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REASSESSMENT OF THE ISLAND'S WATER RESOURCES AND DEMAND

Objective 1 – Output 1.4.2

ASSESSMENT OF GROUNDWATER RESOURCES OF CYPRUS

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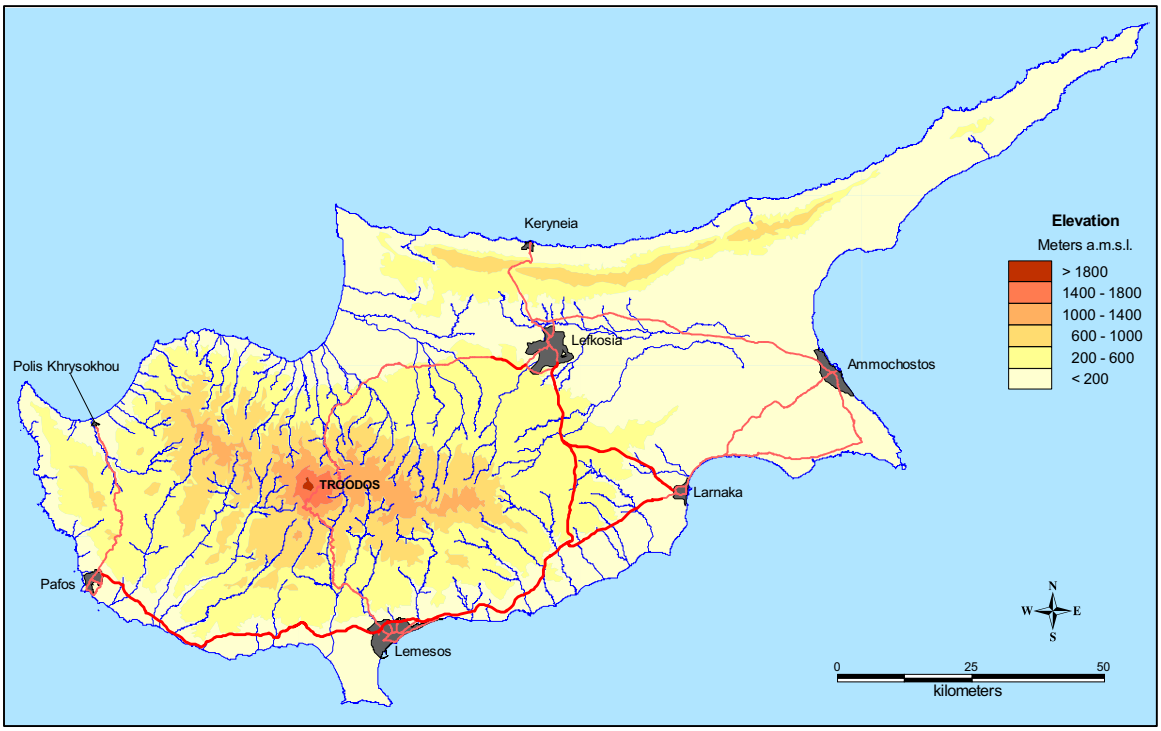
1 INTRODUCTION

The present study forms part of the “Reassessment of the Island’s Water Resources and Demand” project, undertaken by the Water Development Department (WDD) in cooperation with the Land and Water Development Division of the United Nations Food and Agriculture Organization (FAO). The project commenced at the beginning of 2001 and one of its major targets was the evaluation of present water availability in the Island. Unfortunately the only data available come from the part of the Island under Government control. There are no available data from the Northern part of the Island which is under Turkish occupation since the 1974 Turkish invasion of the Island.

This study started at the end of April, 2001 and its main objective is defined in the terms of reference of the project. It aims to review the aquifer systems in Cyprus including the prevailing groundwater condition and the aquifers’ potential yields, in order to assist in the preparation of the Island’s future water policy. This study covers only the collation and analysis of existing data and information appearing in literature related to the subject. No new investigations were carried out. The study was mainly based on aquifer parameters, conditions and data that prevailed during the last ten years 1991 – 2000. All estimates presented in this report cover the same period. We believe that aquifer hydrogeological conditions in the next 10 years will be very similar to the aquifer hydrogeological conditions which prevailed over the 1991-2000 period examined in the present study.

Cyprus is a semiarid country and water scarcity is one of its major problems. The average yearly precipitation over the part of Cyprus under Government control, for the period 1916 to 2000 is 515 mm. The average yearly rainfall for period 1971 – 2000 is 460 mm and 435 mm for the last decade i.e.1991 – 2000.



Map 1-1: Topographic Map of Cyprus

Water demand in the Island has always been much higher than the available water resources. Great effort was invested in the struggle for water development in the

country. This was manifested mainly by the construction of over 100 dams on almost all rivers of the country. During the last ten to fifteen years and after the completion of the major Cyprus Water Projects repeated droughts have dramatically reduced the water crop of the country and consequently increased water shortages. Ever increasing water deficits, in conjunction with the deterioration of groundwater quality forced the government to opt for desalination to supplement domestic water supply.

The last island-wide groundwater study was carried out some thirty years ago. Studies of individual aquifers carried out within the framework of the major water development projects were completed twenty years ago. The general hydrometeorological, hydrological and hydrogeological conditions have changed dramatically since then. Frequent and long lasting droughts during the last decades have considerably reduced recharge to the aquifers. The problem of reduced recharge to the aquifers was exacerbated by the construction of a great number of dams on the major rivers of the country.

This report which in essence is an 'Atlas' of the Cyprus Aquifers is more concerned with groundwater resources rather than the geological/hydrogeological condition of the aquifers. An electronic form of this report is also available in web-page form. A vast amount of data has been organized and prepared for GIS applications. The majority of the maps presented in this report have been produced using such an application. It is imperative that the Atlas is kept up to date by continuous updating, upgrading and enriching of the Atlas's supporting database. Regrettably the very short period allowed for this study in combination with the very limited human resources available did not allow an in-depth study of all aquifers. The boundaries of many aquifers need to be refined in the future. It is important that additional information on each aquifer's geological, hydrogeological, hydrochemical and environmental condition be incorporated in the Atlas in the future.

The study covers all aquifers (Map 5-1 and Map 5-2) in the part of the island under government control and most of them are studied separately. However, in some cases, available information and data did not allow separation of interconnected aquifers. For this reason several of these interconnecting aquifers were treated and presented as a group of aquifers rather than individually. Examples of such groups are the aquifers of Troodos massif, the aquifers of the Central Mesaoria, the aquifers formed in carbonate rocks of Lefkara and Pachna formation etc. Separating the members of these groups will be most useful and should be done in the future. Regrettably only general information on very few aquifers in the occupied and hence inaccessible part of Cyprus is presented in this report.

A standardized format was followed for the presentation of information for each aquifer. This information includes water balance for the aquifer as well as water availability within the aquifer expressed as recommended sustainable extraction. For the sake of comparison water balance estimates carried out within the framework of older water projects and studies are also included.

In view of the fact that Cyprus will join the European Union in the very near future the country is obliged to establish a water policy that is in accordance with the Union's regulations, instructions and directives. In particular Directive 2000/60/EC, which establishes a framework for European Union action on water policy, requires that member states protect, enhance and restore all water systems.

We believe that the present study recommends important practical steps towards the protection and sustainable development of the aquifers. It is expected that the

implementation of these steps will also facilitate our harmonization with European Union mandates on water policy.

2 DISCUSSION

The main purpose of this study was to reassess the country's groundwater situation by analyzing and evaluating all available data and information concerning this important natural resource. The outcome of this report will hopefully form the basis for the preparation of a groundwater management strategy which in turn will form an integral part of the country's Water Policy.

The very limited time available for such ambitious study in conjunction with a serious shortage of personnel assigned to it allowed for neither new investigations nor for the use of sophisticated methods of approach. Conventional, simple methods have been adopted and were applied for the estimation of the different aquifers' parameters. It is believed that this study has succeeded in presenting the groundwater situation on the Island with a high degree of reliability.

The available data have been collected by several WDD Divisions and Regional Offices. These data have been checked for validity, accuracy and reliability. It is obvious that the most important data required for the purpose of assessing water availability are the amount of water extracted from each aquifer, as well as water level fluctuations and groundwater quality conditions recorded over a number of years.

All available data associated with Cyprus aquifers, including results of older water resources studies as well as literature and maps on geology, hydrogeology, hydrology, meteorology etc. prepared by WDD, the Geological Survey Department (GSD), the Meteorological Services etc. have been used in this study.

The greatest bulk of all available data has been digitised and stored in a multipurpose database fully compatible with GIS applications. Various types of data were imported into this database. The database configuration also allows for requirements that may arise in the future. The database is expandable and all data stored in it can, when required, be refined, revised, corrected and updated. It is the first time that boundaries for all aquifers have been defined. With the completion of the present study, aquifer boundaries, groundwater level observation networks (1100 observation boreholes) and various types of maps will be available in a digital form.

Aquifer data used for the preparation of the present report cover the period 1991 to 2000 and all aquifer parameter appearing in it refer to the same period. This is the most critical decade for the natural water resources of the country. We believe that the hydrological and hydrogeological conditions which prevailed during this period will most probably prevail in the next decade as well. It is therefore recommended that these conditions be adopted as the basis for planning purposes. During the last 10 -15 years many of the aquifer's water balance elements have been permanently altered. Most of the dams in the country were completed during this period. This caused great reductions in, and in many cases almost complete elimination of the natural riverbed recharge of the aquifers downstream of these dams. The realization of several water projects and the construction and operation of desalination and sewage treatment plants during the last decade resulted in permanent changes to water resources availability, use and distribution i.e. changes which greatly affect aquifer regimes. Prolonged overpumping over the last decade resulted in the depletion of many aquifers and in many cases to deterioration of groundwater quality as well. In view of the unfavourable hydrometeorological conditions encountered in Cyprus and the very slow aquifer rehabilitation processes we do not expect that the aquifers will be restored to their 1970's or even their 1980's state in the foreseeable future. It is almost certain that in the next decade the conditions will be similar if not

worse than these of the 1991 –2000 decade. Recurring dry years during the 1991 – 2000 period resulted in the reduction of the natural water crop and subsequently in ever-increasing water shortages. Regrettably some of these shortages are covered by aquifer mining.

It is true that the average rainfall (435 mm) over the 1991 – 2000 period examined in this study is by 5% lower than the average rainfall (460 mm) over the 1971 – 2000 30-year period. However, bearing in mind all that was mentioned above, we do not expect that a hypothetical restoration of the rainfall back to its 30-year average will significantly improve the water balance of the aquifers.

A water balance and/or assessment of water availability for each aquifer or group of aquifers are given in this report. All water balance values have been classified as poor, fair, good and very good according to the accuracy of their estimation. The estimation of many of these values was only possible because of the author's long experience on the subject. A summary of these balances is given in Table 3-2 and the methods of estimation are presented in the following paragraphs.

2.1 Replenishment

2.1.1 Recharge from Rainfall

Several mathematical models developed for a number of Cyprus aquifers established that 5 –15% of the average yearly precipitation over the aquifers contributes to the aquifers' recharge. These are the values used to estimate rainfall contribution to aquifer recharge for the study period 1991 – 2000. The average yearly rainfall for period 1991 to 2000 was calculated using a Cyprus isohyetal map (Map 2-1) of the period 1990 to 2000. Similarly the1970-2000 isohyetal map (Map 2-2) was used for the calculation of the average yearly rainfall for the corresponding period.

The percentage of rainfall percolating into the aquifers depends on various aquifer characteristics such as topography and slopes, geology, lithology, soil, vegetation cover as well as the type and intensity of precipitation. The lowest percentage of percolation is encountered in areas with very steep slopes, areas covered with impermeable soils or solid rocks and obviously in areas of very low rainfall. Maximum infiltration occurs in flat areas covered by coarse alluvial deposits.

2.1.2 Recharge from River Flows

Estimation of recharge through riverbeds of gauged rivers is based on river flows recorded at flow gauging stations minus flows 'lost' in-between stations. Estimation of recharge through riverbeds of ungauged streams is based on recharge values of gauged streams featuring similar physical characteristics. However, for the estimation of this type of recharge on both gauged and ungauged rivers, the author's long experience on artificial recharge of river alluvial aquifers in Cyprus was heavily relied upon. The method of artificial recharge most frequently used in Cyprus is that of controlled releases of dam water into the natural riverbed. The maximum quantity released for this purpose was about 1 m^3/sec. Application of this method in Cyprus has revealed that no more than 10 m^3/m/day of water can percolate into clean, coarse alluvial deposits.

2.1.3 Recharge from Return Flow from Irrigation

It is assumed that modern, water saving methods of irrigation are used everywhere. For this reason the return flow is not expected to exceed 3 to 5% of total irrigation.

2.1.4 Recharge from Return Flow of Domestic Water Supply

It is estimated that in residential areas where no central sewerage systems exist, 70 - 80% of the amount of water supplied percolates from effluent absorption pits into the aquifer. In water balance calculations small amounts of this type of recharge are considered as either part of the return flow from irrigation or part of recharge from rainfall.

2.1.5 Recharge from Water Losses from Water Supply Networks

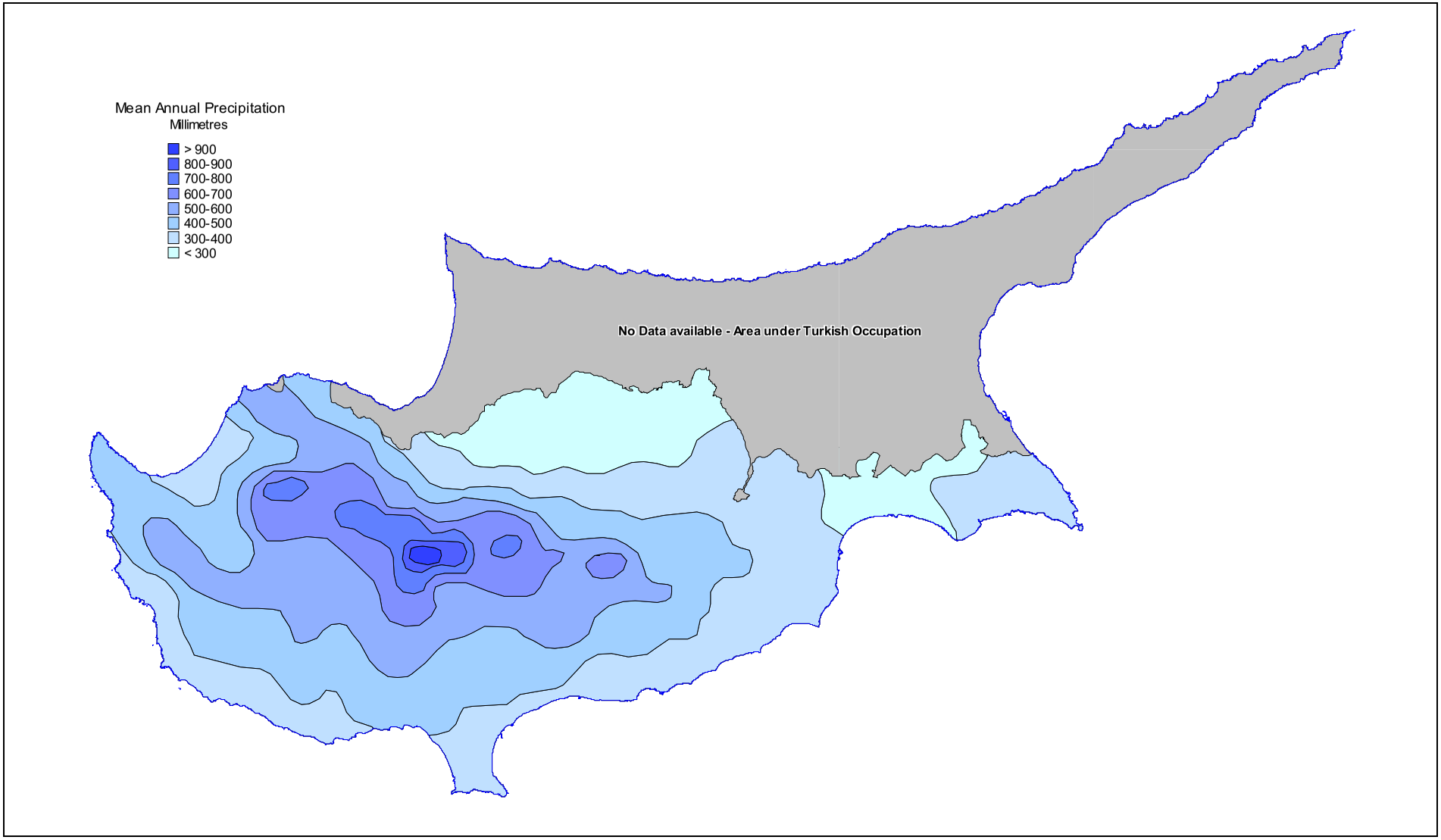
In residential areas water losses form domestic water supply networks are greater than 15%. On average, it is estimated to be approximately 20%. Losses from irrigation networks do not exceed 5%.

2.1.6 Recharge from Groundwater Inflows

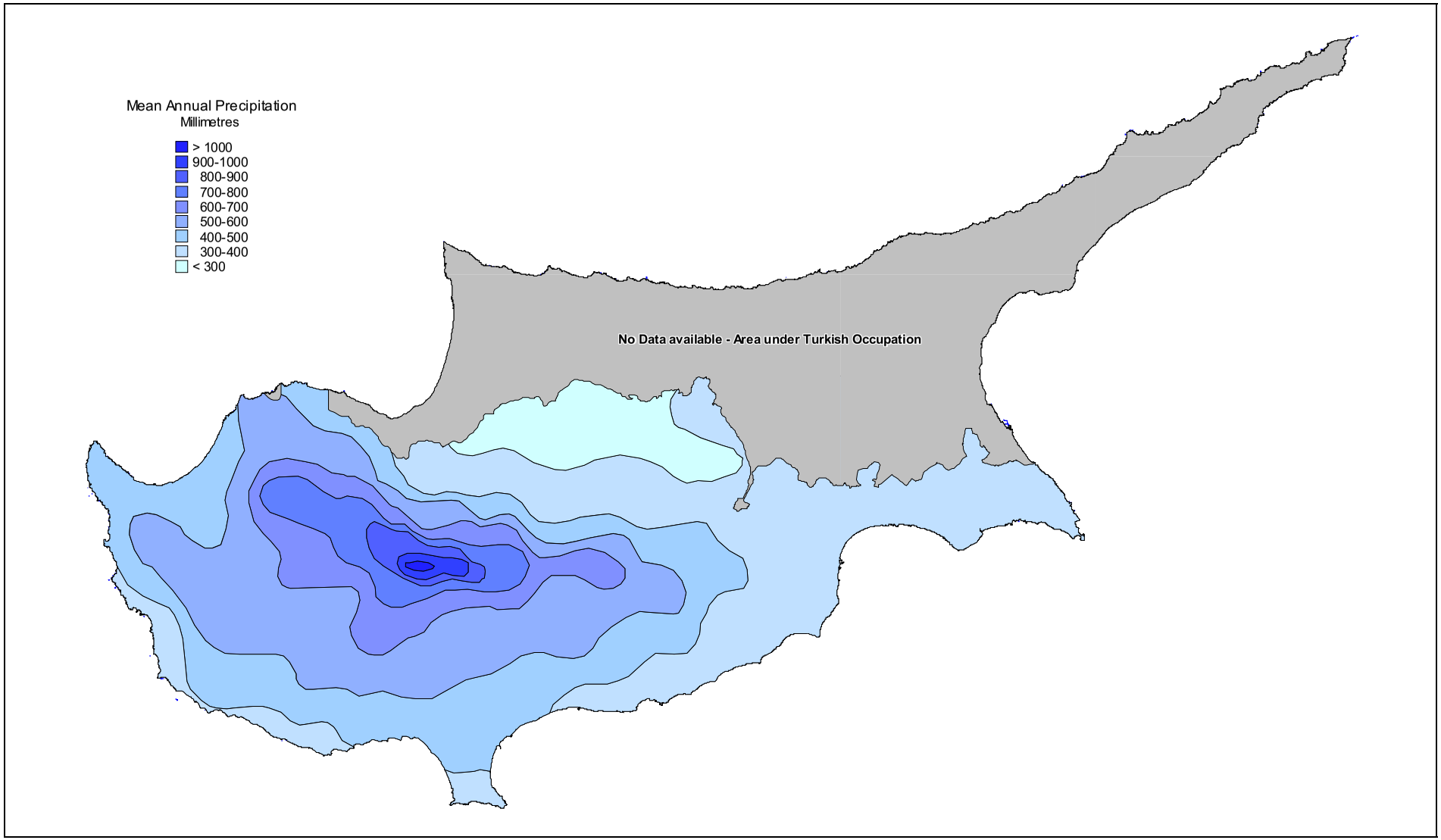
Darcy's law i.e. $Q = k \times A \times i$ is used to calculate recharge from groundwater inflows.

