supplies and public health in Cyprus	Research only
Re-use of effluent for irrigation in Cyprus	Project
Water and waste-water engineering syllabuses and research at university level for characteristics and needs of Cyprus	Research only
A strategy for re-organising the management of sewage works in Cyprus	Project
Waste-water re-use in Cyprus	Research only
A comprehensive model for optimal development of the water resources in a semi-arid region. A case study from Cyprus	Project
Water resource management in Cyprus. Legal and institutional aspects	Research only

APPENDIX B
QUESTIONNAIRE II

Table 1. Introductory Letter
QUESTIONNAIRE II

Dr. George Michaelides
11 Avlonos Street
Peristerona
Nicosia District
Tel: 822499

4 December 1996

Dear colleague,

thank you very much for answering Questionnaire I sent to you some time in the past. Now, I enclose Questionnaire II for you to answer. I am sorry if I cause any nuisance to you. Please note that this is the last questionnaire I am sending to you and I would be grateful if you would answer it. You may send it back to me using the enclosed stamped envelope addressed to myself. Even if none of the questions applies to you, please send the questionnaire back to myself with your name and address.

I remind you that I am a civil engineer and I am carrying out research on “water and waste-water engineering syllabuses and research in university education in the context of the characteristics of Cyprus”.

Yours sincerely

George Michaelides

Table 2. QUESTIONNAIRE II

- Name: Address:
1. Give the following details about training you had in the field of water/waste-water.

Project:

Employer: Length of time:

Who paid for training?

Was training appropriate to characteristics and needs of Cyprus?

.....
 2. Give the following details about your employment in the field of water/waste-water in the last 5 years.
 - (a) Project:
 - Employer: Length of time:
 - Nature of duties:
 - (b) Project:
 - Employer: Length of time:
 - Nature of duties:
 3. (a) Specify which of the following branches of knowledge are required to carry out your present duties in the field of water/waste-water: theory of hydraulics/hydrology/sources of water supply/water demand/water uses/transmission and distribution of water/water storage/water quality/water quality testing/environmental pollution/water treatment/waste-water flows and characteristics/waste-water collection systems/rainwater collection/waste-water treatment/disposal of treated waste-water/reuse of treated waste-water/industrial waste-water treatment/construction of water projects/construction of waste-water projects/supervision of works/maintenance of works/information systems/other (specify):

 You may underline more than one.
 - (b) Specify gaps in the education you received at University so that (if the gaps were not there) you would be in a better position to carry out your present duties in the field of water/waste-water.:
 -
 4. (a) Which postgraduate university course would you follow now (even if you

(continued)

Table 2. (continued)

already possess a postgraduate degree) that would/could be useful for your present or future work?

Public Health Engineering/Environmental Engineering/Environmental Civil Engineering/Environmental Design and Engineering/Public Health and Environmental Control Engineering/Water and Environmental Engineering/Water and Waste Engineering/Water Engineering/Water Resource Systems Engineering/Hydraulic Engineering/Engineering Hydrology/Irrigation Engineering/Groundwater Engineering/Soil and Water Engineering/other (specify):

You may underline more than one.

(b) Would you follow such a course as full-time/part-time/distance learning?

(c) Would you follow such a course if offered in Cyprus?

YES/NO

If NO, why not in Cyprus?

5. (a) Did you do/are you doing any research as part of your present/previous job in the field of water/waste-water in Cyprus?

YES/NO

If YES, specify title of work:

Who funds it? Duration:

(b) If NO, (or, if YES, and you plan to do more research), would you be interested to carry out some research? YES/NO

If YES, which topic?

Who will fund it?

If NO, why not interested?

6. What research do you think (according to your experience) is needed in the field of water/waste-water to obtain benefits for the country and people of Cyprus?

.....

7. Which are the basic problems faced in the field of water/waste-water in Cyprus? Please put them in order of priority.

1.....

2.....

3.....

(continued)

Table 2. (continued)

8. What seminars/workshops/courses in the field of water/waste-water are you interested to attend?
- (a) Give topics:
-
- (b) How should it be delivered? Give in order of priority whether seminar, workshop, 3-week course, 3-month course.
- 1.....
- 2.....
- 3.....
- 4.....
9. Do you co-operate with foreign experts on training, research, seminars, projects design/implementation in the field of water/waste-water in Cyprus? YES/NO
- If YES, give:
- Name of foreign company:
- Project:
- If NO, why not?

Table 3. Employment of respondents in the last 5 years

Employer	Percentage of respondents
Water development (WDD)	44
Self-employed (one case: Consulting Civil Eng.)	9
WDD; Ministry of Interior	3
Nicosia Water Board; State of Bahrain	3
Sewerage Board of Paphos; Town Planning Dept.	3
Larnaca Sewerage Board	3
Governmental General Chemical Laboratory	3
British Bases	3
Hazen and Sawyer; self employed	3
J. and A. Philippou (Consulting Architects)	3
Frederick Institute of Technology	3
No answer	19

Table 4. Employment: Projects

Projects	Percentage of projects
Water Development Department Projects (water supply of all towns and other areas; Irrigation Projects, e.g. . Southern Conveyor, Paphos, Vasilikos-Pentaskinos, Acrotiri; Dams; River hydrology; Planning of off-stream ponds and dams; Central Laboratory of Geotechnics and Concrete; and others.)	48
Sewerage systems (of Paphos, Larnaca, Platres and Kyperounda, Paralimni and Ayia Napa) and upgrading of sewage treatment plants (Dhekelia and Ay. Nicolaos)	16
Water and waste-water analysis of quality	6
Nicosia Water Board	3
Desalination Plant of Dhekelia	3
River flow and pipe flow	3
Waste-water management (Town Planning Dept.)	3
Marine/harbour works (Ayia Napa, Acrotiri)	3
Consulting (various projects)	3
Academic institution	3
Projects outside Cyprus: Bahrain water distribution; New York City Sludge Management Plan	6

Table 5. Subjects required to carry out duties

Branch of knowledge	Percentage of respondents	Order
Theory of hydraulics	63	2
Hydrology	44	9
Sources of water supply	47	6
Water demand	56	3
Water uses	47	6
Transmission and distribution of water	53	5
Water storage	66	1
Water quality	56	3
Water quality testing	44	9
Environmental pollution	38	15
Water treatment	41	12
Waste-water flows and characteristics	25	18
Waste-water collection system	19	22
Rainwater collection	22	19
Waste-water treatment	22	19
Disposal of treated waste-water	28	17
Re-use of treated waste-water	38	15
Industrial waste-water treatment	22	19
Construction of water projects	47	6
Construction of waste-water projects	19	22
Supervision of works	44	9
Maintenance of works	41	12
Information systems	41	12
Other: Effects on biological environment due to construction of water projects	3	24
Other: Sea hydraulics and coastal engineering	3	24
Other: Management techniques and methods	3	24
Other: Mathematical modelling; Personnel management	3	24
Other: All above in relation with road design	3	24

Table 6. Useful postgraduate university courses

Postgraduate university course	Percentage of respondents	Order
Public Health Engineering	6	10
Environmental Engineering	25	1
Environmental Civil Engineering	19	3
Environmental Design and Engineering	19	3
Public Health and Environmental Control Engineering	6	10
Water and Environmental Engineering	22	2
Water and Waste Engineering	6	10
Water Engineering	13	6
Water Resource Systems Engineering	13	6
Hydraulic Engineering	19	3
Engineering Hydrology	6	10
Irrigation Engineering	9	8
Groundwater Engineering	6	10
Soil and Water Engineering	9	8
Other: Environment and water resources management	3	15
Other: Environment chemistry	3	15
Other: Project Management	3	15
Other: Administration	3	15

Table 7. Required research

Proposed topics	Percentage of total number of topics
Water resources (including: definition; use and distribution; new sources; use and management; hydrology of small catchments; optimisation; sustainable management in arid regions; ground water; rainwater; desalination)	27
Water demand	3
Post-evaluation of water projects	3
Water saving/conservation/management/leakage (including: project operation under conditions of lack of water)	16
Water pollution/environmental control (including: extent and sources; groundwater by pesticides and fertilisers)	8
Bathing water quality	3
Waste-water works/treatment/management (including: infrastructure for works; design parameters for treatment; industrial; sludge management)	16
Re-use of waste-water (including: for irrigation; education of farmers in re-use; artificial recharge of aquifers)	22
Toxic wastes management	3