2.1.7 Recharge from Dam Losses

This type of recharge is considered as a separate article only in cases where there is evidence of such losses.



Map 2-1: Average Annual Precipitation (mm) Map of Cyprus Oct. 1990 – Sept. 2000 (scanned and digitised from Meteorological Service-map)



Map 2-2: Average Annual Precipitation (mm) Map of Cyprus Oct. 1970 – Sept. 2000 (scanned and digitised from Meteorological Service-map)

2.2 Outflow

2.2.1 Extraction

Total amount of water extracted from each aquifer is obtained mainly through field surveys carried out by specialized technicians. Extraction from each borehole in the aquifer is estimated using the size of the irrigated area serviced, the type of crop irrigated and the crop's requirements in water per unit area. In cases where part of the irrigation demand is covered by alternative sources such as surface water or dam water, extraction estimates are adapted accordingly. Estimates based on this method are not very accurate but they are of acceptable reliability. Unfortunately, accurate abstraction data exist only for few aquifers in which boreholes are equipped with reliable water meters e.g. the Akrotiri Aquifer.

Field groundwater extraction surveys cover only the major aquifers. Only a very small part of the Island is covered by such surveys (Map 4-4). Extraction from aquifers such as the Troodos Aquifers which are not covered by these surveys is estimated based on the figures of overall water demand given in "The Assessment of Water Demand of Cyprus", prepared by Loucas Savvides, Gerald Dörflinger and Kyriakos Alexandrou. This report was prepared within the framework of project "Reassessment of the Island's Water Resources and Demand" which is carried out in cooperation with FAO.

2.2.2 Groundwater and Sea Outflow

Darcy's law i.e. $Q = k \times A \times i$ is used for the calculation of this part of recharge

2.3 Other Definitions

2.3.1 Recommended Extraction

'Recommended Extraction' is based on the aquifer's 'Water Balance'. Depending on the state of depletion of the aquifer, 'Recommended Extraction' may or may not be in arithmetic balance with the other elements comprising the 'Water Balance'. This is because 'Recommended Extraction' should allow for sustainable exploitation of the aquifer a condition for which the recovery of the aquifer is imperative.

'Artificial Recharge' to the aquifer is not included in the calculation of 'Recommended Extraction'.

Recommended Extraction =
Natural Recharge – (Groundwater/Sea Outflow +
Quantities for Recovery/Sustainability)

After the recovery of the aquifers the 'Recommended Extraction' will have to be recalculated as many elements of the water balance equation e.g. groundwater outflow, sea outflow and sea intrusion will change significantly.

2.3.2 Water Balance

The 'Water Balance' of the aquifer is a mass balance and it is estimated by subtracting total Outflow from total Replenishment. Resulting negative values indicate depletion of the aquifer, general lowering of water levels and possible degradation of the aquifer.

Water Balance = Replenishment – Outflow

where

Replenishment = Natural recharge + Artificial recharge + Sea intrusion

Natural Recharge = Rainfall+ River Flows+ Return from Irrigation/Domestic+
Groundwater Inflow+ Dam losses

and

Outflow = Extraction + Groundwater outflow + Sea outflow

'Fresh Water Balance', also given in this report, is basically the 'Water Balance' of the aquifer from which the amount of sea intrusion has been excluded.

i.e. Fresh Water Balance = Replenishment – Outflow – Sea intrusion

2.3.3 Overpumping

'Overpumping' of an aquifer is defined as the difference between Recommended Extraction and the existing Extraction i.e.

Overpumping = Recommended Extraction – Existing Extraction

A summary of the results of these calculations is given in Table 3-2

2.3.4 Recommended Increase in Pumping

It is estimated that in some aquifers (Table 3-2) extraction can be increased simply by redistributing the amount of extraction over the year i.e. by decreasing pumping during summer and increasing pumping during spring. These quantities are in addition to the 'Recommended Extraction'.

2.3.5 Aquifer Susceptibility

'Aquifer Susceptibility' is defined as the level of vulnerability of the aquifer. It refers to the natural defenses of the aquifer against natural or man-instigated pollution. These are considered under natural conditions i.e. any existing groundwater pollution problems are not included. This susceptibility or natural vulnerability is very high in shallow phreatic aquifers consisting of highly permeable materials. The lowest susceptibility appears in the confined aquifers protected by impermeable ceilings.

3 SUMMARY

Under the study of reassessment of groundwater resources of the Island, sixty-six aquifers, individually or in groups, have been considered. The study covers all the aquifers of the country in the area under Government control. Some information on aquifers in the occupied northern part of Cyprus are also given. A list of the aquifers is given in Table 3-2 and Table 5-1.

Most of the aquifers of the Island are phreatic aquifers developed in river or coastal alluvial deposits. These are the biggest and the most dynamic aquifers mainly replenished from river flows and rainfall. During the last decade almost all aquifers, exhibit depleting trends. This phenomenon can be clearly seen on borehole hydrographs. Frequent droughts have reduced the direct and indirect groundwater recharge; construction of dams resulted in reduced recharge of the downstream aquifers. At the same time farmers, in their effort to maintain agricultural production levels have continued extracting the same quantities of groundwater and in most cases have even greatly increased these quantities. All these adverse conditions resulted in saline water intrusion and hence quality deterioration of coastal aquifers and the depletion of inland aquifers.

The recommended values of groundwater extractions given in this report are based on the philosophy of sustainable management and protection of groundwater resources. Further quality deterioration of the groundwater should be prevented. This can be achieved by introducing integrated water management rules and measures to reduce pumping and prevent pollution.

A summary of water balances of the aquifers is given in Table 3-1. Table 3-2 gives detailed water balance for each aquifer.

Table 3-1: Annual Groundwater Balance of all Cyprus Aquifers
(averaged over period 1991-2000)

Replenishment of the aquifers ($x10^6$ m^3):

Natural Recharge from:			
	Rainfall	205.1	
	River flows	44.8	
	Return from irrigation/domestic	22.1	
	Groundwater inflow	8.8	
	Dam losses	1.7	
	Natural Recharge	282.5	282.5
Artificial recharge			9.8
Sea intrusion			12.8
REPLENISHMENT (TOTAL RECHARGE)			**305.1** mcm

Outflow from the aquifers ($x10^6$ m^3):

Extraction	129.1	
Groundwater Outflow	166.7	
Sea Outflow	24.6	
TOTAL OUTFLOW	**320.4**	mcm

Total Water Balance = Replenishment – Outflow
= 305.1 – 320.4 = -15.3 mcm

In general, the resulting Total Water Balance is reflected in an annual lowering of groundwater levels.

Fresh Water Balance = Replenishment – Outflow – Sea intrusion
= 305.1 – 320.4 – 12.8 = – 28.1 mcm

Overpumping = 32.5 mcm (Table 3-2 and chapter 2.3.3)

Recommended Extraction = 81.3 mcm (Table 3-2 and chapter 2.3.1).

The present level of extraction is estimated to be 129.1 mcm/year. Ten million of these were made available by artificial recharge. The amount of extracted groundwater originating from natural recharge is therefore of the order of 120 mcm/year.

The average extraction for domestic water supply over the period 1991 - 2000 is estimated to be of the order of 25 mcm/year; for irrigation it is estimated to be around 102 mcm/year and for industrial use it is estimated to be around 2.5 to 3 mcm. The use of groundwater for domestic water supply gradually decreases. It has been significantly reduced during the last years to levels of 18 to 20 mcm.

The recharge of the aquifers and the groundwater outflow in mountainous area is very high. Aquifers discharge through springs and seepages feeding several rivers, the base flows of which are maintained by these discharges. Significant quantities of the groundwater are consumed by the forests and evaporate from extensive seepages. Because of the fact that the estimation of recharge-discharge values is not very accurate these are given tentatively (Table 3-2).

Total recommended extraction from all aquifers is of the order of 81 mcm/year. This estimation is based on the water balance of each aquifer and the philosophy for their sustainable development and recovery. It is therefore not always in arithmetic balance with the other members of the water balance equation.

‘Overpumping’ of the aquifers is the difference between Recommended Extraction and the existing present-day Extraction i.e.

Overpumping = Recommended Extraction – Existing Extraction

It is estimated that in some aquifers the extraction can be increased simply by redistributing the amount of extraction over the year i.e. by decreasing pumping during summer and increasing pumping during spring. The recommended increase is of the order of 4 mcm/year (Table 3-2). These quantities are over and above the recommended extraction.

The most common water quality problem in the country is the contamination of groundwater caused by sea intrusion. The coastal zones of the major aquifers in Cyprus e.g. Kokkinochoria, Kiti-Perivolia, Akrotiri, Morfou etc. have been abandoned because of this phenomenon. Intensive agriculture and excessive use of fertilizers resulted in nitrate pollution of many aquifers. Similar nitrate pollution problems appear in aquifers developed in inhabited areas because of direct sewage disposal in

adsorption pits. Nitrate ion concentration in these cases usually exceeds 100 mg/lit. Groundwater in the igneous rocks is in general, of very good quality. Groundwater in sedimentary rocks is generally hard because of the abundance of carbonate sediments. Average $CaCO_3$ hardness in these sediments is of the order of 450 to 500 mg/lit.

The existing monitoring system of the aquifers in most cases is insufficient and inadequate and it only covers the main aquifers. A great number of smaller aquifers of local importance are not monitored at all. The networks and the surveys for quality control of the aquifers have been neglected for many years. Monitoring which is so crucial to qualitative water management has been almost completely abandoned in the last five years because of serious stall shortage in the chemical laboratories of WDD.

Table: 3-2 CYPRUS AQUIFERS - SUMMARY OF ANNUAL WATER BALANCES (Average of the period 1991 - 2000)

				REPLENISHMENT x10^{6}m^3/year									OUTFLOW x10^{6}m^3/year				BALANCE	Recom.	Over-	Recom.
				NATURAL RECHARGE:					TOTAL	Artificial	Sea	TOTAL	Extraction	Groundwat.	Sea	TOTAL	(Change in	extraction	pumping	increase
				Rain	River	Return irrigat./ domest.	Ground-water inflow	Dam losses	Natural Recharge	Recharge	Intrusion	RECH-ARGE		outflow	outflow		storage)			in pumping
	Name of the aquifer	Group															x10^{6}m^3/year			
1	Kokkinochoria		LARNAKA/AMMOCHOSTOS	8		2	0.1	0.1	10.2		5.5	15.7	14		1.5	15.5	0.2	8	-6	
2	Aradippou			1.5	0.4				1.9			1.9	0.8	1.1		1.9	0	1		0.2
3	Aradippou Gypsum			0.2	0.3		0.1		0.6			0.6	1			1	-0.4	0.6	-0.4	
4	Kiti - Perivolia			1.2	0.1	0.2		0.2	1.7		0.3	2	1.9		0.1	2	0	0.7	-1.2	
5	Tremithios Riverbed			0.4	0.8				1.2	0.2		1.4	1	0.4	0	1.4	0	1	0	
6	Softades-Zygi (coastal plain)			1.5			0.1		1.6		0.1	1.7	0.4	0	1.3	1.7	0	0.7		0.3
7	Puzis Riverbed			0.1	0.35				0.45		0	0.45	0.3	0	0.2	0.5	-0.05	0.25	-0.05	
8	Xeropotamos (Alaminos) Riverbed			0.1	0.6				0.7		0	0.7	0.5	0	0.2	0.7	0	0.5	0	
9	Pentaschoinos Riverbed			0.2	0.6	0.2			1		0.2	1.2	1	0.1	0.1	1.2	0	0.7	-0.3	
10	Ag. Theodoros Sandstones			-	-	-	-	-	-	-	-	?	-	-	-	?	-	-	-	-
11	Maroni Riverbed			0.1	0.3				0.4			0.4	0.2	0.1	0.1	0.4	0	0.2	0	
12	Vasilikos Riverbed			0.1	0.4				0.5		0.1	0.6	0.3	0.2	0.1	0.6	0	0.3	0	
13	Maroni Gypsum			0.3	0.3		0.3		0.9			0.9	1.3			1.3	-0.4	0.9	-0.4	
14	Skarinou-Klavdia Fault Zone			1			1		2		0	2	1.3	1	0	2.3	-0.3	1	-0.3	
15	Anglisides Lavas			0.3			0.3		0.6		0	0.6	0.4	0.3	0	0.7	-0.1	0.3	-0.1	
16	Pyrgos-Parekklisia		LEMESOS	0.8	0.05	0.05	0.6		1.5		0	1.5	1.8	0	0	1.8	-0.3	1.4	-0.4	
17	Moni Riverbed			0.1	0.05				0.15		0	0.15	0.1	0	0.05	0.15	0	0.1	0	
18	Germasogeia Riverbed			0.3		0.2		1	1.5	5.1	0.1	6.7	6.4	0	0.3	6.7	0	1.4	0	
19	Lemesos Town (Garyllis)			0.4	0.2	7.9	0.4		8.9		1.5	10.4	7.9	0	3	10.9	-0.5	0	-2	
20	Akrotiri			4.2	0.5	1.8	0.2		6.7	3.3	3	13	10.8	2.7	0.5	14	-1	0	-4	
21	Symvoulos Riverbed			0.03		0.02	0.05		0.1		0	0.1	0	0	0.1	0.1	0	0.07		0.7
22	Paramali			0.12	0.05	0.03	0.05		0.25		0.36	0.61	0.6	0	0.02	0.62	-0.01	0.15	-0.45	
23	Avdimou			0.12	0.05	0.02	0.01		0.2		0.15	0.35	0.33	0	0.02	0.35	0	0.15	-0.18	0
24	Pissouri Riverbed			0.15	0.05	0.05	0.05		0.3		0	0.3	0	0.05	0.25	0.3	0	0.2		0.2
25	Pissouri East Gypsum			0.08		0.02	0.05		0.15		0	0.15	0.12	0.05	0	0.17	-0.02	0.1	-0.02	
26	Pissouri West Gypsum			0.2		0.1	0.1		0.4		0	0.4	0.7	0	0	0.7	-0.3	0.4	-0.3	
27	Pafos Coastal Plain		PAFOS	4.8		4.4	0.4		9.6		0.1	9.7	4.5	0.1	5.1	9.7	0	6		1.5
28	Chapotami Riverbed			0.05	0.25				0.3		0.07	0.37	0.03	0	0.37	0.4	-0.03	0.13		0.1
29	Diarizos Riverbed			0.6	7.5	0.4			8.5		0.1	8.6	7	0	1.6	8.6	0	5	-2	
30	Xeropotamos Downstream Riverbed			0.2		0.1	0.1	0.4	0.8	1.1	0.1	2	1.6	0.1	0.3	2	0	0.5	0	
31	Xeropotamos Upstream Riverbed			0.4	3.4	0.1			3.9	0.1	0	4	3.7	0.3	0	4	0	3.5	-0.2	
32	Ezousas Riverbed			0.4	4.2	0.1			4.7		0.1	4.8	3	0	1.8	4.8	0	3	-0.1	
33	Letymvou -Lemona - Polemi Gypsum	Letimvou-Giolou Gypsum aquifer		2.5					2.5		0	2.5	0.9	1.8(*)	0	2.7(*)	-0.2	0.7	-0.2	
34	Stroumpi-Giolou Gypsum																			
35	Pegeia			0.4		0.1	0.3		0.8		0.4	1.2	0.8		0.5	1.3	-0.1	0.3	-0.5	
36	Arodes-Kritou Terra Limestone			0.6			0.2		0.8			0.8	0.4	0.6		0.9	-0.1	0.3	-0.1	
37	Androlikou Limestone			1.5		0.1	0.5		2.1		0.2	2.3	0.6	0.4	1.4	2.4	-0.1	0.3	-0.3	
38	Chrysochou Pliocene			2.(*)		0.3(*)			2.3(*)			2.3(*)	0.0(*)	0.6(*)	1.7(*)	2.3(*)	0	1		1
39	Chrysochou Riverbed			0.4	0.9	0.3	1.2		2.8			2.8	1.3	1.7		3	-0.2	1.1	-0.2	
40	Chrysochou-Gialia Coastal plain			1.4		0.3	0.3		2		0.1	2.1	0.6	0.1	1.5	2.2	-0.1	0.4	-0.2	
41	Mirmikofou Riverbed			0.03	0.1	0.02	0.01		0.16			0.16	0.04		0.14	0.18	-0.02	0.03	-0.01	
42	Limnis Riverbed			-	-	-	-	-	-	-	-	-	0	-	-	-	0	0	0	
43	Argaka - Makounta Riverbed			0.07	0.4	0.05	0.1		0.62		0.05	0.67	0.2		0.5	0.7	-0.03	0.1	-0.1	
44	Xeropotamos Riverbed			0.03	0.11	0.02	0.01		0.17		0.01	0.18	0.04		0.15	0.19	-0.01	0.02	-0.02	
45	Gialia Riverbed			0.05	0.15	0.02	0.01		0.23			0.23	0.05		0.2	0.25	-0.02	0.03	-0.02	
46	Xeros Riverbed			0.05	0.05	0.02	0.03		0.15		0.05	0.2	0.07		0.15	0.22	-0.02	0.05	-0.02	
47	Pomos Riverbed			0.07	0.4	0.05	0.05		0.57			0.57	0.1		0.5	0.6	-0.03	0.1	0	
48	Pachyammos Riverbed			0.03	0.12		0.05		0.2			0.2	0.03		0.18	0.21	-0.01	0.03	0	
49	Pyrgos			0.1	1.1	0.1	0.1		1.4		0.2	1.6	1		0.7	1.7	-0.1	0.6	-0.4	
50	Pentageia	Western Mesaoria aquifers	OCCUPIED	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
51	Morfou																			
52	Karyotis Riverbed																			
53	Atsas Riverbed																			
54	Nicosia-Athalassa Formation	Central Mesaoria aquifers	LEFKOSIA	8	21	3	2		34		0	34	29	11	0	40	-6	22	-7	
55	Elea Riverbed																			
56	Peristerona Riverbed																			
57	Akaki Riverbed																			
58	Pedieos Riverbed																			
59	Gialias Riverbed																			
60	Kato Moni Limestone																			
61	Nisou -Dali Gypsum																			
62	Lemesos - Pafos area	Lefkara and Pachna formation aquifers		30(*)					30(*)		0	30(*)	8	24(*)	?	32(*)	-2	6	-2	
63	Larnaka-Lefkosia area																			
64	Troodos area	Troodos Igneous Massive aquifers		130(*)					130(*)		0	130(*)	13	120(*)	?	133(*)	-3	10	-3	
65	Limassol Forest (Arakapas sequence)																			
66	Pentadaktylos Limestone	OCCUPIED	KERYNEIA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	ANNUAL TOTAL			205.18	44.78	22.07	8.77	1.7	282.5	9.8	12.8	305.1	129.1	166.7	24.6	320.3	-15.3	81.3	-32.5	4.0

(*) = Tentative values

4 CONCLUSIONS AND RECOMMENDATIONS

Water balance estimates of the aquifers are based on the hydrometeorological, hydrological and hydrogeological conditions of the aquifers during the last decade i.e. 1991 to 2000. These are average values that can be used for the development of a long-term water policy. The year-to-year water management must of course be based on the prevailing hydrogeological conditions of each aquifer at the time of study.

Even though the average rainfall (435 mm) over the period under examination is 5% lower than the average rainfall (460 mm) of the 1971-2000 30-year period it was believed that a hypothetical restoration of the rainfall back to its 30-year average will not significantly affect the water balance of the aquifers. It would be more appropriate to use the 1991-2000 value to estimate aquifer water balances (see Chapter 2 'DISCUSSION').

Out of a total of 66 aquifers examined in this study, 49 aquifers, including all the major aquifers in the country, are overexploited. It is estimated that they are overpumped by an overall amount of 32.4 mcm/year. Total recommended extraction is of the order of 81 mcm/year. It is obvious from these figures that groundwater resources in Cyprus are overexploited by 40% of their sustainable extraction.

These figures should form the basis of groundwater management in Cyprus which in turn should form an integral part of the general water policy for the Island.

Map 4-1 is a map of Cyprus which shows the existing situation of the aquifers. It is based on the 'Overpumping' to 'Recommended Extraction' ratio (Overpumping/Recommended Extraction) of each aquifer. This ratio is an indication as to the extent of overexploitation of the aquifer. The map shows the aquifers grouped in 5 classes. The first class includes all aquifers where there is no overpumping and their Overpumping/Recommended Extraction ratio is zero whereas the fourth class includes the aquifers in which 'Overpumping' exceeds 'Recommended Extraction' by more than two times i.e. the ratio of 'Overpumping' to 'Recommended Extraction' is greater than 1. The fifth class is a separate group and it includes the aquifers where extraction can be increased simply by redistributing the amount of extraction over the year.

Overexploitation of the aquifers resulted in the depletion of all inland aquifers and the deterioration of groundwater quality in most of the important coastal aquifers because of sea intrusion. It is vital for the Island's water resources that this trend is checked and reversed without delay. This can be achieved only by a drastic reduction of extraction which in many aquifers should be accompanied by artificial recharge. If these corrective measures are not immediately implemented life giving aquifers will be lost to many future generations.