Table 8. Problems in water/waste-water in Cyprus

Problems	Percentage of total units
Inadequacy of water resources/droughts/ larger demand than availability	24
Losses (dams, water systems) and inadequate monitoring systems	6
Management/policies/planning/priorities/ Productivity/coordination/criteria on Decisions/political motivation	26
Water conscience needed	3
Water quality and water pollution	8
Enviromental effects due to large projects	6
Treatment	6
Rainwater disposal	1
Waste-water systems and re-use (including management)	18
Lack of funds	1
Lack of training	1
No research	1

APPENDIX C

LETTERS TO ORGANISATIONS

Type 1

See Table 1. This type of letter was sent to the following organisations in Cyprus: The Water Development Department and the Water Use Branch of the Department of Agriculture of the Ministry of Agriculture, Natural Resources and the Environment; the Town Water Boards of Nicosia, Limassol and Larnaca; the Town Sewerage Boards of Nicosia, Limassol-Amathus, Larnaca, Paphos, Paralimni and Ayia Napa.

Type 2

This is as Type 1 and it was sent to some organisations in Cyprus with the following modifications:

- for the Agricultural Research Institute: only on the sectors of irrigation and use of waste-water.
- for the Environment Service: only on water pollution.
- for the State General Laboratory: only on water quality.
- for the Department of Town Planning and Housing: only on public health engineering.

Type 3

See Table 2. It was sent to the Industrial Training Authority of Cyprus.

Type 4

Several other letters were sent to organisations and individuals abroad involved in educational, training and research activities.

Table 1. Letter sent to Organisations in Cyprus
(Type 1)

Director,
Organisation.

Dear Sir/Madam,

I am a civil engineer and I carry out research (on my own initiative) in the topic 'education, training and research in water and waste-water engineering in the context of the characteristics and needs of Cyprus'. Please give me the following information:

- a) the titles of all the research programmes your Department/Board has been involved in the last ten years and the funders of it;
- b) a catalogue of postgraduate university education of professional personnel employed by your Department/Board in the last ten years and the funders of it;
- c) a catalogue of seminars, conferences and other training programmes that your Department/Board has organised in the last five years;
- d) records of participation of professional personnel of the Department/Board in seminars, conferences, and other training programmes abroad in the last five years and funders of it;
- e) future plans of the Department/Board in research, postgraduate education and training of professional personnel;
- and f) your co-operation in the matters mentioned above with organisations abroad.

Yours sincerely,

G. Michaelides

Table 2. Letter sent to Organisations in Cyprus
(Type 3)

Director,
Industrial Training Authority,
Nicosia.

Dear Sir,

I am a civil engineer and I am carrying out research on my own initiative on 'education, training and research in water and waste-water engineering in the context of the characteristics and needs of Cyprus'. Please give me the following information:

- a) a catalogue of seminars, conferences and other training programmes for professional personnel that the Authority has organised and/or funded in the sector of water and waste-water in Cyprus in the last five years; and
- b) a catalogue of participation (numbers and titles) of Cypriot professionals in seminars or conferences or other training programmes abroad in the sector of water or waste-water in the last five years that the Authority has funded.

Yours sincerely,

G. Michaelides

APPENDIX D
UNIVERSITY COURSES

Table 1. First-degree courses in Environmental Engineering and other related courses in the UK