Immediate action is required to solve the pressing groundwater contamination problems caused by agricultural practices and direct disposal of domestic sewage and other pollutants into the aquifers as well as sea intrusion resulting from the overexploitation of the aquifers.

As mentioned above total Recommended Extraction from all aquifers is estimated to be 81 mcm/year. This estimation is based on the sum of the Water Balances of all aquifers and it does not include the amount of extraction made possible through artificial recharge. It is not in arithmetic balance with the sum of the rest of the elements comprising the Water Balances because Recommended Extraction should

allow for sustainable exploitation of the aquifers. Recovery of the aquifers is, of course, prerequisite for their sustainable exploitation. Water balance values for all aquifers are given in Table 3-2.

Water level and quality observation networks cover only the main and most productive aquifers of the country. About 1100 boreholes in these aquifers are monitored, some of them for several decades. Groundwater for the greatest part of the Island is erratically monitored if at all (Map 4-2 and Map 4-3). Many of the existing networks have not been revised for many years. Most of the data collection and processing programs have been partly or, worse, completely abandoned because of chronic and serious personnel shortages in the Water Development Department.

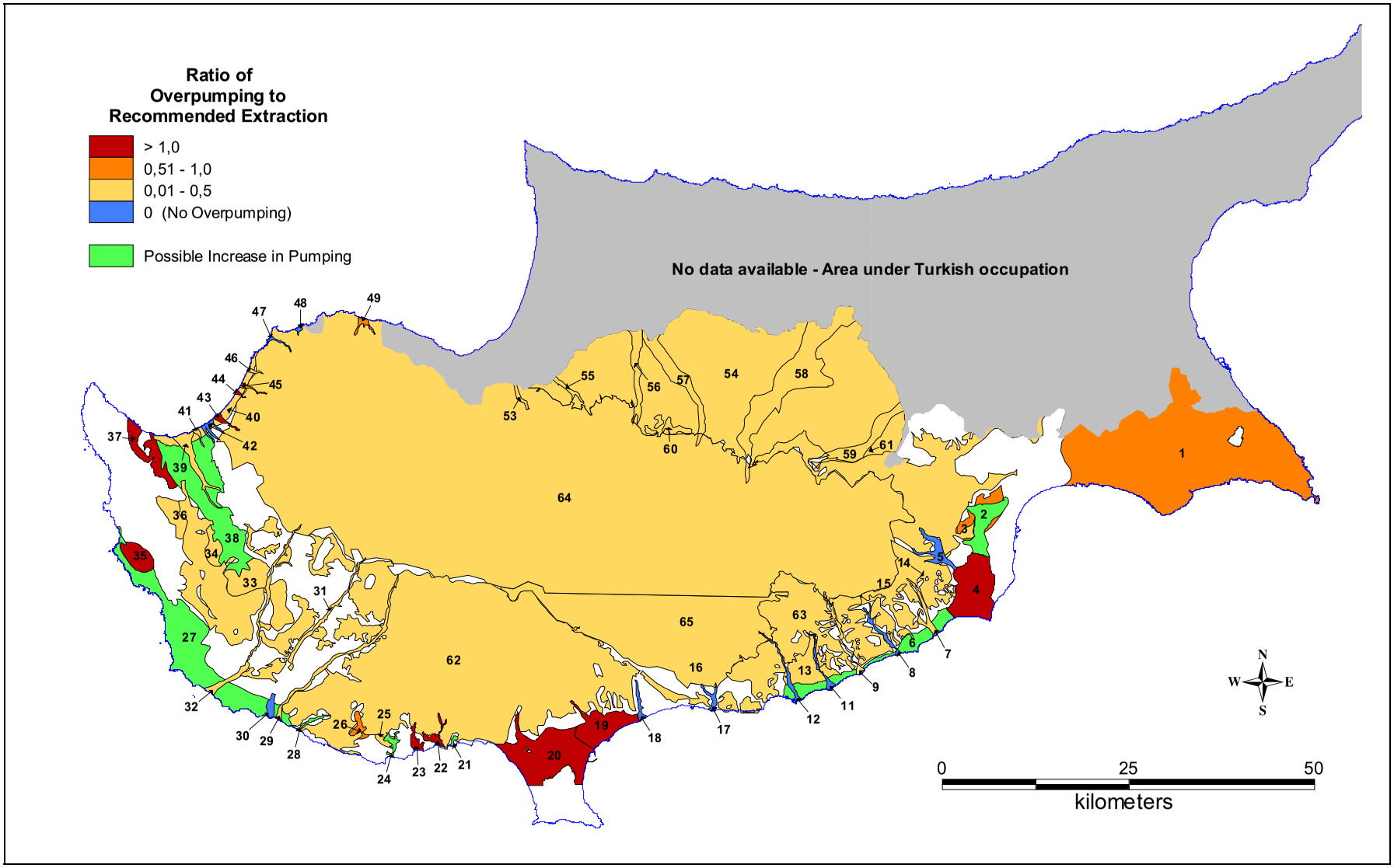
Unfortunately, with few exceptions, no new water extraction surveys were carried out since 1995. Furthermore the old surveys covered only the most important of the large aquifers of the country (Map 4-4). A great number of smaller but locally important aquifers e.g. Troodos Aquifers are not covered by these surveys.

An additional failing of the highly inadequate groundwater monitoring system in place today, is the great lack of information on the number and location of existing boreholes (Map 4-5). However many thousands of existing boreholes have been mapped. These have been plotted on 1:5000 or 1:2500 cadastral maps. The last borehole mapping was carried out as far back as 1995.

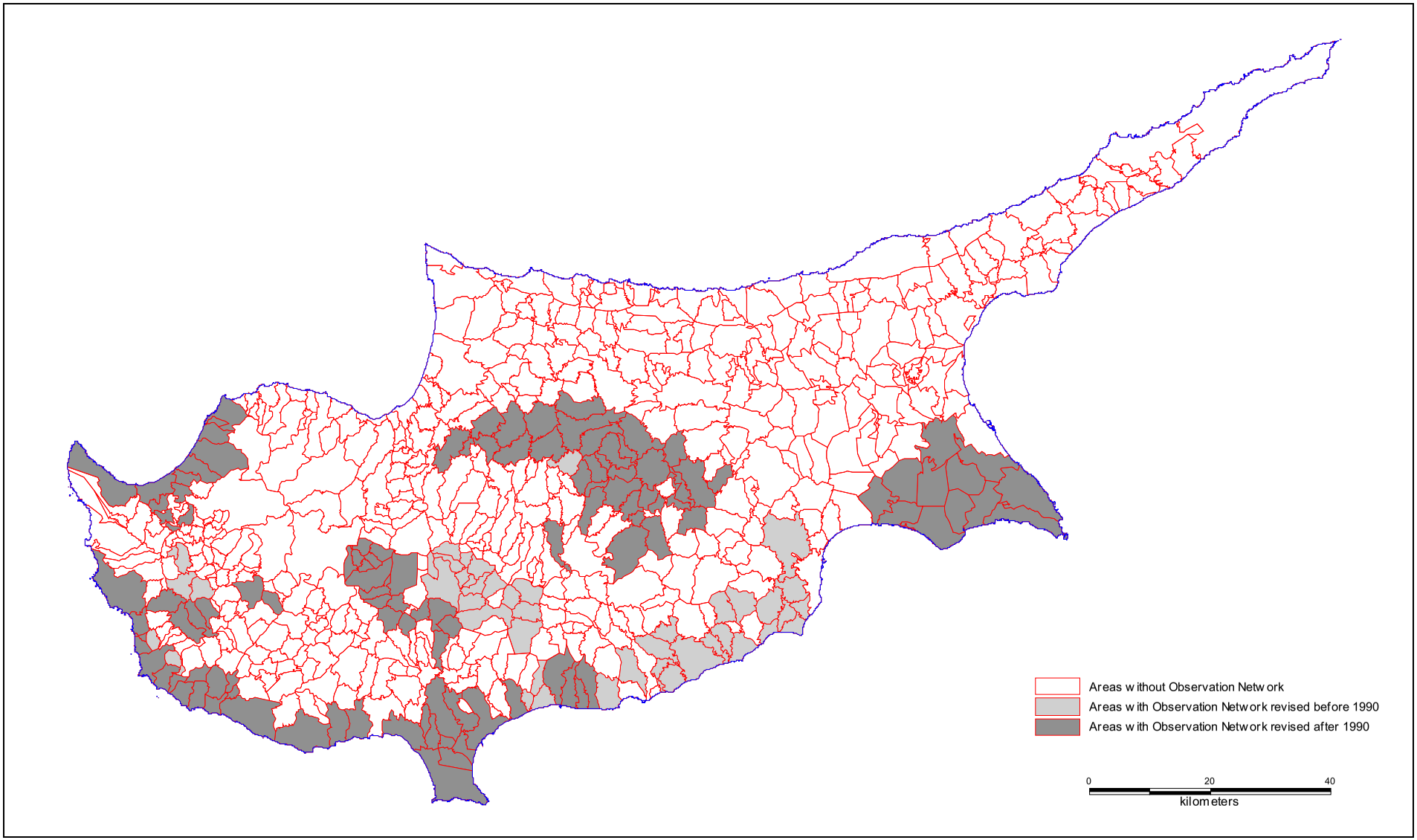
It is obvious that both the system of aquifer monitoring and that of the organization and storing of the data are inadequate and highly inefficient and they are in urgent need of revision. A database compatible with GIS applications should be developed for all aquifer data. The updating of the database should form part of an ongoing process and should be carried out by personnel trained on appropriate software programs. The use of patchy and unreliable data is a guaranteed recipe for inefficient and unreliable groundwater management. A general water policy based on inefficient and unreliable groundwater management will sooner or later prove disastrous to a country’s water resources.

Quantitative and qualitative degradation of most of the aquifers in Cyprus, the constant pressure on the Island’s water resources as well as the country’s aspiration to join the European Union all point towards the need for the establishment of an island-wide groundwater monitoring system which will include rational data collection and data processing programs.

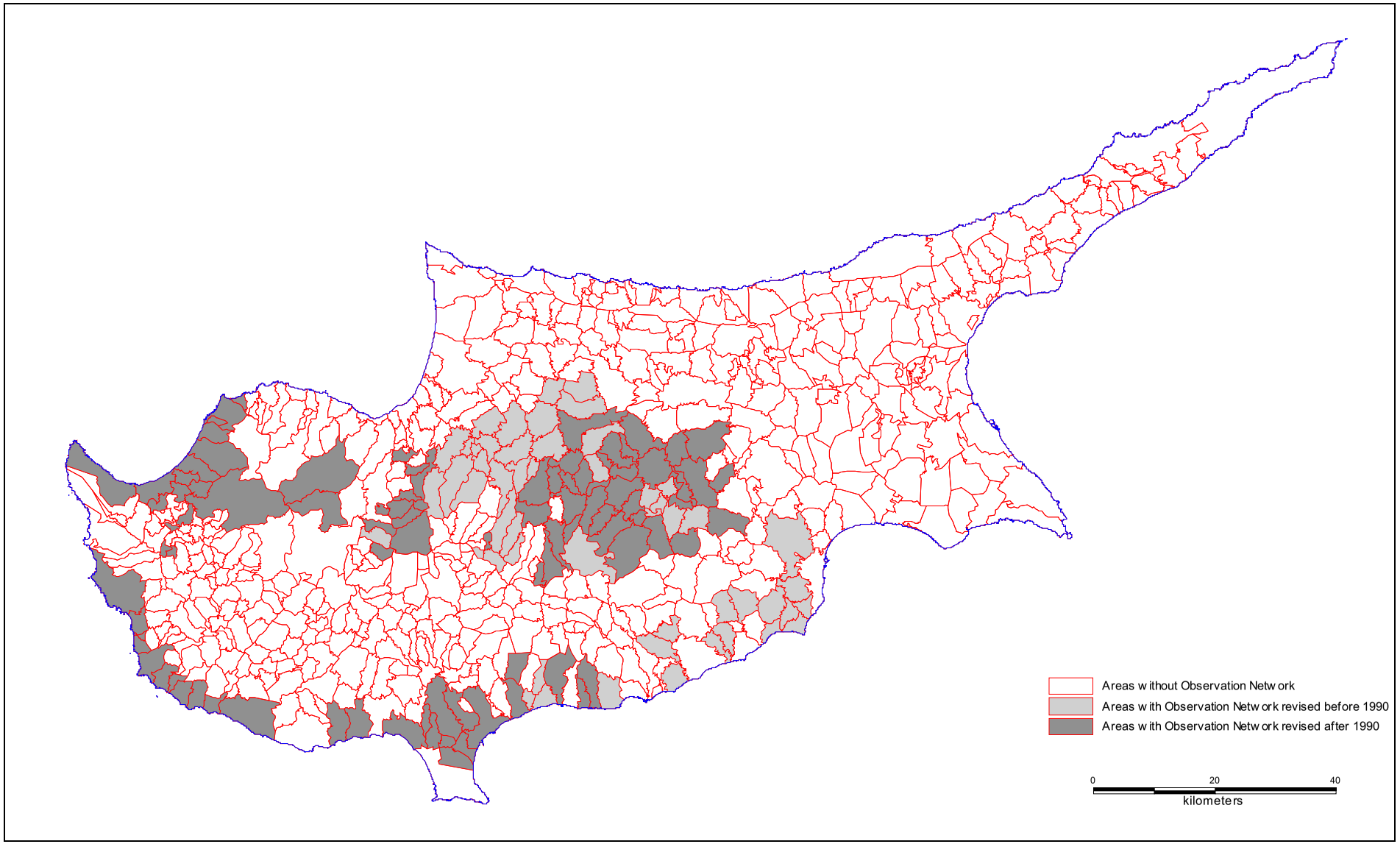
According to the European Union Directives, aquifers in a country should be managed in ways that guaranty adequate quantities of good quality water.



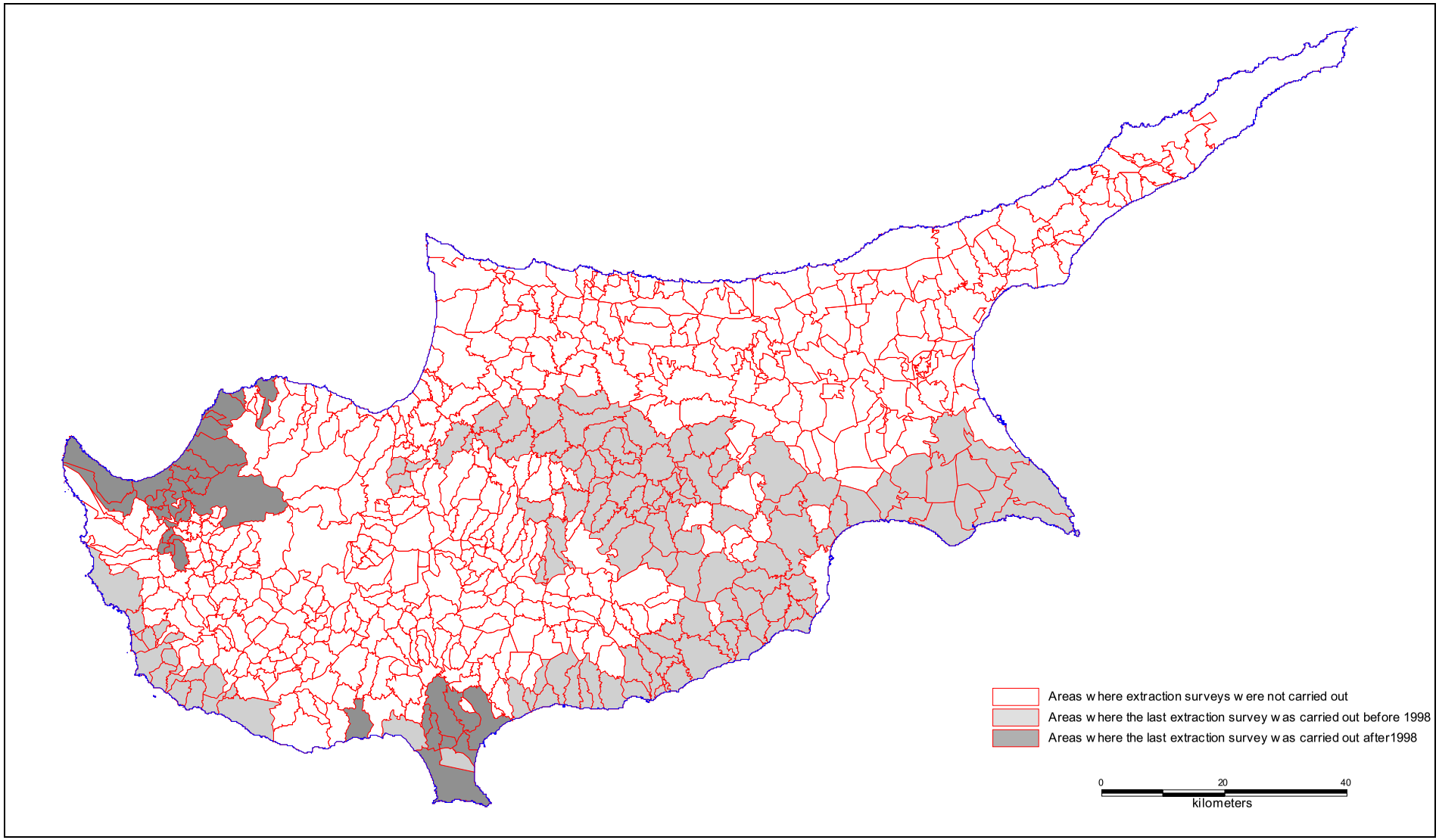
Map 4-1: Aquifers of Cyprus – Ratio of Overpumping to Recommended Extraction



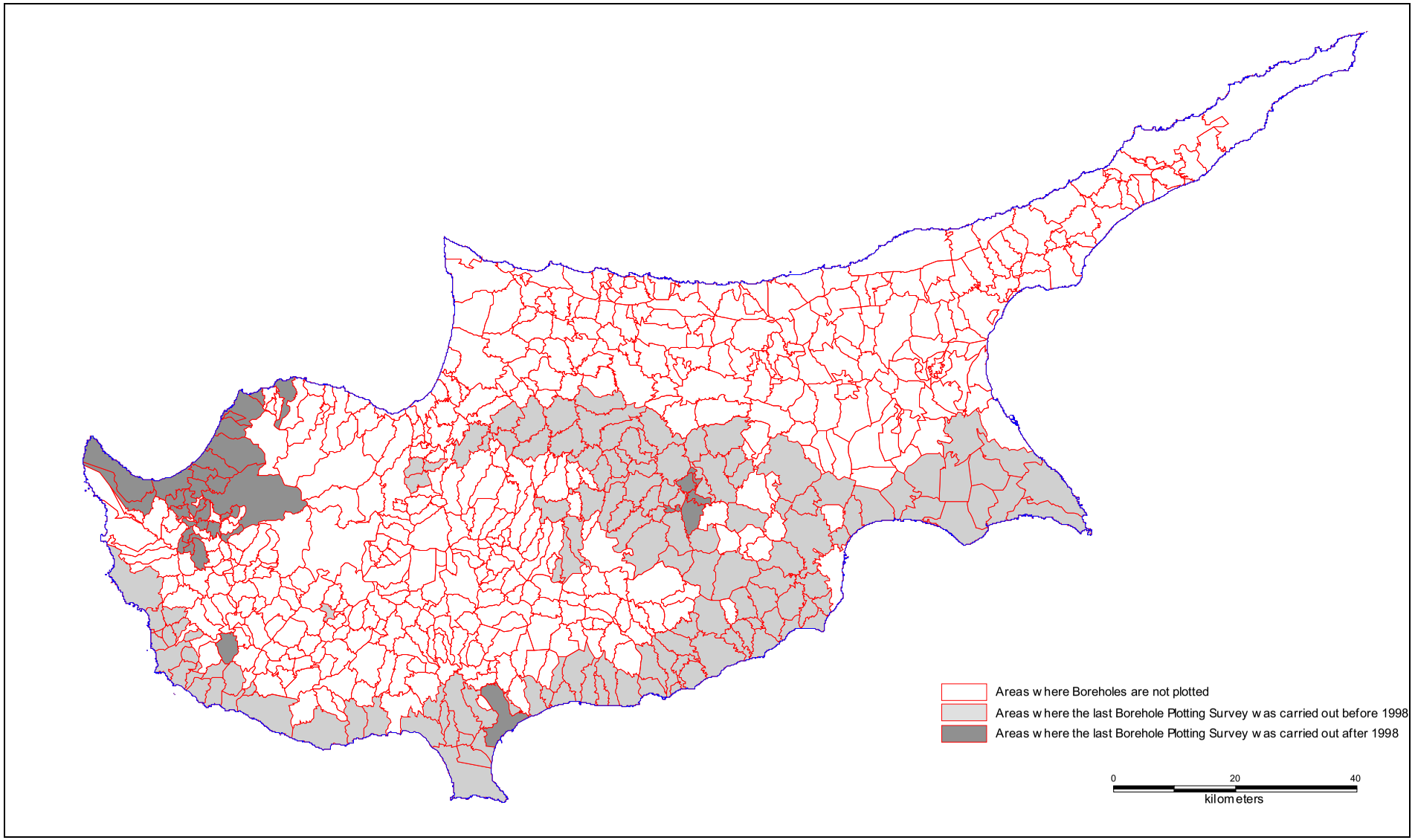
Map 4-2: Areas covered with Groundwater Level Monitoring Network



Map 4-3: Areas covered with Groundwater Quality Monitoring Network



Map 4-4: Groundwater Extraction Surveyed Areas



Map 4-5: Areas with Plotted Boreholes

5 THE AQUIFERS

A list of all Cyprus aquifers together with some of their characteristics is given on Table 5-1. Their location is shown in Map 5-1 and Map 5-2. The first aquifer appearing in the study is the Kokkinochoria (Aquifer Ser. No. 1) at the east of the country. The rest of the aquifers presented follow a clockwise direction around the Island.

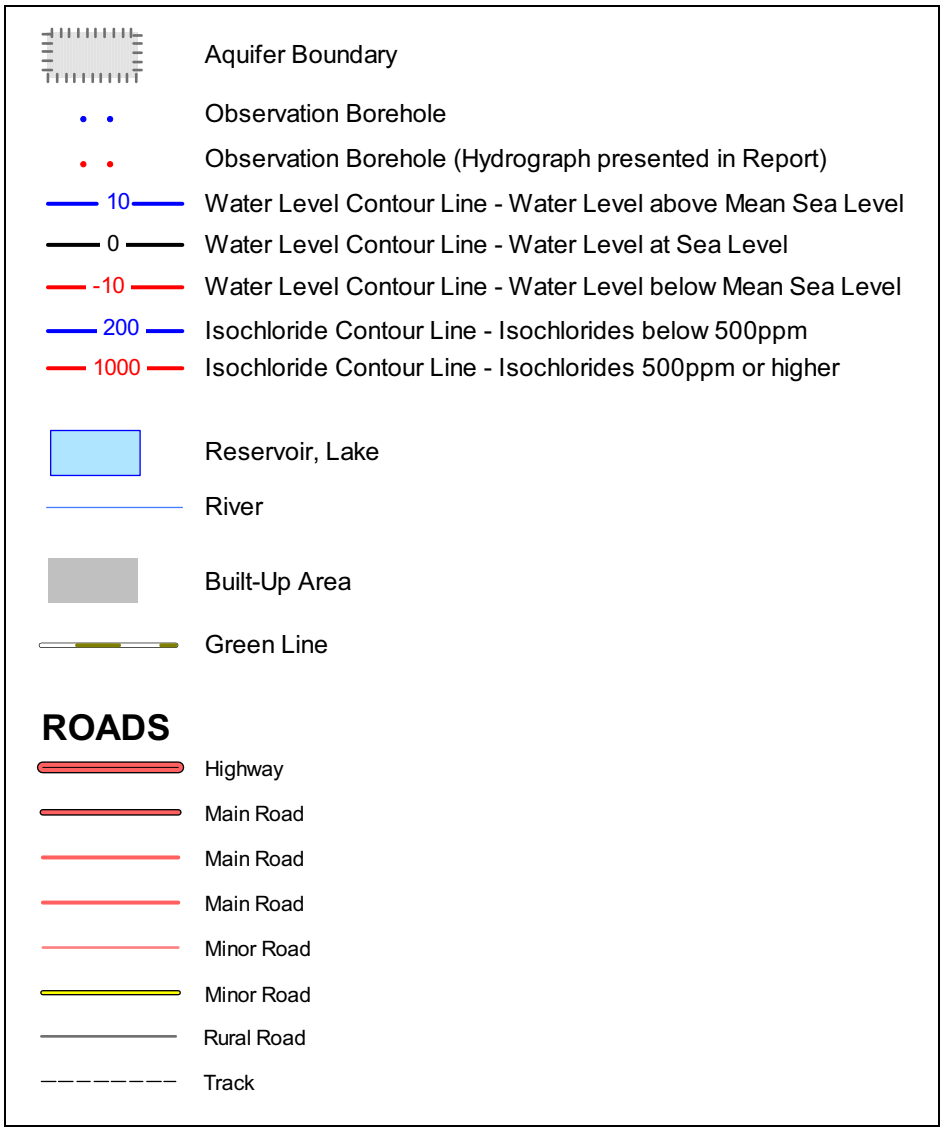
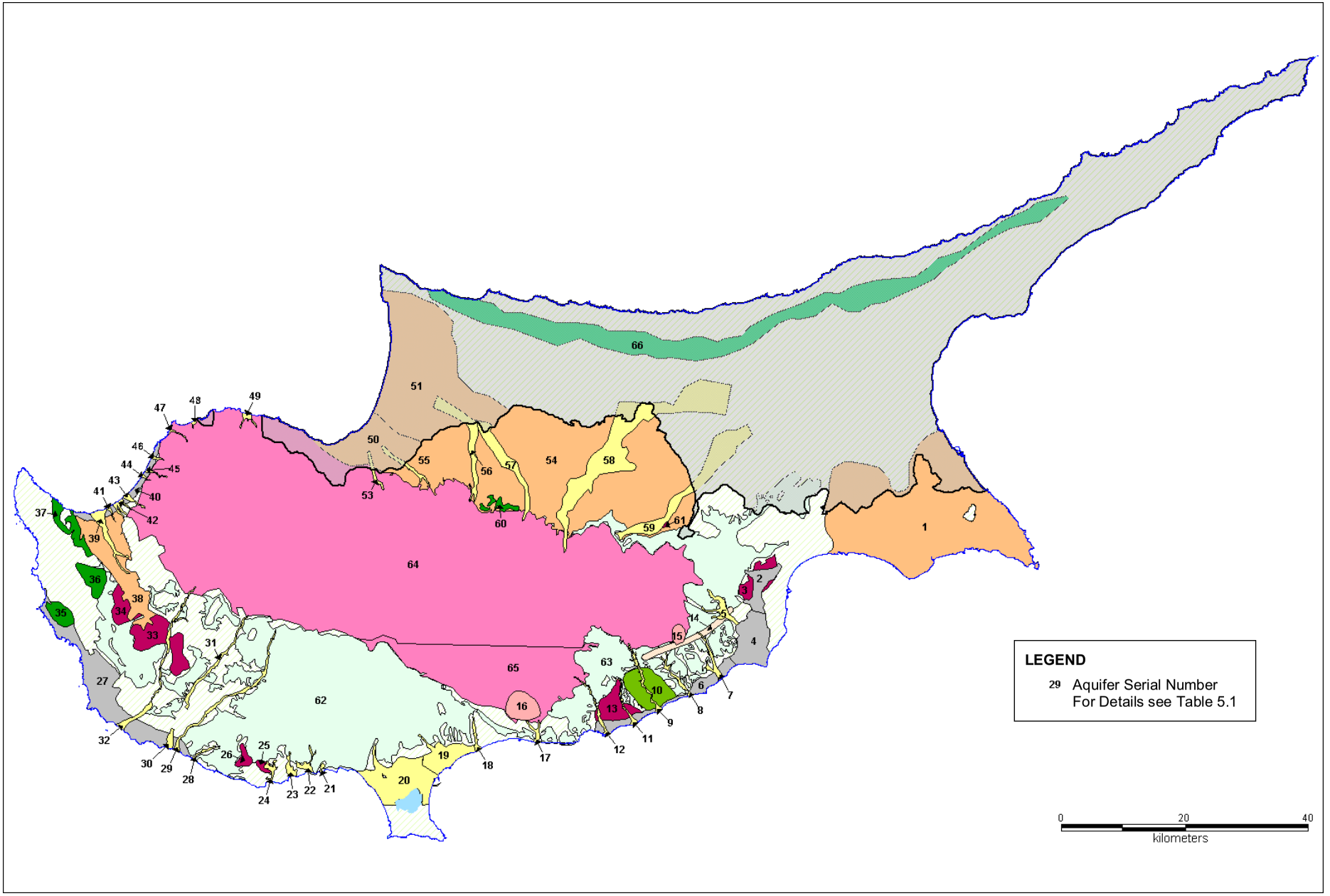
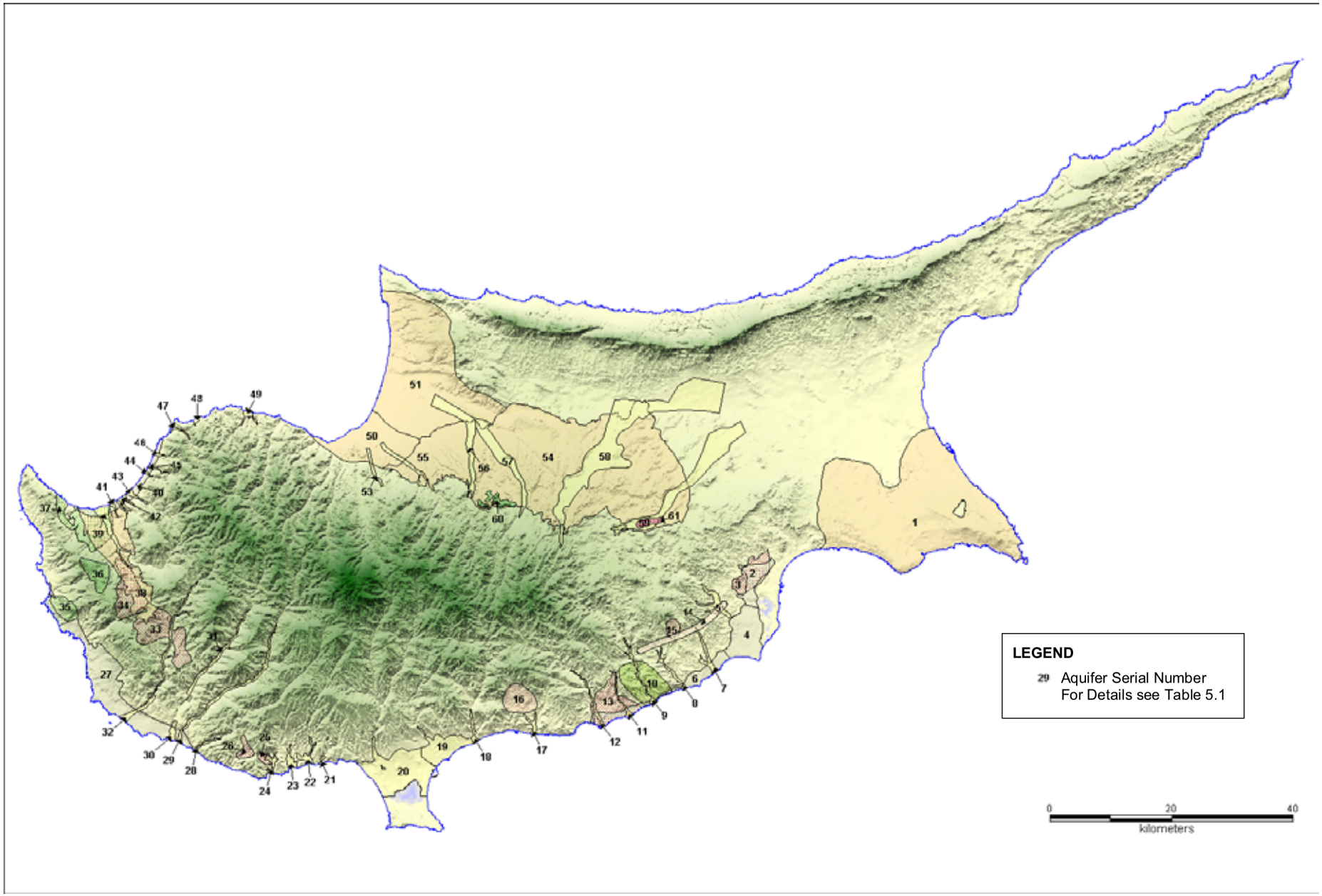


Figure 5-1: Legend for Location Maps, Water Level Contour Maps and Isochloride Contour Maps of Chapter 5 – The Aquifers



Map 5-1: Aquifers of Cyprus



Map 5-2: Aquifers of Cyprus on shaded relief topography (based on Digital Elevation Model)

Table 5-1: Cyprus Aquifers

Ser. No.	NAME	EPOCH/PERIOD FORMATION	LITHOLOGY
1	Kokkinochoria	PLIO/PLEISTOCENE	
		Fanglomerates	Gravel, sand, silt
		Athalassa	Sandstones, sandy marls, conglomerates
		Nicosia	Sandstones, sands, silts, gravel, marl, limestone
		Pachna	Reef limestone (Terra and Koronia)
2	Aradippou	PLIO/PLEISTOCENE	
		Nikosia	
		Terrace Deposits	Calcarenite, Marl, gravel, sand, silt
3	Aradippou Gypsum	MIOCENE (upper)	
		Kalavasos	Gypsum, chalks, marls
4	Kiti – Perivolia	PLEISTO/HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
		Terrace Deposits	Calcarenite, gravel, sand, silt
5	Tremithios Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
6	Softades-Zygi (coastal plain)	HOLOCENE	
		Alluvium/Colluvium	Sand, gravel, silt, clay
7	Puzis Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
8	Xeropotamos (Alaminos) Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
9	Pentaschoinos Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
10	Ag. Theodoros Sandstones	MIOCENE (middle)	
		Pachna	Calcarenite
11	Maroni Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
12	Vasilikos Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
13	Maroni Gypsum	MIOCENE (upper)	
		Kalavasos	Gypsum, chalks, marls
14	Skarinou-Klavdia Fault Zone	EO/OLIGOCENE	
		Lefkara	Fault zone in chalks and Lavas
15	Anglisides Lavas	Lavas	Lavas
16	Pyrgos-Parekklisa	Lavas	Lavas
17	Moni Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
18	Germasogeia Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
19	Lemesos Town (Garyllis)	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay

Ser. No.	NAME	EPOCH/PERIOD FORMATION	LITHOLOGY
20	Akrotiri	PLEISTO/HOLOCENE Alluvium Athalassa	 Sand, gravel, silt Sandstones, sandy marls
21	Symvoulos Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
22	Paramali	PLIO/HOLOCENE Alluvium Nicosia/Athalassa	 Sand, gravel, silt Sandstones, sands, silts, gravel, marl
23	Avdimou	PLIO/HOLOCENE Alluvium Nicosia/Athalassa	 Sand, gravel, silt Sandstones, sands, silts, gravel, marl
24	Pissouri Riverbed	PLIO/HOLOCENE Alluvium	 Sand, gravel, silt
25	Pissouri East Gypsum	MIOCENE (upper) Kalavasos	 Gypsum, chalks, marls
26	Pissouri West Gypsum	MIOCENE (upper) Kalavasos	 Gypsum, chalks, marls
27	Pafos Coastal plain	PLEISTOCENE Terrace Deposits	 Calcarenite, marl, gravel, sand, silt
28	Chapotami Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
29	Diarizos Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
30	Xeropotamos Downstream Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
31	Xeropotamos Upstream Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
32	Ezousas Riverbed	HOLOCENE Alluvium	 Sand, gravel, silt, clay
33	Letymvou –Lemona – Polemi Gypsum	MIOCENE (upper) Kalavasos	 Gypsum, chalks, marls
34	Stroumpi-Giolou Gypsum	MIOCENE (upper) Kalavasos	 Gypsum, chalks, marls
35	Pegeia Limestone	MIOCENE (lower) Pachna	 Terra Limestone
36	Arodes-Kritou Tera Limestone	MIOCENE (lower) Pachna	 Terra Limestone
37	Androlikou Limestone	MIOCENE (lower) Pachna	 Terra Limestone
38	Chrysochou Pliocene	PLIO/PLEISTOCENE Nicosia/Athalassa	 Sandstones, sands, silts, gravel, marl

Ser. No.	NAME	EPOCH/PERIOD FORMATION	LITHOLOGY
39	Chrysochou Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
40	Chrysochou-Gialia Coastal plain	PLEISTO/HOLOCENE	
		Fanglom./Terrace Dep./Alluvium	Calcarenite, marl, gravel, sand, silt
41	Mirmigofou Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
42	Limnis Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
43	Argaka - Makounta Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
44	Xeropotamos Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
45	Gialia Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
46	Xeros Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
47	Pomos Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
48	Pachyammos Riverbed	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
49	Pyrgos	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
50	Pentageia (see Western Mesaoria Aquifers)	PLEISTO/HOLOCENE	
		Fanglomerates/Alluvium	Calcarenite, marl, gravel, sand, silt
51	Morfou (see Western Mesaoria Aquifers)	PLEISTO/HOLOCENE	
		Fanglomerates/Alluvium	
		Athalassa	Calcarenite, marl, gravel, sand, silt
52	Karyotis Riverbed Aquifer (see Western Mesaoria Aquifers)	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
53	Atsas Riverbed Aquifer (see Western Mesaoria Aquifers)	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay
54	Nicosia-Athalassa Formation (see Central Mesaoria Aquifers)	PLIO/PLEISTOCENE	
		Fanglomerates	Gravel, sand, silt
		Athalassa	Sandstones, sandy marls, conglomerates
		Nicosia	Sandstones, sands, silts, gravel, marl, limestone
55	Elea Riverbed Aquifer (see Central Mesaoria Aquifers)	HOLOCENE	
		Alluvium	Sand, gravel, silt, clay

Ser. No.	NAME	EPOCH/PERIOD FORMATION	LITHOLOGY
56	Peristerona Riverbed Aquifer (see Central Mesaoria Aquifers)	HOLOCENE Alluvium	Sand, gravel, silt, clay
57	Akaki Riverbed Aquifer (see Central Mesaoria Aquifers)	HOLOCENE Alluvium	Sand, gravel, silt, clay
58	Pedieos Riverbed Aquifer (see Central Mesaoria Aquifers)	HOLOCENE Alluvium	Sand, gravel, silt, clay
59	Gialias Riverbed Aquifer (see Central Mesaoria Aquifers)	HOLOCENE Alluvium	Sand, gravel, silt, clay
60	Kato Moni Limestone Aquifer (see Central Mesaoria Aquifers)	MIOCENE (lower) Pachna	Koronia reef Limestone
61	Nisou -Dali Gypsum Aquifer (see Central Mesaoria Aquifers)	MIOCENE (upper) Kalavasos	Gypsum, chalks, marls
62	Lemesos - Pafos area (see Lefkara and Pachna Formation Aquifers)	PALAEOGENE - MIOCENE Pachna Formation Lefkara Formation	Chalks and marls
63	Larnaka-Lefkosia area (see Lefkara and Pachna Formation Aquifers)	PALAEOGENE - MIOCENE Pachna Formation Lefkara Formation	Chalks and marls
64	Troodos area (see Troodos Igneous Massif Aquifers)	UPPER CRETACEOUS	Pillow Lavas Diabase Gabro and other Serpentinite/Harsburgite
65	Limassol Forest (Arakapas sequence) (see Troodos Igneous Massif Aquifers)	UPPER CRETACEOUS	Pillow Lavas Diabase Gabro and other Serpentinite/Harsburgite
66	Pentadaktylos Limestone	PERMIAN - CRETACEOUS Kantara, Dhikomo, Sykhari, Hilarion	Limestone

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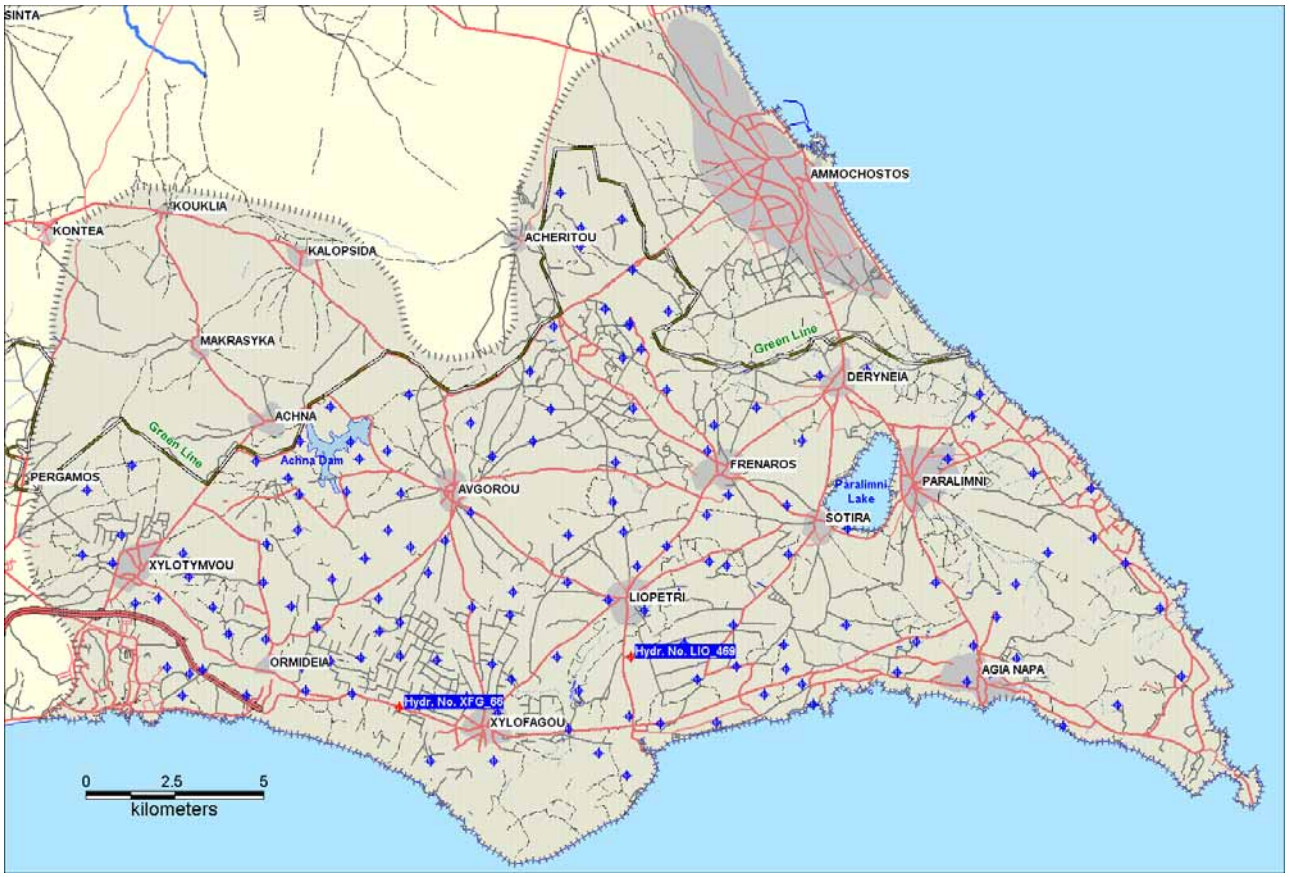
KOKKINOCHORIA AQUIFER

INTRODUCTION

Kokkinochoria is the largest aquifer in eastern Cyprus. It used to be one of the most productive aquifers on the island. However, extensive overpumping during the last 40 to 45 years has resulted in a dramatic depletion of this aquifer. Water levels in the aquifer within 2 km from the coast have dropped from 0 m a.m.s.l in the late 1950's to –50 m a.m.s.l. It should be noted that in the last few years water levels in coastal areas have risen because of sea intrusion. The amount of groundwater mined from the aquifer during this period is roughly estimated to be around 350 million m³ (mcm).