- Environmental Engineering at 13 Universities (Brighton, Cranfield-Silsoe, Kingston, Liverpool John Moores, Nescot, North E. Wales I, Portsmouth, Salford, Sheffield Hallam, Southampton, Strathclyde, Ulster, Wales-Cardiff).
- Civil and Environmental Engineering at 11 Universities (Bradford, Edinburgh, Heriot-Watt, Leeds, Liverpool, London Imperial, London UCL, Newcastle, Nottingham Trent, Paisley, Sheffield).
- Environmental Technology at 7 Universities (Abertay, Central England, Durham, Huddersfield, Northumbria, Nottingham, Wolverhampton).
- Civil Engineering and Environmental Management at UMIST.
- Civil Engineering and Environmental Technology at Hertfordshire.
- Energy and Environmental Engineering at Napier.
- Energy and Environmental Technology at Glamorgan.
- Engineering (environmental processes) at Writtle C.
- Engineering for the environment at Brunel.
- Engineering with environmental science at London QMW.
- Environmental and Earth Resources Engineering at London Imperial.
- Environmental Civil Engineering at Glasgow Caledonian.
- Environmental Engineering and Resource Management at Nottingham.
- Environmental Management and Technology at Bradford.
- Environmental Systems Engineering at Lancaster.
- European Environmental Engineering Science at Middlesex.

Table 2. First-degree Civil Engineering (and related) courses in the UK offering water/waste-water engineering as final-year specialisation

- Civil and Environmental Engineering (Heriot-Watt, London Imperial, Newcastle, Paisley, Sheffield).
- Civil and Maritime Engineering (Liverpool).
- Civil and Structural Engineering (Bradford, Liverpool, Nottingham Trent, Sheffield, UMIST).
- Civil Engineering (Aston, Belfast, Birmingham, Bristol, City, Coventry, Exeter, Glamorgan, Greenwich, Heriot-Watt, Hertfordshire, Liverpool, London Imperial, London QMW, London UCL, Loughborough, Napier, Newcastle, Nottingham, Nottingham Trent, Oxford, Oxford Brookes, Paisley, Plymouth (MEng only), Portsmouth, Sheffield Hallam, Southampton, South Bank, Sunderland, Teeside, UMIST, Wales-Cardiff, Wales-Swansea).
- Civil Engineering and Law (Sheffield).
- Civil Engineering Commercial Management (Kingston).
- Civil Engineering Construction (Coventry).
- Civil Engineering Design (South Bank).
- Civil Engineering Design and Management (Wales - Cardiff).
- Civil Engineering Studies (Kingston).
- Civil Engineering Systems (London QMW).
- Civil Engineering with a minor (Greenwich, Surrey).
- Civil Engineering with Architecture (Sheffield).
- Civil Engineering with Computational Mechanics (Birmingham).
- Civil Engineering with Environmental Management (Birmingham, UMIST).
- Civil Engineering with Management (Birmingham, Nottingham Trent).
- Civil Engineering with Surveying (City).
- Construction Engineering (Anglia).
- Construction Management (Paisley).
- Construction Management and the Environment (Plymouth).
- Engineering (Civil) at Warwick.
- Structural Engineering (London UCL).

Table 3. 1998 Postgraduate Taught Courses in the UK on Water and Waste-water

Title of Course	University	Degree	Full-time/ Part-time and duration
Coastal and River Hydraulics	Oxford Brookes	MSc/PgDip	1 year F; 2-3 yrs P
Community Water Supply	Cranfield, Silsoe	MSc	1 or 2 yrs F
Desalination Technology	Glasgow	Dip/MSc	1 year F; 3 yrs P
Engineering Hydrology	Newcastle	Dip/MSc	9 m or 1 yr F; P available
Environmental Sciences: Hydrogeology	UEA	MSc	1 year F
Environmental Water Eng.	Bradford	MSc/PgDip	12 m F
Environmental Water Management	Cranfield, Silsoe	MSc	1 or 2 yrs F
Environmental Water Pollution Control	Sheffield	MSc (Eng.)/ MSc (Tech)/ Dip.	12 m F; 24 – 36 m P
Groundwater Engineering	Newcastle	Dip/MSc	9 m or 1 yr F
Hydraulics, Hydrology and Coastal Engineering	Strathclyde	MSc/PgDip	9 m, 12 m or 21 m F
Hydrogeology and Groundwater Chemistry	Reading	Dip/MSc	6 m or 1 yr F; 2 yrs P
Hydrology for Environmental Management	London (Imperial)	DIC/MSc	1 yr F; 2 yrs P
Integrated Water Planning	Middlesex	MSc	1 year F; 2 yrs P
Irrigation Engineering	Cranfield, Silsoe	MSc	1 or 2 yrs F
Irrigation Engineering	Southampton	Dip/MSc	9 m or 12 m F
Irrigation Water Management	Cranfield, Silsoe	MSc/PgDip	9 m, 1 yr or 2 yrs F
Public Health and Environmental Control Eng.	Strathclyde	MSc/PgDip	9 m, 12 m or 21 m F
Water and Environmental Eng.	Surrey	Dip/MSc	8 m or 12 m F
Water and Environmental Management	Loughborough	MSc	12 m F
Water and Environmental Management	Sheffield Hallam	MSc/PgCert /PgDip	1 year F; 2 yrs P
Water and Waste Eng.	Loughborough	MSc	12 m F
Water and Waste-water Technology	Cranfield	MSc/PgDip	P
Water Engineering	Strathclyde	MSc/PgDip	9 m, 12 m or 21 m F
Water Policy & Management	Cranfield, Silsoe	MSc	1 year F