Kokkinochoria Aquifer - Location Map

The Kokkinochoria region is a world renown early-potato producing area. In the late 1970's early-potatoes were very important to the island's economy. For this reason and because of the fact that the aquifer was already depleted a sizeable part of the Kokkinochoria area was included in the Southern Conveyor Project irrigation areas. However tourist development and ever-increasing water deficits in the area greatly reduced both the number of farmers and the area under irrigation.

The North extension of this aquifer has not been included in the present study because it has been under Turkish occupation and hence inaccessible for monitoring and data collection since the1974 Turkish Invasion of the Island.

GEOLOGY

The impervious base of the aquifer consists mainly of Palaeogene marls, chalky marls and upper Cretaceous bentonitic clays.

The oldest sediments of the aquifer are the lower Miocene reef limestone, developed around Xylophagou and Paralimni villages. Plio/Pleistocene sediments consisting of sandstones, sands, gravels, conglomerates, silts, marls and all their possible combinations appear over the older sediments. The thickness of the aquifer at its deepest parts in Xylophagou, Liopetri and Phrenaros areas is 100 to 130 m.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 3 months, since 1964, 156 boreholes.
QUALITY OBSERV. NETWORK: No, last sampling in 1994, 80 boreholes (Ionic Analysis)
ARE ALL BOREHOLES PLOTTED? : No, last update over the period 1975-1980
EXTRACTION SURVEY: Last survey in 1978.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

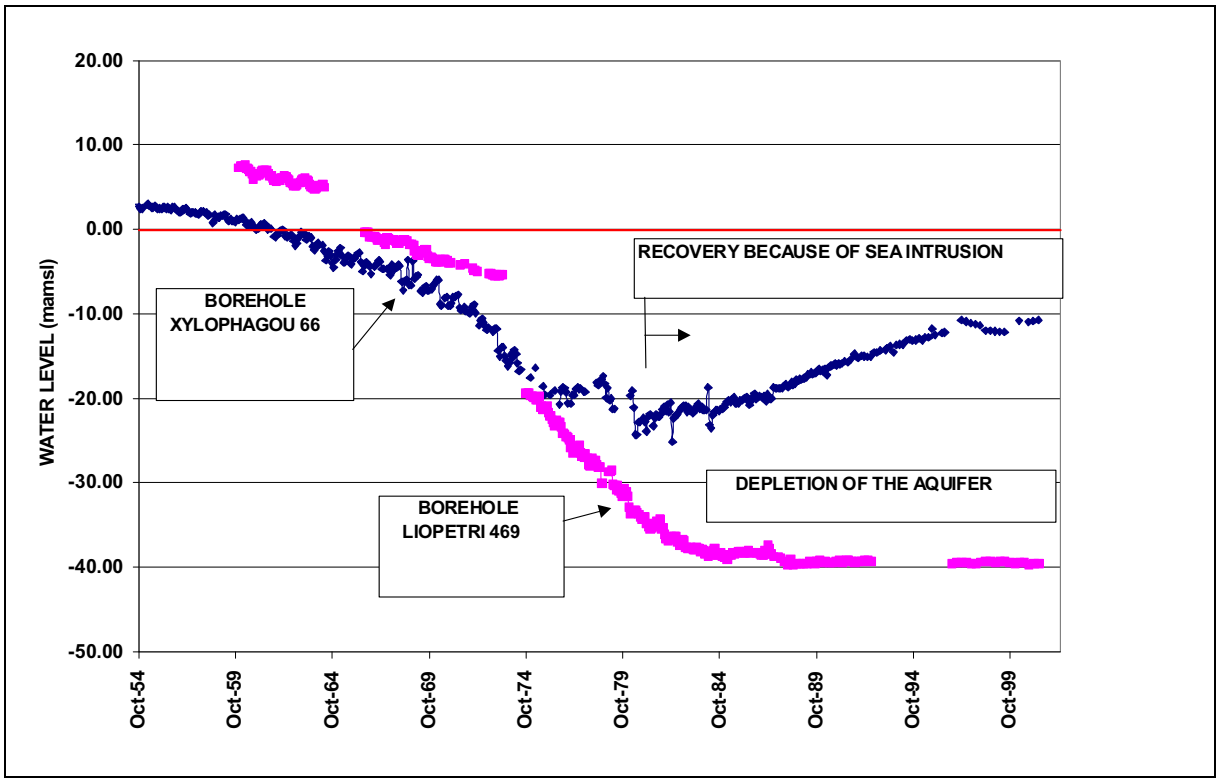
AREA OF THE AQUIFER (Under Government control): 295 Km², WIDTH: 13 km, Length: 23 km, Outcrop Area: 295 Km².
AVERAGE RAINFALL: Period 1990-2000: 300 mm, (Period 1970-2000: 330 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 5 m/day, from 1 to 25 m/day
Average S = 7 %, from 0.1 to 15 %
BOUNDARIES: East and South: Sea, permeable, **West**: Impermeable,
North: Occupied area, Variable Head, General direction of flow: South
CONFINED/UNCONFINED: mainly unconfined, semiconfined in places.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Medium (deep to very deep water table, presence of semi to impermeable layers).

HYDROGEOLOGICAL CONDITIONS TODAY

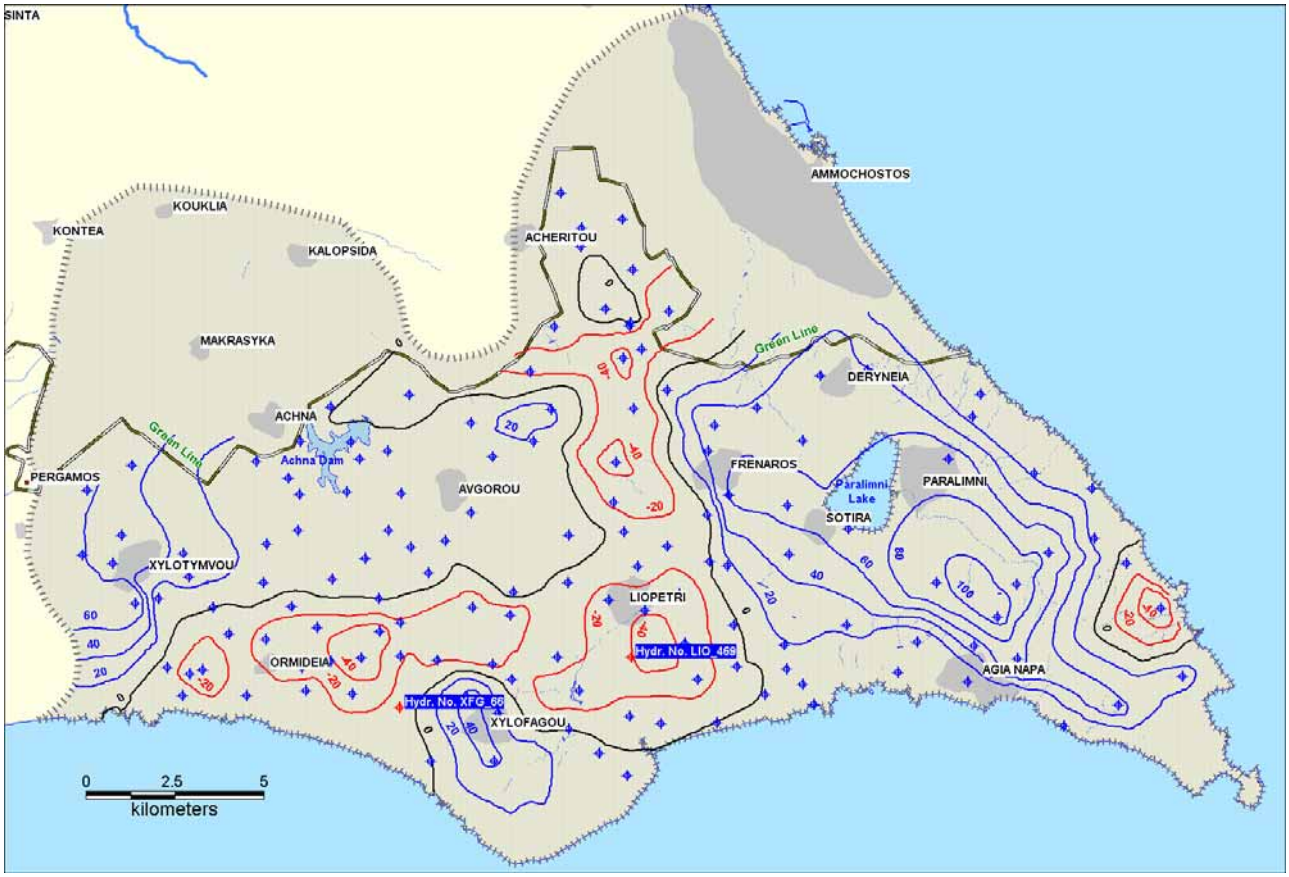
The most productive parts of the aquifer (Ormidhia, Xylophagou, Liopetri, Phrenaros), have been sea intruded and abandoned since the early 1980s. The less productive parts are already depleted with dramatically reduced borehole yield.

It is estimated that over 5000 boreholes operate in the area today. Yields of these boreholes have reduced from an average of 10 m³/hour in 1980 to 1 to 2 m³/hour in 2000. Boreholes with yields of 2-3 m³/day are still in operation. In effect the farmers are rapidly and inexorably drying out the aquifer. A rough estimate of the average annual extraction during the past 10 years is estimated to be around 12 to 14 mcm.

Low rainfall during the last decade has resulted in substantially reduced natural recharge to the aquifer. The situation was made worse by the fact that a great part of this recharge is lost once it reaches the sea-intruded areas. The only sources of aquifer recharge are rainfall and return flow from irrigation. No rivers exist in the area.



Hydrograph of boreholes Xylophagou 66 and Liopetri 469 (Elev. 52.61 and 30.74m amsl)



Kokkinochoria Aquifer - Water Level (m amsl) Contour Map September 2000

HISTORIC GROUNDWATER BALANCE

Average water balance 1963 – 1978 (15 years). SCP Feasibility Study, Result of a mathematical model applied in an area of 172 km².
Average rainfall: 330 mm

Replenishment (mcm/year)						**Outflow (mcm/year)**		
	Rainfall	Return irrigat.	Subsurf. inflow	Sea intrusion	TOTAL	Abstraction	Subs. Outflow	TOTAL
Average	8.2	4.7	1.1	2.9	16.9	27.1	0.4	27.5

Balance –10.6 mcm/year
Change in storage (1963 – 1975): - 165 mcm (Average 11 mcm/year).

GROUNDWATER BALANCE TODAY

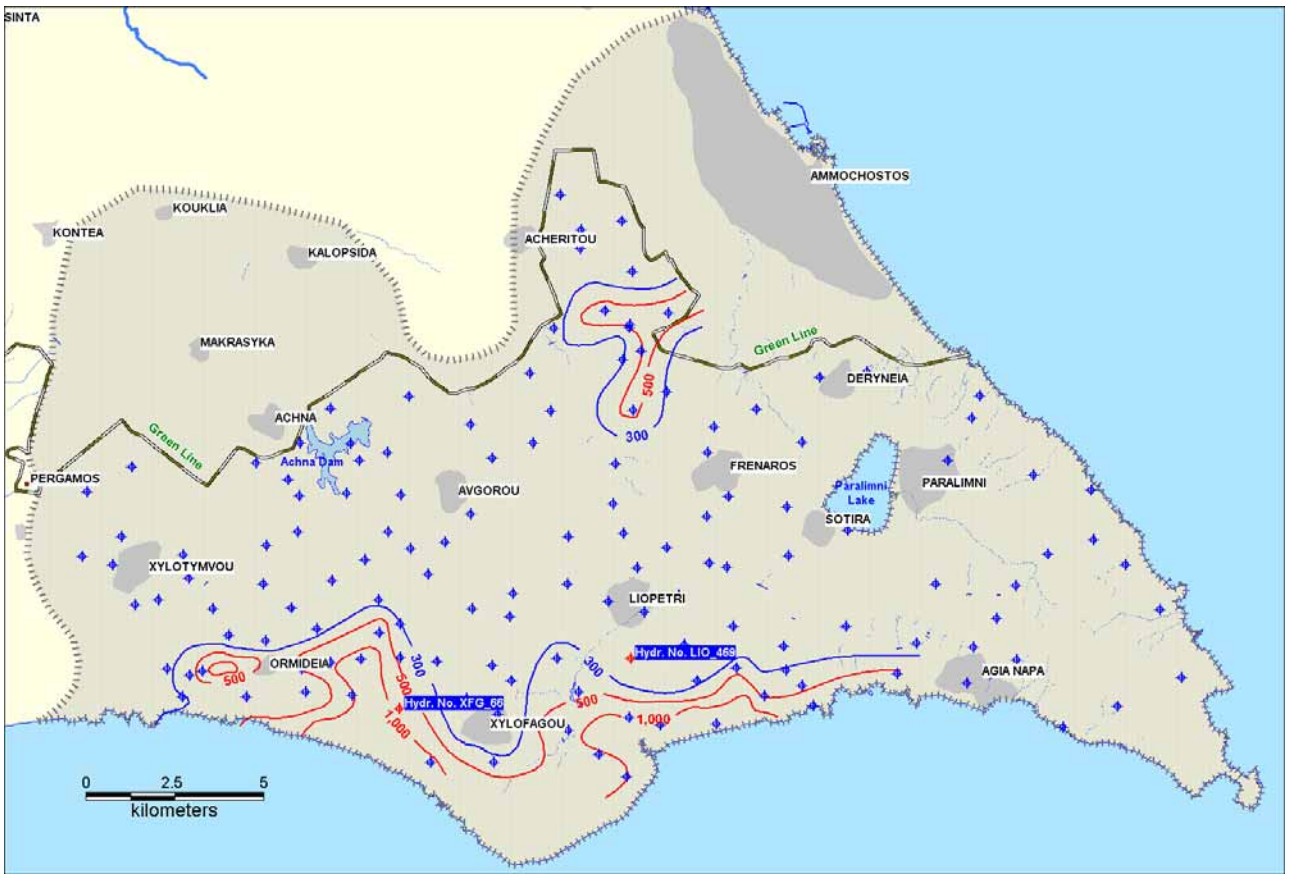
Period 1991 – 2000. Accuracy of estimates: Good. Aquifer's area: 295 km².
Average rainfall: 300mm.

Replenishment (mcm/year)							
	Rainfall	Return irrigat.	Return Domestic	Return Dam Loss	Subsurf. inflow	Sea intrusion	TOTAL
Average	8	0.5	1.5	0.1	0.1	5.5	15.7

Outflow (mcm/year)		
Abstraction	Subs. Outflow	TOTAL
14	1.5	15.5

Fresh water balance: **- 5.3** mcm/year
General Balance: **+ 0.2** mcm/year
Change in storage (1991 – 2000): **~ 0** mcm (based on water level changes averaged over the entire aquifer area)
Recommended extraction: **8** mcm/year (only from parts of the aquifer that are not susceptible to sea intrusion).

It should be noted that, when sea intrusion and sustainability of the aquifer are taken into consideration, the real deficit in fresh water in the aquifer is greater than 5.3 mcm/year.



Kokkinochoria Aquifer - Isochloride (ppm) Contour Map June 1994

ARADIPPOU AQUIFER

INTRODUCTION

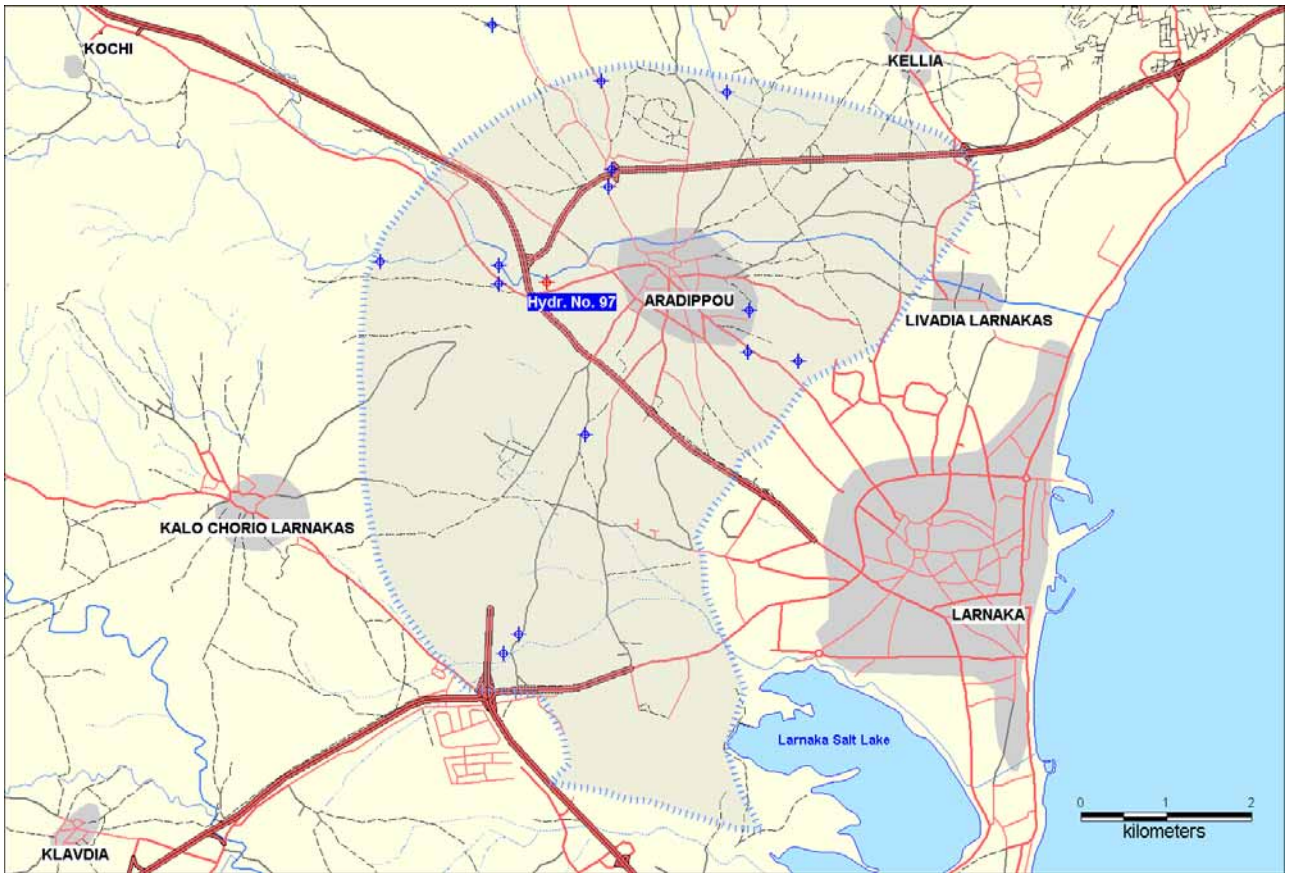
Aradippou is a phreatic aquifer situated northwest of Larnaka town, in a relatively flat area. It extends eastwards to the saline aquifer of the Larnaka town and Livadia village. Even though it is an important aquifer locally it has yet to be studied properly. It is of local importance aquifer, not very well studied. Many local farmers exploit it periodically for private irrigation. The aquifer overlies the Aradippou Gypsum aquifer. The relation and the interconnection of these two aquifers are not well known.