(continued)

Table 3. (continued)

Title of Course	University	Degree	Full-time/part-time and Duration
Water Pollution Control	Middlesex	MSc	1 year F
Water Pollution Control	Westminster	Dip/MSc	2 yrs P
Water Pollution Control Technology	Cranfield	Dip/MSc	1 year F
Water Resources	Bangor	Dip/MSc	1 year F
Water Resources Engineering	City	MSc/PgDip	1 year F; 2-3 yrs P
Water Resources Engineering Management	Glasgow	Dip/MSc	1 year F; 2 or 3 yrs P
Water Resources Engineering Management	Heriot-Watt	MSc/PgDip	12 m F; 2 yrs P
Water Resource Systems Engineering	Newcastle	Dip/MSc	9 m or 12 m F
Water Resources Technology and Management	Birmingham	MSc (Eng.)	12 m F; 18 m P

Note: Titles of courses appear in alphabetical order.

Table 4. Related postgraduate taught courses in the UK
(partly involving water and waste-water)

- Bridge Engineering at Surrey
- Catchment of the Water Environment at Hertfordshire
- Civil Engineering at Belfast, Dundee, East London, Glamorgan and Portsmouth.
- Civil and Structural Engineering at Bradford and Sheffield.
- Civil, Geotechnical or Structural Eng. at Cardiff (Wales).
- Earth Science and the Environment at Kingston.
- Engineering Design of Buildings at Paisley. Engineering for Development (Infrastructure, Water Supply and Sanitation) at Southampton.
- Engineering Geology at Durham, Leeds and Imperial.
- Environmental and Ecological Sciences at Lancaster.
- Environment and Landscape Eng. at Cranfield (Silsoe).
- Environmental Civil Engineering at Liverpool and South Bank.
- Environmental Engineering at Belfast, Imperial, Newcastle, Nottingham and Portsmouth.
- Environmental Management at Sunderland and at Wye College (London).
- Environmental Management/Engineering at Sunderland.
- Environmental Resources at Salford.
- Environmental Protection at Salford.
- Environmental Protection and Management at SAC (Edinburgh).
- Environmental Science at Strathclyde.
- Environmental Technology at Imperial and UMIST.
- Geo-environmental Engineering at Durham.
- Geography, Environmental Sustainability, Surface and Groundwater Resources at Huddersfield.
- Geotechnical Engineering at UMIST.
- Management and Implementation of Development Projects at UMIST.
- Planning and Management for Development (Agriculture or Land and Water Engineering) at Southampton.
- Public Health Engineering at Leeds.
- Soil and Water Engineering at Cranfield (Silsoe).
- Tropical Public Health Engineering at Leeds.

Note: They are presented in alphabetical order.