The main sources of the aquifer's recharge are rainfall and flows of small rivers in the area. High intensity rainfalls are not uncommon in the area and even though they cause problems of flooding they at the same time recharge the aquifer. It is assumed that a part of this recharge penetrates into the deeper gypsum aquifer.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls, chalks and chalky marls of the Pachna formation.

The aquifer consists of Plio/Pleistocene silts, silty sands and silty gravels. In the Aradippou riverbed some thin alluvial deposits are present. The thickness of the aquifer varies from few a meters to 25 meters. The average thickness is estimated to be around 10 meters.



Aradippou Aquifer - Location Map

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, since 1975, 9 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 6 months, only Cl, 9 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1975.
EXTRACTION SURVEY: Last survey in 1996

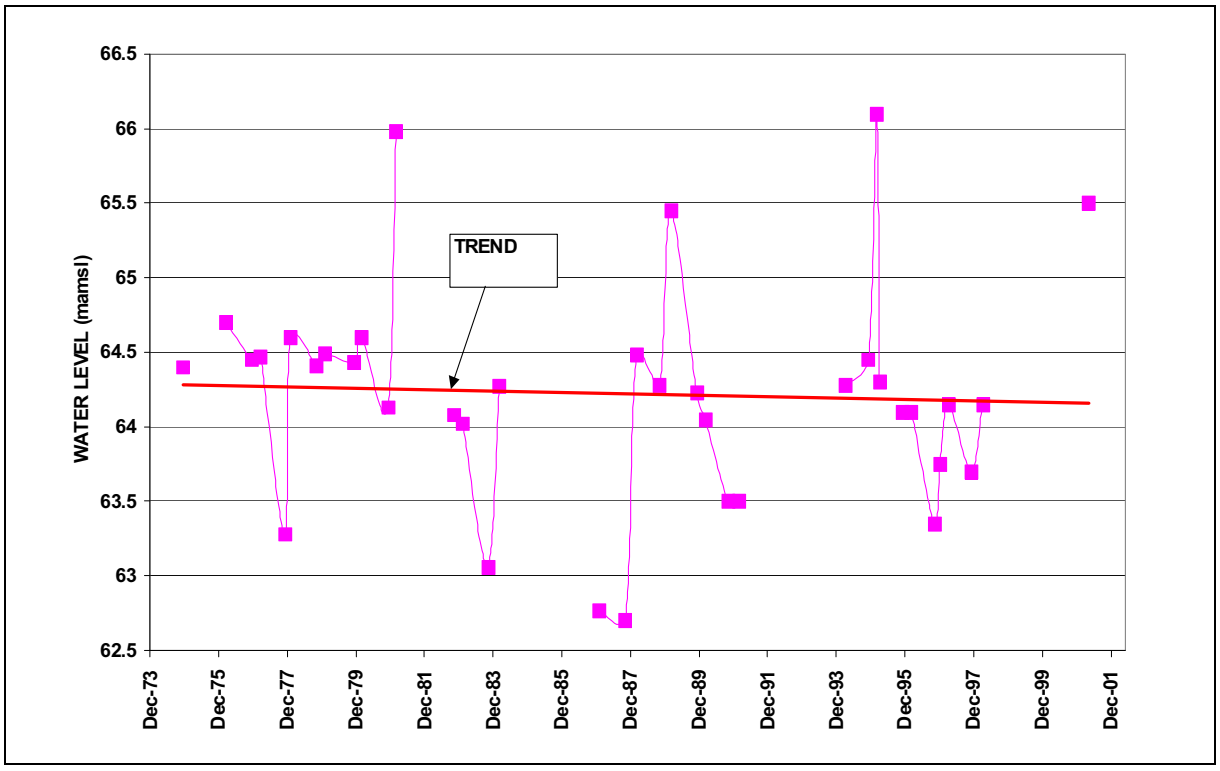
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 35 Km², Width: 7 km, Length: 5 km, Accuracy of Delineation: Poor, Outcrop Area: 35 Km².
AVERAGE RAINFALL: Period 1990-2000: 350 mm, (Period 1970-2000: 380 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 5 m/day (estimated).
Average S = 2 - 3% (estimated).
BOUNDARIES: East: Permeable, **West:** Impermeable**, North and South:** Permeable**.**
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

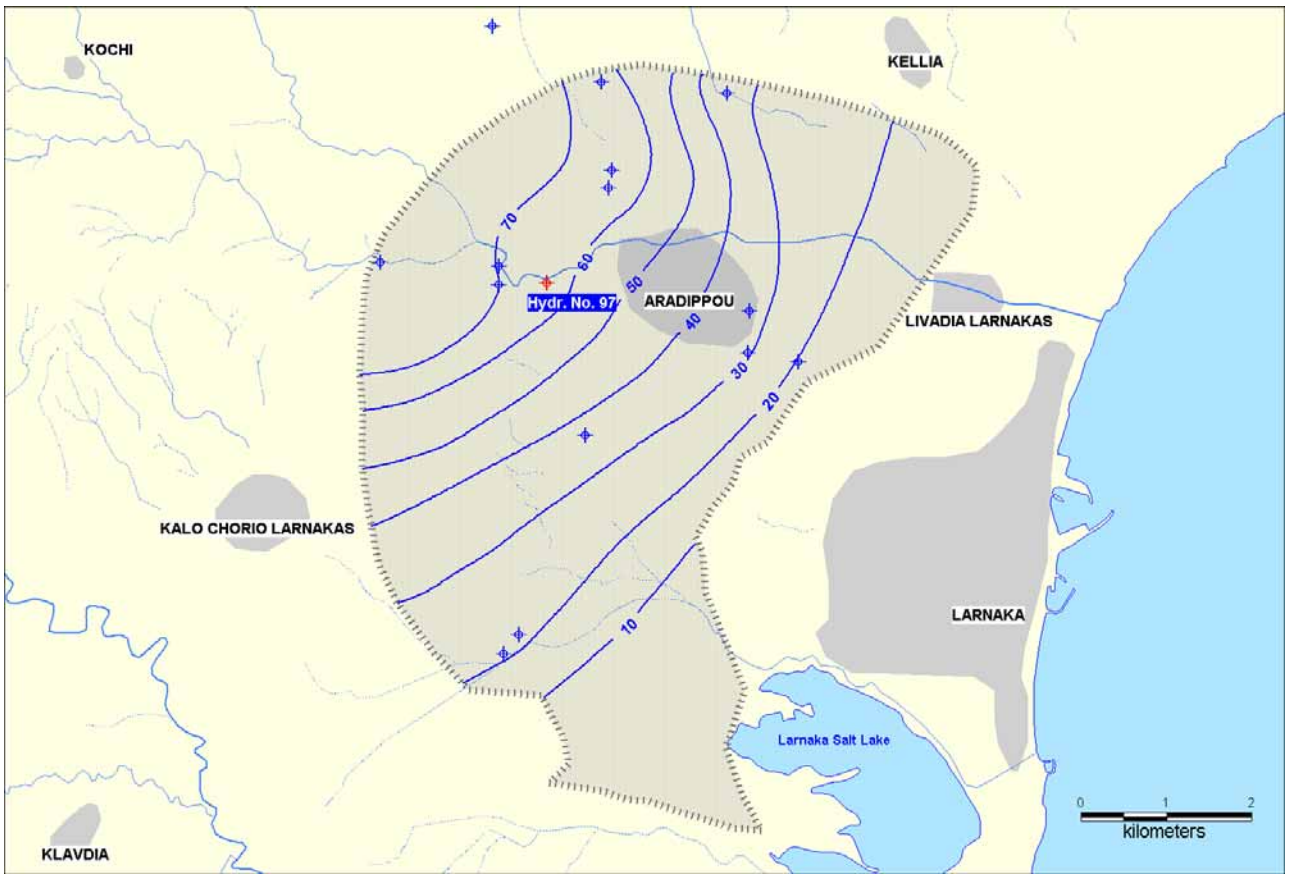
HYDROGEOLOGICAL CONDITIONS TODAY

Reduced aquifer recharge due to low rainfall and low river flows during the last decade, caused depletion problems in the aquifer. Water level fluctuation depends directly on the amount of rainfall. The general groundwater flow direction is towards the Larnaka town. This water recharges the local saline aquifer.

Many of the exploitation boreholes penetrate both the upper phreatic and the gypsum aquifer. This fact makes both the calculation of extraction from each aquifer and the interpretation of the boreholes network observations very difficult. 160 to180 boreholes operate in both aquifers extracting 1.8 mcm per year. Approximately 0.8 mcm of this amount is extracted from the phreatic aquifer.



Hydrograph of borehole 97 (Appr. Elev. 70 m amsl)



Aradippou Aquifer - Water level (m amsl) contour map, April 2001

HISTORIC GROUNDWATER BALANCE

Not available.
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Area of the aquifer: 35 Km². Average rainfall: 350mm.

Replenishment (mcm/year)			
	Rainfall	River Recharge	Total
Average	1.5	0.4	1.9

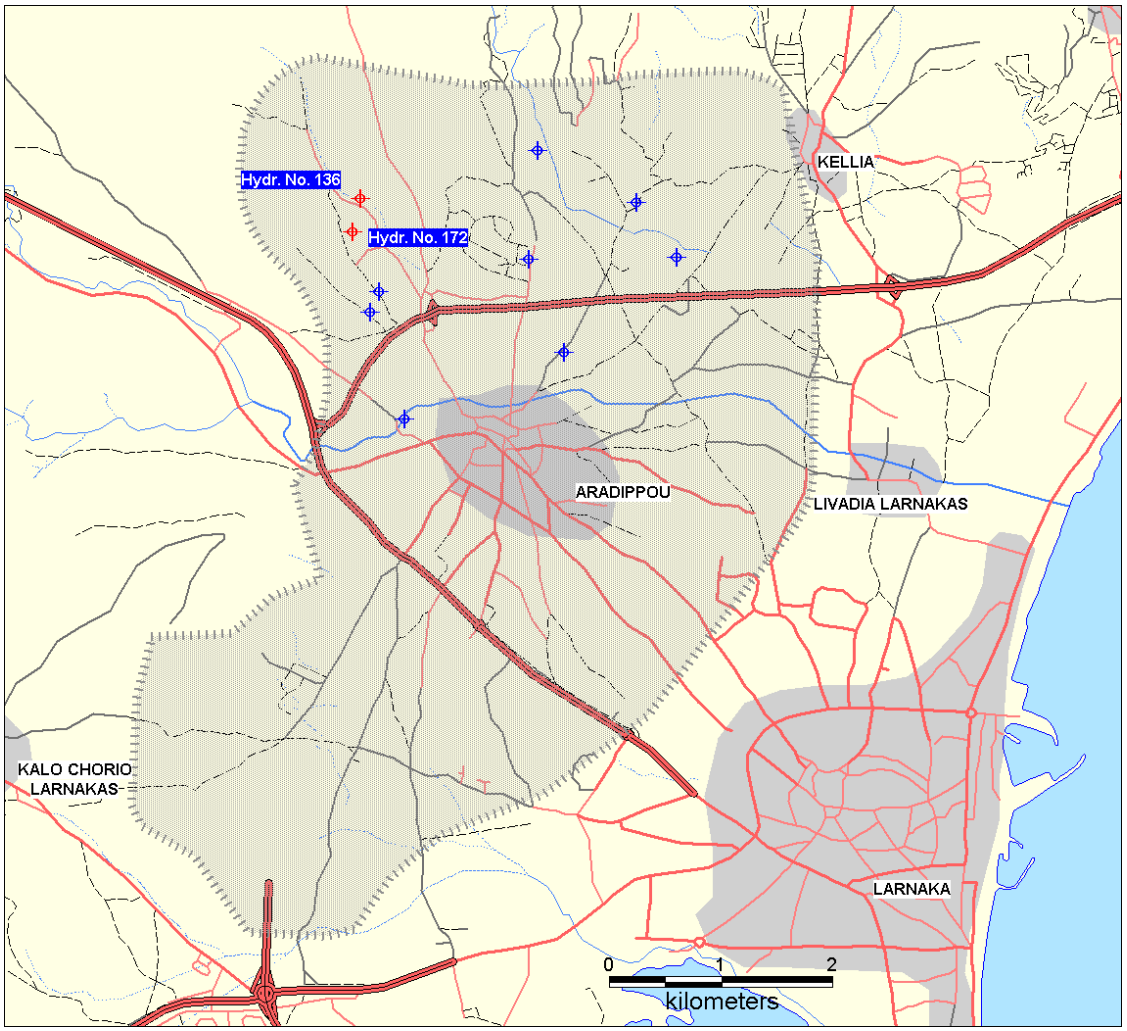
Outflow (mcm/year)				
	Abstraction (irrigation)	To gypsum aquifer	To Larnaka aquifer	Total
Average	0.8	0.1	1.0	1.9

Balance: **0.0** mcm/year
An increase of extraction during the spring period will result in a significant increase in the yield of the aquifer.
Recommended average extraction: **1.0** mcm/year

ARADIPPOU GYPSUM AQUIFER

INTRODUCTION

The Aradippou Gypsum Aquifer is a very important local aquifer in the Aradippou area particularly for the farmers and stockbreeders who use the water for fodder production. The aquifer is situated Northwest of Larnaka town. It is a semiconfined aquifer outcropping in its West-Northwestern part. The aquifer has not been properly studied. It is imperative that the boundaries and recharge conditions of the aquifer, the hydraulic connection between its various parts, its relationship and the hydraulic connection of it to the overlying Aradippou phreatic aquifer are studied comprehensively. A brief description and a rough water balance is given below.



Aradippou Gypsum Aquifer - Location Map

The main source of recharge is the Aradippou river. In Rizoelia area the gypsum either outcrops in the riverbed or it is in a direct contact with the river alluvium. The gypsum has karstic features which induce recharge of the aquifer. Another source of recharge is infiltration through, or leakage from the overlying phreatic aquifer.

Gypsum i.e. calcium sulfate ($CaSO_4$) is a mineral highly soluble in water. The groundwater in this aquifer assumed to be saturated in sulfate ions (SO_4^{--}), at the level of 1400 to 1500 mg/l.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls, chalks and chalky marls of the Pachna formation.

The gypsum belongs to the Kalavasos formation, of Upper Miocene age. The karstification of the Gypsum is well developed. The layers or lenses of gypsum are intercalated with Marls and the maximum thickness of the whole formation is estimated to be around 100 m. It extends to depths of 160 to 180 meters.

The ceiling of the aquifer consists of Plio/Pleistocene marls, sandy marls and terrace deposits such as gravels, sand, silts, sandy silty marls etc.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, since 1975, 9 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 6 months, only Cl, 9 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1975.
EXTRACTION SURVEY: Last survey in 1996

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

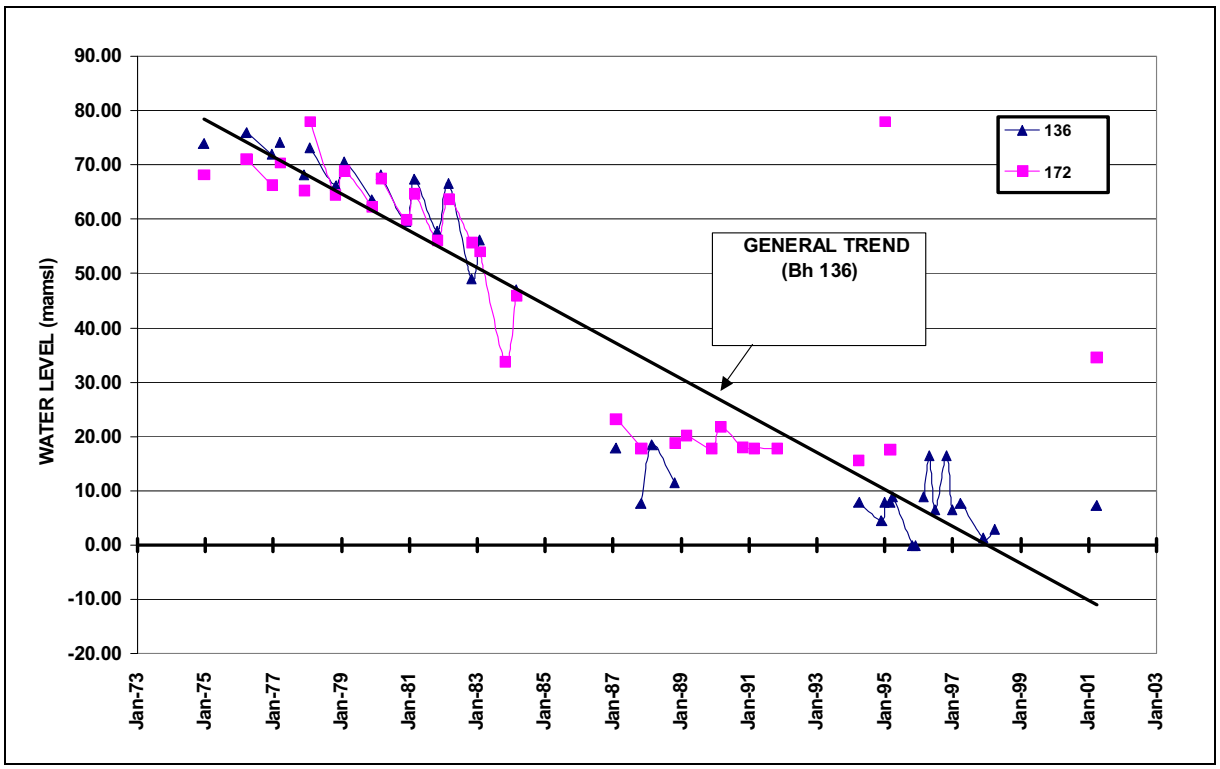
AREA OF THE AQUIFER: 31 Km², Width: 6 km, Length: 5 km, Accuracy of Definition: Poor, Outcrop Area: 6 Km².
AVERAGE RAINFALL: Period 1990-2000: 350 mm, (Period 1970-2000: 380 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30 m/day (estimated)
Average S = 0.002 (estimated).
BOUNDARIES: East, West, North and South: Impermeable**.**
CONFINED/UNCONFINED: Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Reduced aquifer recharge due to low rainfall and low river flows during the last decade as well as overpumping of the aquifer create serious depletion problems in the biggest part of the aquifer.

Most of the exploitation boreholes penetrate both the upper phreatic and the gypsum aquifers. This fact makes both the calculation of extraction from each aquifer and the interpretation of the boreholes network observations very difficult. Around 160 boreholes extract 1.3 mcm per year. It is estimated that the biggest portion, appr. 1 mcm, is extracted from the gypsum aquifer.

The groundwater is mainly used for irrigation of clover, a crop which is tolerant to high sulfate concentration as well as high salinity.



Hydrograph of boreholes 136 and 172 (Appr. elev. 80 and 78 mamsl)

HISTORIC GROUNDWATER BALANCE

Not available.