Table 5. Graduate programmes in Water Resources Engineering in the USA in 1998

University	Faculty/College	Department	Course	Degree
Auburn	Engineering	Civil Eng.	Hydraulics/Hydrology *	MCE, MS, Ph.D.
Colorado State	Engineering	Civil Eng.	Hydrologic Science & Engineering	MS, Ph.D.
Cornell	Graduate Fields of Engineering	Civil and Environmental Eng.	Water resource systems *	MEng, MS, Ph.D.
Florida Institute of Technology	Engineering	Eng. Science; Programme in Civil Eng.	Water Resources *	MS
Louisiana State	Engineering	Civil and Environmental Eng.	Water Resources	MSCE, Ph.D.
Marquette	Engineering	Civil and Environmental Eng.	Environmental/Water resources Eng. *	MS, Ph.D.
New Mexico Institute of Mining and Technology		Mineral and Environmental Eng.	Environmental Eng. with one of options in Water quality Eng. and science *	MS
Ohio	Graduate studies; Eng. and Technology	Civil Eng.	Water Resources *	MS
Oregon State	Graduate; Engineering	Bioresource Eng.		
Pennsylvania State	Engineering	Civil and Environmental Eng.	Water Resources Eng. *	MEng, MS, Ph.D.
Princeton		Civil Eng. and Operations Research and Geosciences	Environmental Eng. and Water Resources	Ph.D.
State University of New York at Buffalo	Graduate; Eng. and Applied Sciences	Civil Eng.	Water Resources and Environmental Eng. *	MEng, MS, Ph.D.
Texas A and M	Engineering	Civil Eng.	Water Resources Eng.	MEng, MS, DEng, Ph.D.
Tufts	Arts and Sciences; Engineering	Civil and Environmental Eng.	Environmental Eng. with one of options in Water Resources Eng. *	MS, Ph.D.
California, Berkeley	Engineering	Civil and Environmental Eng.; Division: Environmental Eng.	Environmental Water Resources Eng.	MEng, MS, DEng, Ph.D.
California, Irvine	Engineering	Civil and Environmental Eng.	Water Resources and Environmental Eng.	MS, Ph.D.

(continued)

Table 5. (continued)

University	Faculty/College	Department	Course	Degree
California, Los Angeles	Engineering and Applied Science	Civil and Environmental Eng.	Water Resource Systems Eng. *	MS, Ph.D.
Colorado at Boulder	Eng. and Applied Science	Civil, Environmental and Architectural Eng.	Water Resources Eng. *	MS, Ph.D.
Delaware	Engineering	Civil and Environmental Eng.	Water Resources Eng.	MCE, Ph.D.
Kansas	Engineering	Civil and Environmental Eng.	Water Resources Eng. *	MS
Maryland, College Park	Agriculture	Biological Resources Eng.		MS, Ph.D.
Memphis	Engineering	Civil Eng.	Water Resources Eng. *	MS
Missouri-Columbia	Engineering	Civil Eng.	Water Resources *	MS, Ph.D.
Missouri- Rolla	Engineering	Civil Eng.	Hydrology and Hydraulic Eng. *	MS, DE, Ph.D.
Southern California	Graduate; Engineering	Civil Eng.	Water Resources	MS
Virginia	Eng. and Applied Science	Civil Eng.	Environmental Eng.; Water Resources *	ME, MS, Ph.D.
Utah State	Engineering	Biological and Irrigation Eng.	Irrigation Eng.	MS, Ph.D.
Villanova	Engineering	Civil and Environmental Eng.	Water Resources and Environmental Eng. *	MSWREE

* = offerings include

Table 6. Graduate programmes in Environmental Engineering in the USA

Graduate programmes in Environmental Engineering are offered in the following 135 American Universities: Arizona State, Auburn, California Institute of Technology, California Polytechnic State, Carnegie Mellon, Case Western Reserve, Catholic of America, Clarkson, Clemson, Colorado School of Mines, Colorado State, Columbia, Cornell, Dartmouth College, Drexel, Duke, Florida Institute of Technology, Florida International, George Washington, Georgia Institute of Technology, Harvard, Idaho State, Illinois Institute of Technology, Iowa State (of Science and Technology), Johns Hopkins, Lamar, Lehigh, Louisiana State, Loyola Marymount, Manhattan College, Marquette, Massachusetts Institute of Technology, Michigan State, Michigan Technology, Milwaukee School of Engineering, Mississippi State, Montana State (Bozeman), Montana Tech of The University of Montana, Murray State, New Jersey Institute of Technology, New Mexico State, New Mexico Institute of Mining and Technology, New York Institute of Technology, North Dakota State, North-eastern, North-western, Ohio, Oklahoma State, Old Dominion, Oregon Graduate Institute of Science and Technology, Oregon State, Pennsylvania State (Great Valley Graduate Centre), Pennsylvania State (Harrisburg Campus of the Capital College), Pennsylvania State (University Park Campus), Polytechnic University (Brooklyn Campus), Polytechnic University (Farmingdale Campus), Polytechnic University (Westchester Graduate Center), Princeton, Rensselaer Polytechnic Institute, Rice, Rose-Hulman Institute of Technology, Rutgers (State University of New Jersey), South Dakota State, State University of New York at Buffalo, State University of New York College of Environmental Science and Forestry, Stevens Institute of Technology, Syracuse, Temple, Texas A and M, Texas A and M (Kingsville), Texas Tech, Tufts, Tulane, Alabama, Alabama (at Birmingham), Alabama (in Huntsville), Alaska Anchorage, Alaska (Fairbanks), Arizona, Arkansas, California (Berkeley), California (Davis), California (Irvine), California (Los Angeles), California (Santa Barbara), Central Florida, Cincinnati, Colorado (at Boulder), Connecticut, Dayton, Delaware, Detroit Mercy, Florida, Houston, Illinois (at Urbana - Champaign), Iowa, Kansas, Maine, Maryland (College Park), Massachusetts Amherst, Massachusetts Lowell, Memphis, Michigan, Missouri-Columbia, Missouri-Rolla, Nebraska Lincoln, Nevada (Las Vegas), Nevada (Reno), New Haven, North Carolina at Chapel Hill, Notre Dame, Oklahoma, Pennsylvania, Pittsburgh, Rhode Island, Southern California, South Florida, Tennessee (Knoxville), Texas at Arlington, Texas at Austin, Texas at El Paso,

(continued)

Table 6. (continued)

Virginia, Washington, Wisconsin - Madison, Wyoming, Utah State, Vanderbilt, Villanova, Virginia Polytechnic Institute and State University, Washington State, Washington, West Virginia Graduate College, West Virginia, Worcester Polytechnic Institute, Youngstown State.

Table 7. Graduate programmes in Environmental and Water Resources Engineering in Canada in 1998

University	Faculty/ College	Department	Course	Degree	Average duration (full-time)	Degree requirements	Part- time
Alberta	Graduate Studies and Research	Civil and Environmental Eng.	Water Resources Eng.	MEng, MSc, Ph.D.	Master: 2.1 yrs; Ph.D.: 4.7 yrs	MEng: 10 courses, project; MSc: 8 courses, thesis; Ph.D.: dissertation	available
Alberta	Graduate Studies and Research	Civil and Environmental Eng.	Environmental Eng.	MEng, MSc, Ph.D.	Master: 2.1 yrs; Ph.D.: 4.7 yrs	MEng: 10 courses, project; MSc: 8 courses, thesis; Ph.D.: dissertation	available
Alberta	Graduate Studies and Research	Civil and Environmental Eng.	Geoenvironmental Eng.	MEng, MSc, Ph.D.	Master: 2.1 yrs; Ph.D.: 4.7 yrs	MEng: 10 courses, project; MSc: 8 courses, thesis; Ph.D.: dissertation	available
Guelph	Physical and Eng. Science	School: Engineering	Water Resources Eng.*	MEng, MSc, Ph.D.	Master: 1.9 yrs; Ph.D.: 4 yrs	Master: thesis (some programmes); Ph.D.: dissertation	
Guelph	Physical and Eng. Science	School: Engineering	Environmental Eng.*	MEng, MSc, Ph.D.	Master: 1.9 yrs; Ph.D.: 4 yrs	Master: thesis (some programmes); Ph.D.: dissertation	
McGill	Graduate Studies and Research; Engineering	Civil Eng. And Applied Mechanics	Environmental Eng. and Water Resources Management	MEng, MSc, Ph.D., Diploma	MEng: minimum 1 yr; Ph.D.: minimum 3 yrs	MEng: 5 courses and thesis or 8 courses and project; Ph.D.: dissertation	available; also Evening/ Weekend
McGill	Graduate Studies and Research; Engineering	Civil Eng. And Applied Mechanics	Fluid Mechanics And Hydraulic Eng.	MEng, MSc, Ph.D., Diploma	MEng: minimum 1 yr; Ph.D.: minimum 3 yrs	MEng: 5 courses and thesis or 8 courses and project; Ph.D.: dissertation	available; also Evening/ Weekend