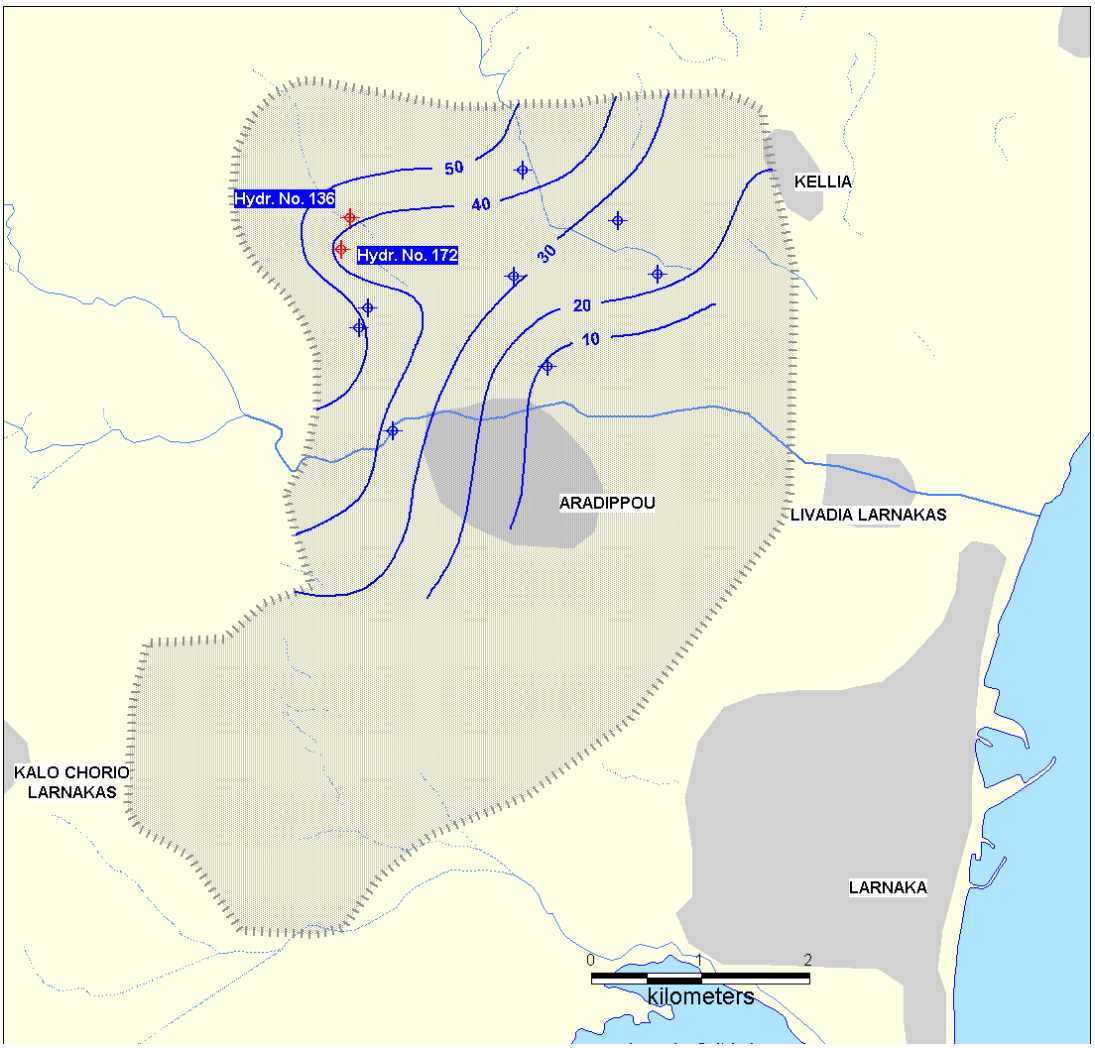
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimates: Fair. Average rainfall: 350mm.

Replenishment (mcm/year)				
	Rainfall	River Recharge	Infiltration from Phreatic Aquifer	Total
Average	0.2	0.3	0.1	0.6

Outflow (mcm/year)		
	Abstraction (irrigation)	Total
Average	1.0	1.0

Balance: **-0.4** mcm/year
Recommended average extraction: **0.6** mcm/year

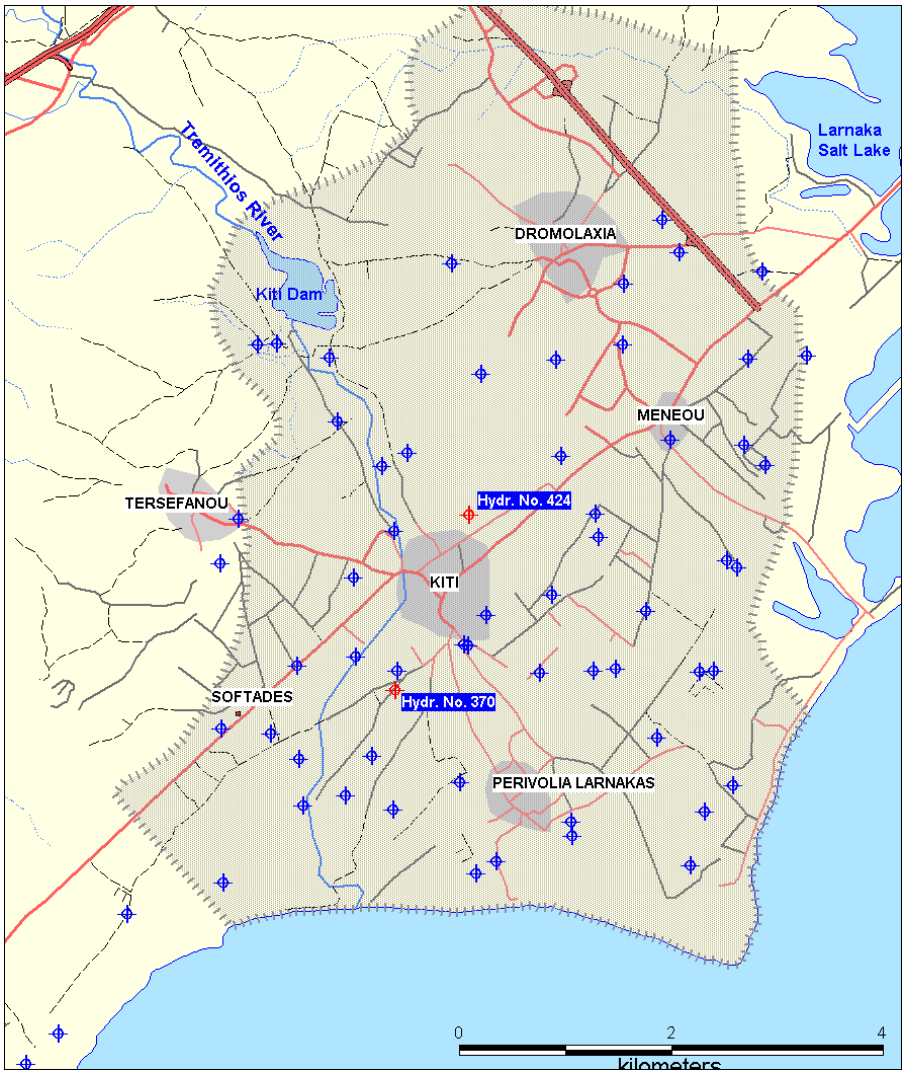


Aradippou Gypsum Aquifer - Water level (m amsl) contour map, April 2001

KITI - PERIVOLIA AQUIFER

INTRODUCTION

The Kiti – Perivolia is a small phreatic aquifer located in the Larnaka district. Despite its size it is of great local importance as most of irrigation water is drawn out of this aquifer. However over-development and over-pumping of the aquifer since the late seventies caused sea intrusion in its coastal zone.



Kiti Pervolia Aquifer - Location Map

The aquifer at its western part is in hydraulic connection with the Tremithios river alluvial deposits. In 1964 Kiti dam was constructed on this river for recharge purposes, at the northwestern corner of the aquifer. Kiti dam has a capacity of 1.6 mcm. The Southern Conveyor Project covers some of the irrigation demand in the villages Kiti, Perivolia and Meneou. The coastal zone of the aquifer is a rapidly developing tourist area.

GEOLOGY

The impervious base of the aquifer consists mainly of Palaeogene marls chalks and chalky marls.

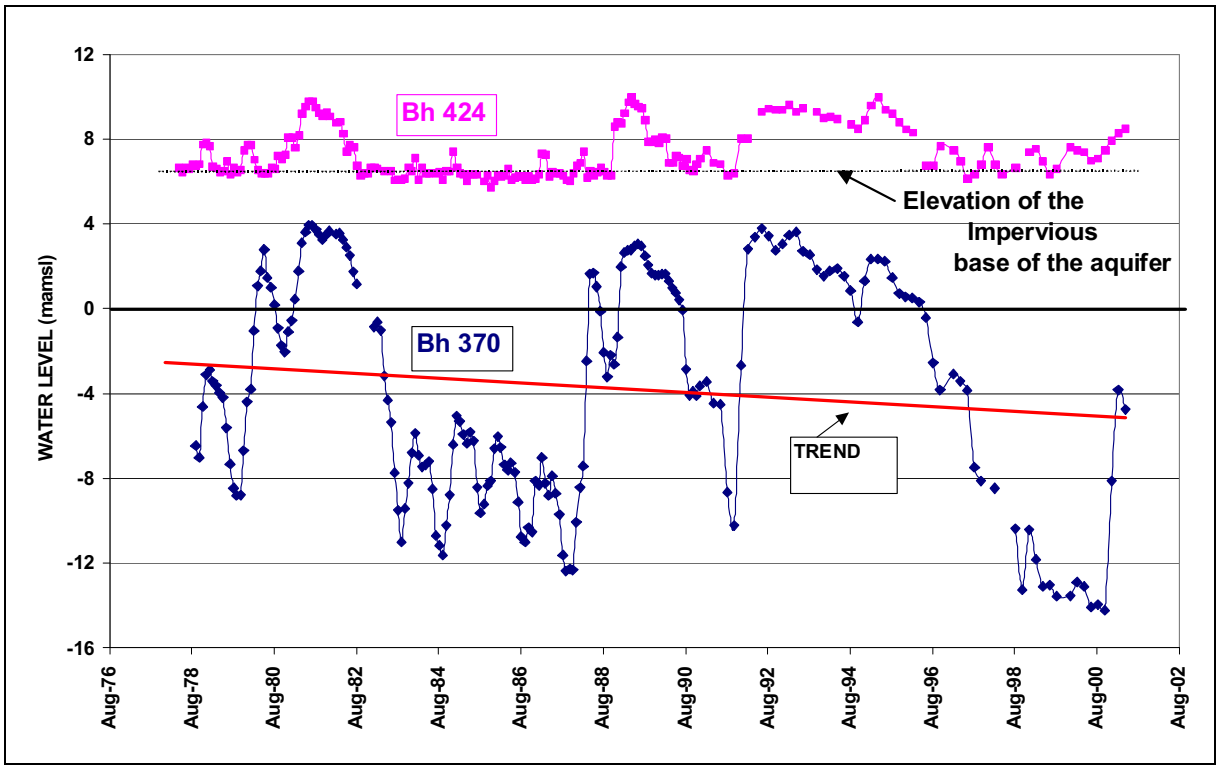
The sediments of the aquifer are 20 to 30 m thick and they consist of Pleistocene marine terrace deposits such as silts, gravel and sands. Aquifer sediments along the Tremithios riverbed consist of 20 to 45m thick river alluvial deposits.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 3 months, since 1975, 52 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, last sampling 1998, 20 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last update during 1974-1976 period
EXTRACTION SURVEY: Last WDD survey in 1996.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 38 Km², WIDTH: 5.5 km, LENGTH: 7 km, ACCURACY OF DEFINITION: 100%, OUTCROP AREA: 38 Km².
AVERAGE RAINFALL: Period 1990-2000: 320 mm (Period 1970-2000: 350 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 4 m/day, from 2 to 8 m/day
Average S = 8 %, from 2 to 14
BOUNDARIES: East: Salt Lake, permeable, (Inflow/Outflow), **South**: Sea (Inflow/Outflow),
West and North: No inflow/No outflow, permeable.
CONFINED/UNCONFINED: mainly unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): High, Phreatic aquifer



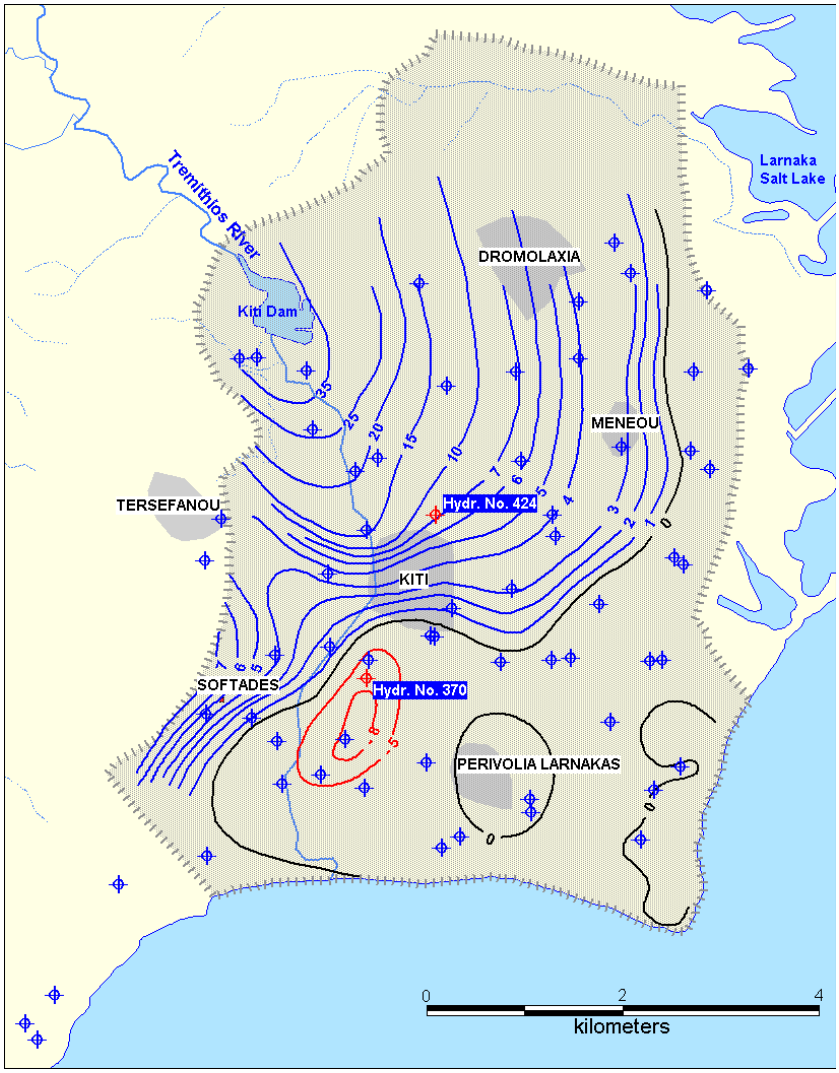
Hydrograph of boreholes Kiti 370 and 424 (Elev. 16.59 and 25.9 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

The most productive parts are located in the areas of Kiti, Perivolia and Meneou villages, where the aquifer thickness ranges between 20 and 45 m. These most productive parts of the aquifer have been sea intruded and consequently abandoned as early as the early 80s. The less productive parts are depleted and borehole yields have dropped dramatically.

It is estimated that around 300 boreholes operate in the area today. An amount of about 2 mcm/year is extracted from these boreholes. Yields of these production wells vary between 2 and 10 m³/hour depending on the year's recharge. This recharge comes directly from rainfall, from riverbed infiltration when the dam spills and through underground leakages from the Kiti dam.

Decrease in the rainfall during the last ten years resulted in reduced direct natural recharge of the aquifer and diminished river flows. This in turn resulted in diminished inflows to the dam and consequently diminished recharge from dam leakages and spills.



Kiti Pervolia Aquifer – Water Level (m amsl) Contour Map January 2001

HISTORIC GROUNDWATER BALANCE

Average water balance: 1978 – 1980 (2 years). (SCP FEASIBILITY STUDY), result of a mathematical model applied in an area of 29.25 km². Average rainfall: 350mm

Replenishment (mcm/year)							
	Rainfall	Riverbed	Subsurf . Inflow	Sea intrusion (Sea/S. Lake)	Return from irrigation	Artificial recharge	Total
Average	1.5	0.42	0.35	0.1	0.57	0.21	3.1

Outflow (mcm/year)			
	Abstraction	Subs. Outflow (Sea/ S. Lake)	TOTAL
Average	2.83	0.11	2.94

Balance +0.2 mcm/year

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimates: Good. Aquifer area: 38 km².
Average rainfall: 320 mm.

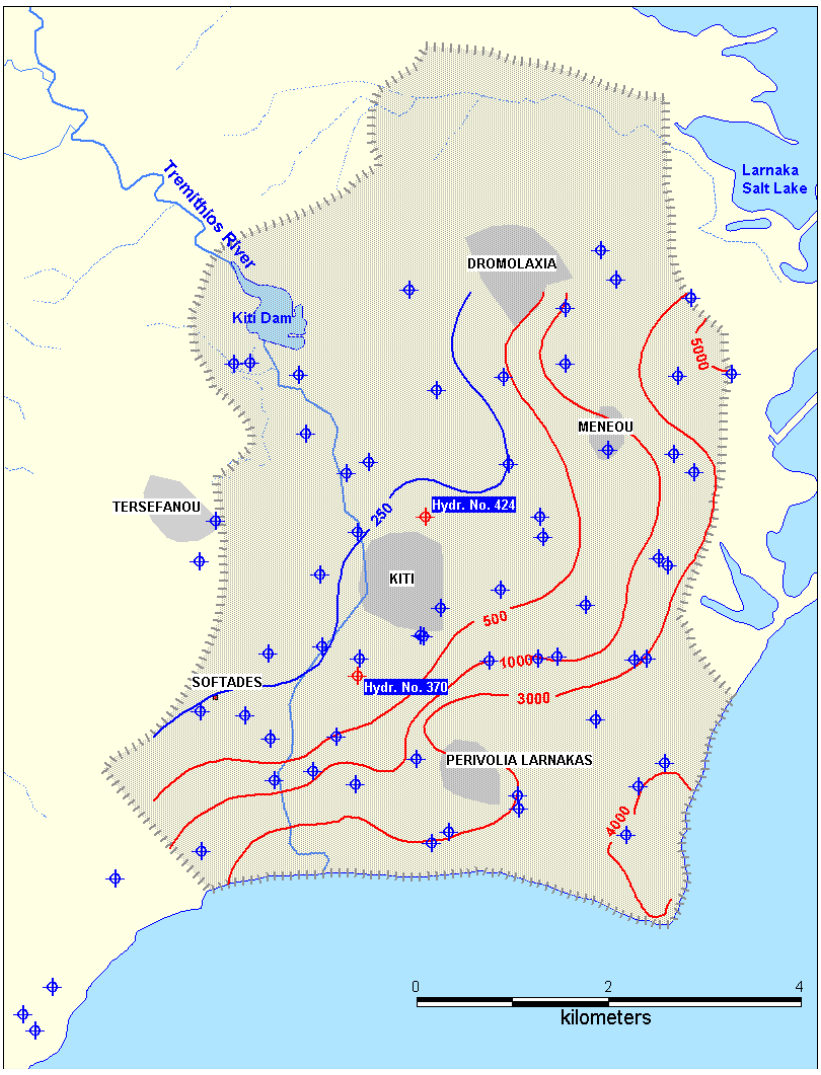
Replenishment (mcm/year)							
	Rainfall	Riverbed	Subsurf. Inflow (Dam)	Sea intrusion (Sea/S. Lake)	Return irrigat.	Artificial recharge	Total
Average	1.2	0.1	0.2	0.3	0.2	0	2.0

Outflow (mcm/year)			
	Abstraction	Subs. Outflow (Sea/ S. Lake)	TOTAL
Average	1.9	0.1	2.0

Balance: **0** mcm/year

Change in storage (1991 – 2000) = **0** mcm.

Recommended average extraction from the aquifer (sea intruded areas excluded): **0.7** mcm/year.

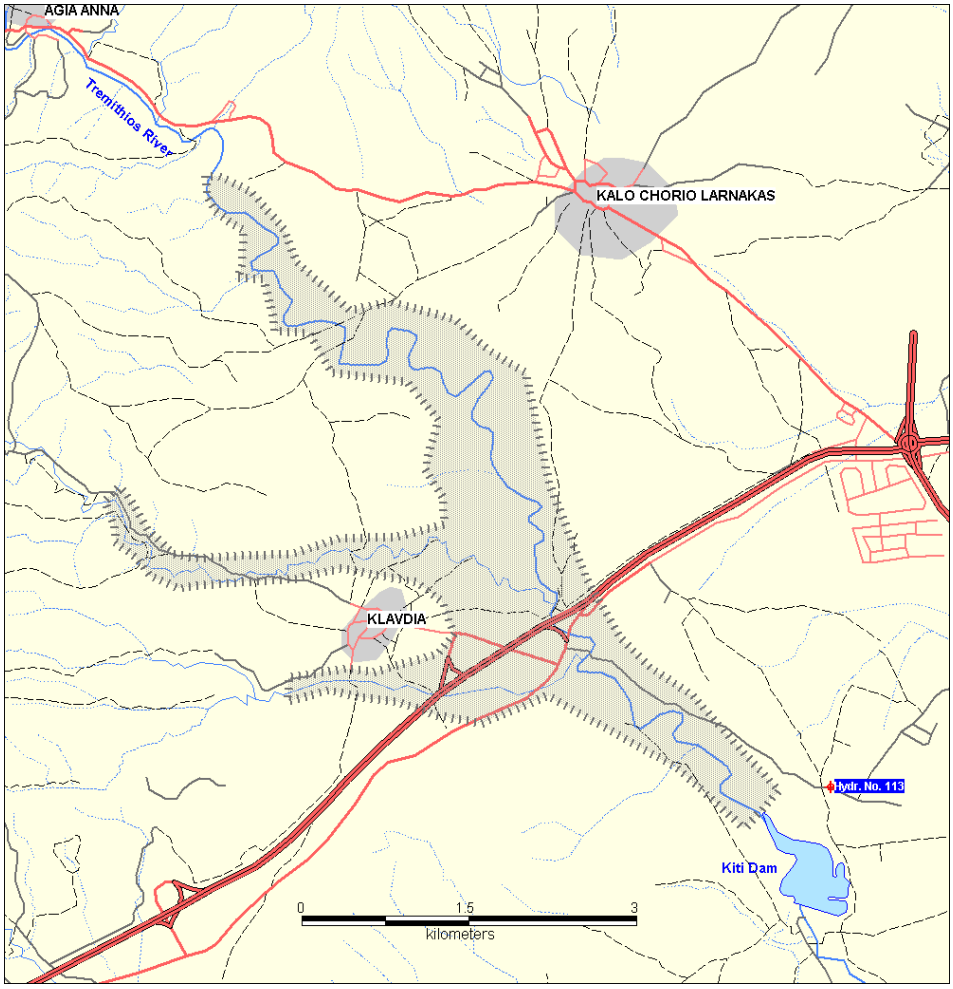


Kiti Pervolia Aquifer – Isochlorides (ppm) Contour Map April/May 2001

TREMITHIOS RIVERBED AQUIFER

INTRODUCTION

Tremithios riverbed aquifer is an alluvial aquifer situated a few kilometers west of Larnaka town and developed along the Tremithios river valley. It is extended from Agia Anna and Pyrga villages to the Kiti dam. Even though it is an important aquifer for the Larnaka district it has not yet been studied in depth.