(continued)

Table 7. (continued)

University	Faculty/ College	Department	Course	Degree	Average duration (full-time)	Degree requirements	Part-time
Ecole Polytechnique de Montreal		Civil Eng.	Environmental Eng. *	MEng, MScA, Ph.D.		Thesis/dissertation	
New Brunswick	Engineering	Civil Eng.	Environmental Eng. *	MEng, MScE, Ph.D.		Master: thesis; Ph.D.: dissertation, Qualifying exam	
Regina	Graduate Studies and Research; Engineering		Regional Environmental Systems Eng.	MASc, MEng, Ph.D.		Master: thesis; Ph.D.: dissertation	
Saskatchewan	Engineering	Division: Environmental Eng.		MEng, MSc, Ph.D., Diploma		Master and Ph.D.: Thesis/dissertation	
Sherbrooke	Applied Sciences		Environment	MEnv.		Thesis	
Toronto	Graduate Studies; Applied Science & Eng.		Collaborative Programme in Environmental Eng.	MaSc, MEng, Ph.D.		Thesis/dissertation	available
Windsor	Engineering	Civil and Environmental Eng.		MaSc, Ph.D.	Ph.D.: 5 yrs	Thesis/dissertation	available

Note: * = offerings include

Table 8. Financial aid in Graduate studies in Environmental/Water Engineering programmes in Canada in 1996-97

University	No. of Students receiving aid	Research assistantships: no. and amount in \$	Fellowships: no. and amount in \$	Scholarships: no. and amount in \$	Teaching assistantships: no. and amount in \$
Alberta	125 (for whole dept.)	8, 1100/month (average)			21 1100/month (average)
McGill	15	9, 1250/month (maximum) and 51158 (total)	4 7790 (total)		14, 1050/sem. and 14175 (total)
Regina	15	2, 1000/month (average)	3131/month (average)	8 750/month (average)	5 880/month (average)
Windsor		Available	4 857/month (average) and 10284 (total)		1067/month (average) and 85200 (total)

Notes:

- The University of Alberta Ph.D scholarship programme provides both a stipend (\$13000 in 1997-98) and payment of tuition and fees. Students who have spent one year in their programme may apply.
- In McGill University, institutionally sponsored loans are also available.
- Unfortunately, no information is available on what percentage of students receive aid (and what income group they or their families come from). Alternatively, it would be useful (if information were available) to relate the actual amount of financial aid to either fees and/or average cost of living or salary.

Table 9. Examples of postgraduate coursework programmes in water engineering in Australia

- | |
|---|
| <ul style="list-style-type: none"> - University of New South Wales: Grad. Cert. in Hydrology; Grad. Dip./MEngSc (water engineering or public health engineering) - University of Wollongong: Grad. Dip./MEng (water engineering or environmental engineering) - University of Melbourne: Grad. Cert./Grad. Dip./MEngSc (water engineering or environmental engineering) - Monash University: Grad. Dip./MEngSc (water engineering or environmental engineering) - Deakin University: Grad. Dip. (water engineering and management or environmental engineering) - University of Queensland: Grad. Cert./Grad. Dip. (environmental management); MEngSc (hydrology, public health engineering) - Griffith University: Grad. Cert./Grad. Dip./MEngSc (water care); Grad. Dip./MEngSc (environmental engineering) - University of Adelaide, University of South Australia and Flinders University (joint programme): Grad. Cert./Grad. Dip./MEngSc/MEng/MSc (hydrology and water resources) - University of Adelaide: Grad. Cert./Grad. Dip. (environmental engineering) |
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