Tremithios Riverbed Aquifer - Location Map

The main source of recharge is the river flow. The water is mainly infiltrating along the section lying between Agia Anna weir and Klavdia bridge, on the old Larnaka – Lemesos road. It is believed that the aquifer is crossing the Skarinou – Klavdia fault zone, north of the old Larnaka – Lemesos road and that there is a hydraulic connection between them. Some of the groundwater is leaking to the aquifer formed by this 25 km long fault zone.

The most water productive part of the Tremithios aquifer lies south of Klavdia village. Along this section, south of the old Larnaka – Lemesos road, several boreholes are operating for the Larnaka domestic water supply. Periodically, during very dry periods, some Southern Conveyor Project water is being released in the area of these boreholes for artificial recharge of the aquifer. The aquifer is used as a natural treatment plant.

Some of the boreholes are penetrating deep into the bedrock extracting water from fissured zones in chalks. It is believed that this water is part of the water that has infiltrated in the alluvial aquifer.

GEOLOGY

The impervious base of the aquifer consists of Miocene (Pachna formation) marls, chalks and chalky marls in the downstream section and of Palaeogene (Lefkara formation) marls, chalks and chalky marls in the upper section. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

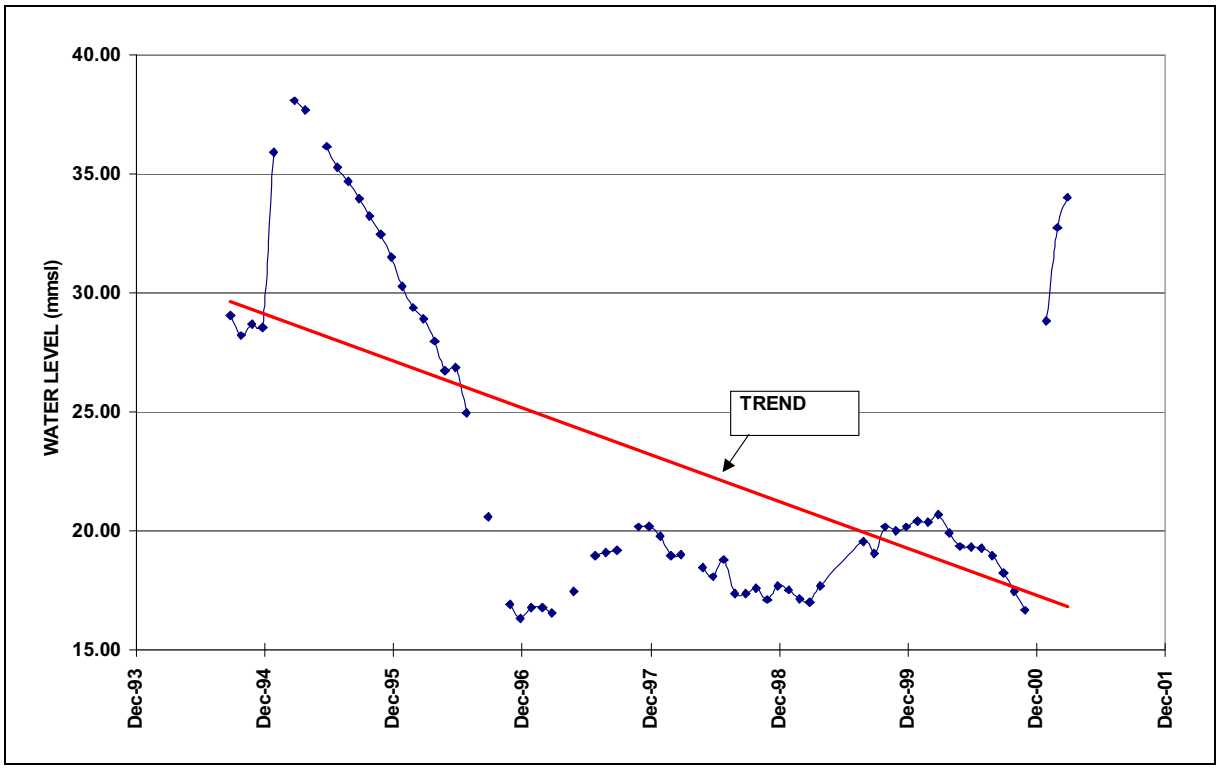
WATER LEVEL OBS. NETWORK : Yes. Every 6 months. In Klavdia area only, 5 boreholes.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1986.
EXTRACTION SURVEY: Only in Klavdia village, in 1996.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 8 Km², WIDTH: 800m, LENGTH: 10 Km, OUTCROP: 8 Km².
THICKNESS: Few meters at the Northern end, 25m at the Kiti dam.
AVERAGE RAINFALL: Period 1990-2000: 370 mm (1970-2000: 380 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day (estimated)
Average S = 8% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Kiti aquifer.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

It is estimated that 25 to 30 boreholes are operating in the aquifer. The most important boreholes are the ones operating for Larnaka domestic purposes. The extraction of these boreholes varies from 0.5 to 1.5 mcm/year with an average extraction of 0.7 to 0.8 mcm per year. Their yield depends on the yearly river recharge. The total extraction is estimated to be about 1 mcm/year. The yields of the boreholes vary from 5 to 50 m³/hour. The average natural recharge for the same period is estimated to be about 1.4 mcm/year. The low rainfall of the last ten years has reduced the total flow of the river and consequently the aquifer's recharge.



Hydrograph of borehole Klavdia 113 (Elev. 52.96 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 8 km². Average rainfall = 370mm.

Replenishment (mcm/year)				
	Rainfall	Riverbed recharge	Artificial recharge	Total
Average	0.4	0.8	0.2	1.4

Outflow (mcm/year)				
	Abstraction	Outflow to Kiti aquifer	GWT Outflow to Fault zone	Total
Average	1.0	0.2	0.2	1.4

Balance: **0** mcm/year.
Recommended sustainable extraction: **1.0** mcm/year

SOFTADES-ZYGI COASTAL PLAIN AQUIFER

INTRODUCTION

Softades-Mazotos-Alaminos-Maroni-zygi coastal plain aquifer is developed along a 25 km long coastal strip, stretching from Softades village to the Vasilikos river in the Mari village area. On average it has a width of 1.5 km varying from 0.5 to 2.5 km. The east part of the aquifer is included in the Southern Conveyor Project irrigation area and its western part is included in the Vasilikos – Pentaschinos Project irrigation area.

The aquifer is crossed by the alluvial riverbed aquifers of Pouzis, Xeropotamos (Alaminos), Pentaschinos, Maroni and Vasilikos. Between these riverbed aquifers and the coastal plain aquifer there are underground connections and interchange of groundwater; however in this stage of the study it is not possible to quantify these.

The aquifer has a low storativity. Its recharge depends almost entirely on rainfall. The low rainfall and the consequent low recharge of the last decade has diminished the aquifer's yield. This, in turn, has forced a reduction in the extraction from the aquifer. Because of its short width, it drains very quickly after the end of the wet season. The total yield of the aquifer may be increased by increasing the extraction during the spring months.

GEOLOGY

The impervious base of the aquifer in its southeastern part consists mainly of Miocene (Pachna formation) and Palaeogene (Lefkara formation) marls, chalks and chalky marls.

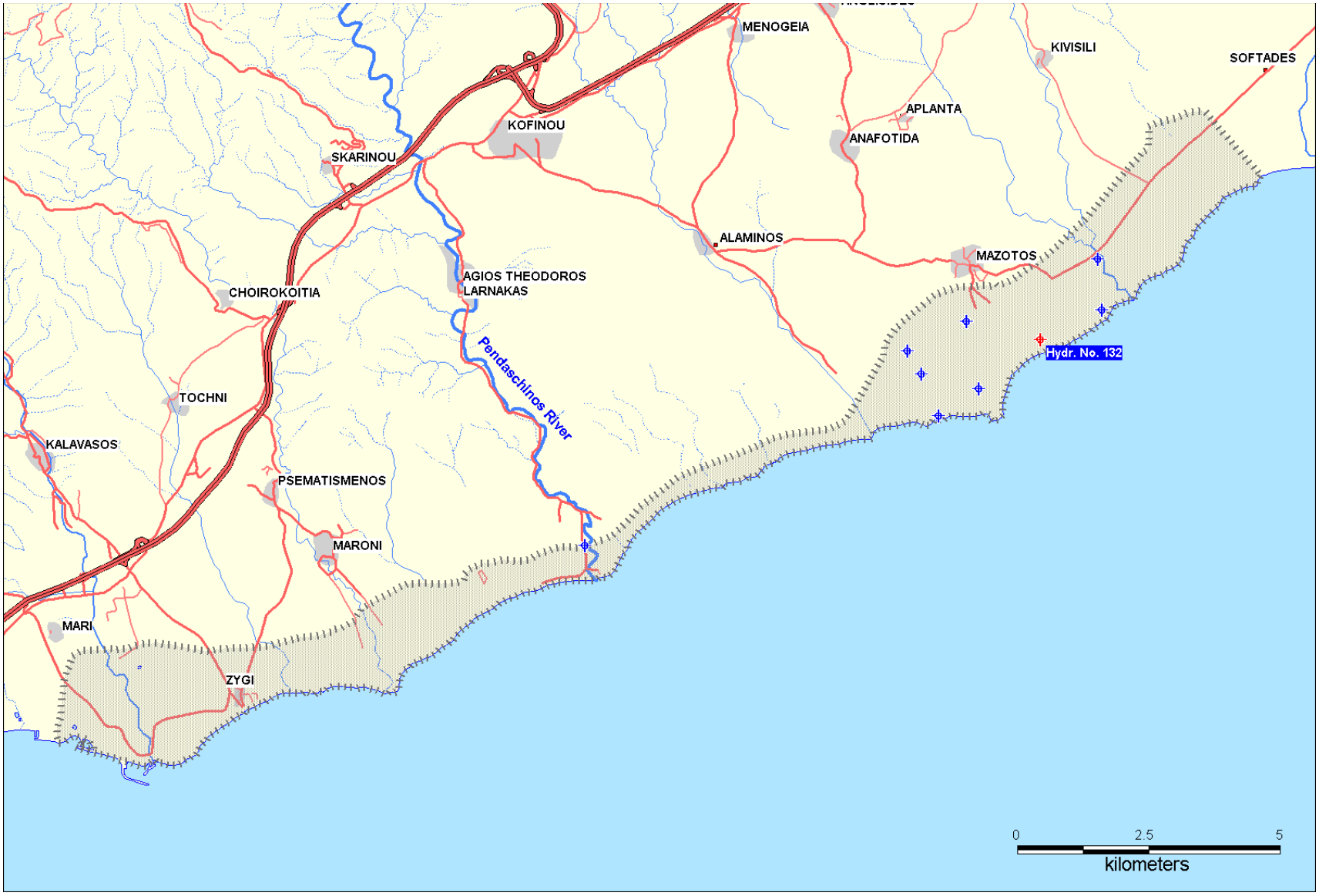
The aquifer is mainly developed in marine alluvial deposits, silty sands, gravels and calcarenites.

GENERAL INFORMATION

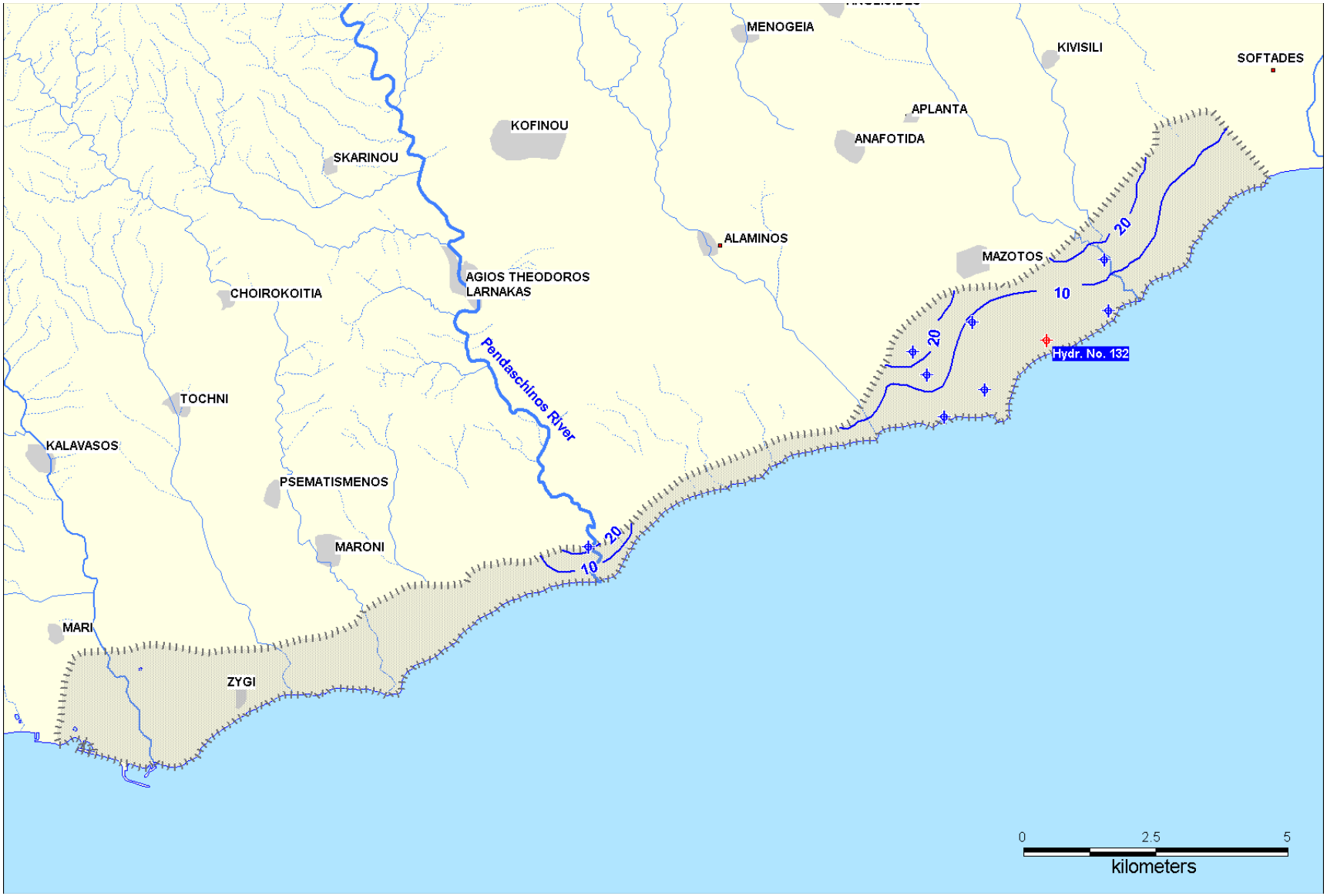
WATER LEVEL OBS. NETWORK : Yes, every 6 months, 5 unevenly distributed boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 6 months, only Cl analyses, from 5 unevenly distributed boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1976.
EXTRACTION SURVEY: Last survey in 1996.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 37 Km², WIDTH: 1.5 km, LENGTH: 25km, OUTCROP: 37 Km².
AVERAGE RAINFALL: Period 1990-2000: 370 mm (1970-2000: 380 mm).
THICKNESS: Up to 15 m.
HYDROGEOLOGICAL PARAMETERS: Average K = 10 m/day (estimated).
Average S = 5 % (estimated).
BOUNDARIES: East, West and North: Impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): High. Phreatic aquifer



Softades-Zygi Coastal Plain Aquifer - Location Map

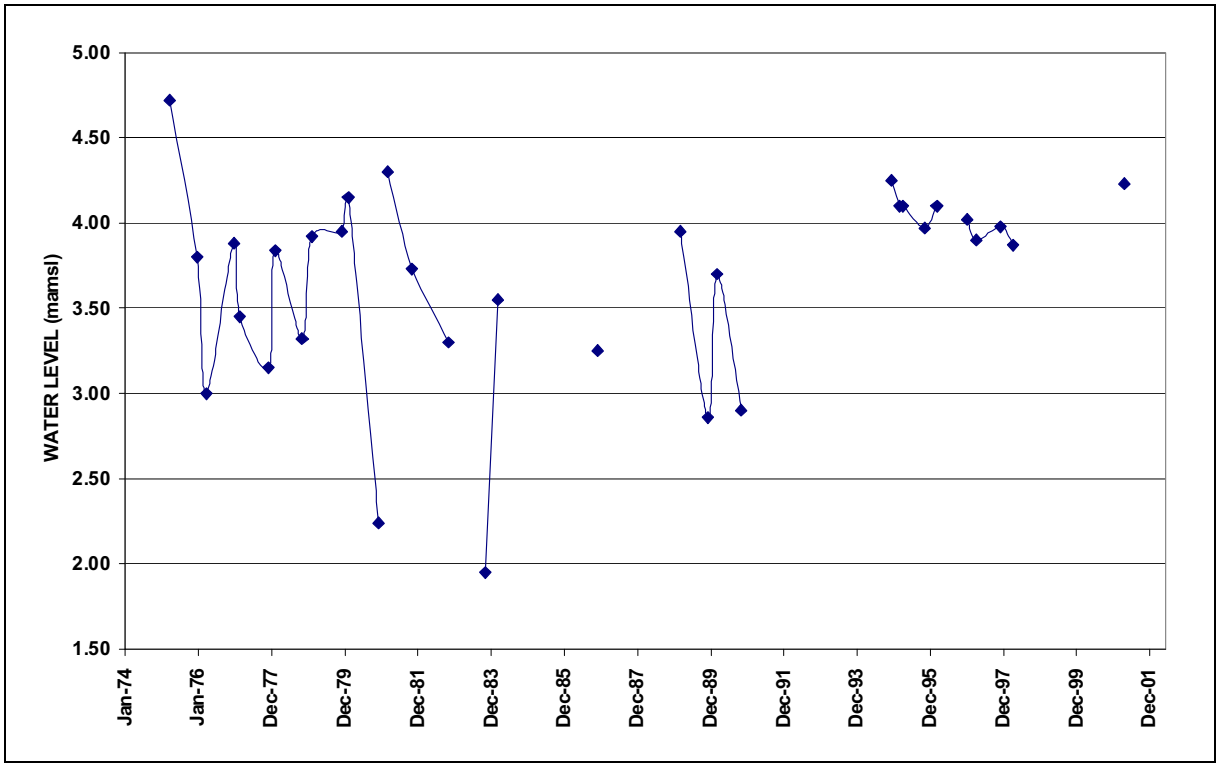


Softades-Zygi Coastal Plain Aquifer - Water Level (m amsl) Contour Map April 2001

HYDROGEOLOGICAL CONDITIONS TODAY

It is estimated that today, around seventy private boreholes and wells operate in the area. The yields of these boreholes range from 1 - 5 m³/hour. The average extraction in the last ten years is roughly estimated to be about 0.3 - 0.4 mcm/year. The droughts of the last decade gradually diminished the yield of the aquifer. The problem was exaggerated in the last five years.

Some evidence of sea intrusion is localized in few coastal zones.



Hydrograph of borehole Mazotos 132 (Appr. elev. 9 m amsl)

HISTORIC GROUNDWATER BALANCE

The yearly extraction from the aquifer in the seventies was estimated to be about 0.3 mcm and the respective rainfall recharge was estimated to be about 1 mcm (VASILIKOS – PENTASCHINOS PROJECT, Feasibility Study, Volume III – Water Resources, Nicosia July 1977). In this study only the western part of the aquifer was included.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 37 km².
Average rainfall: 370mm.

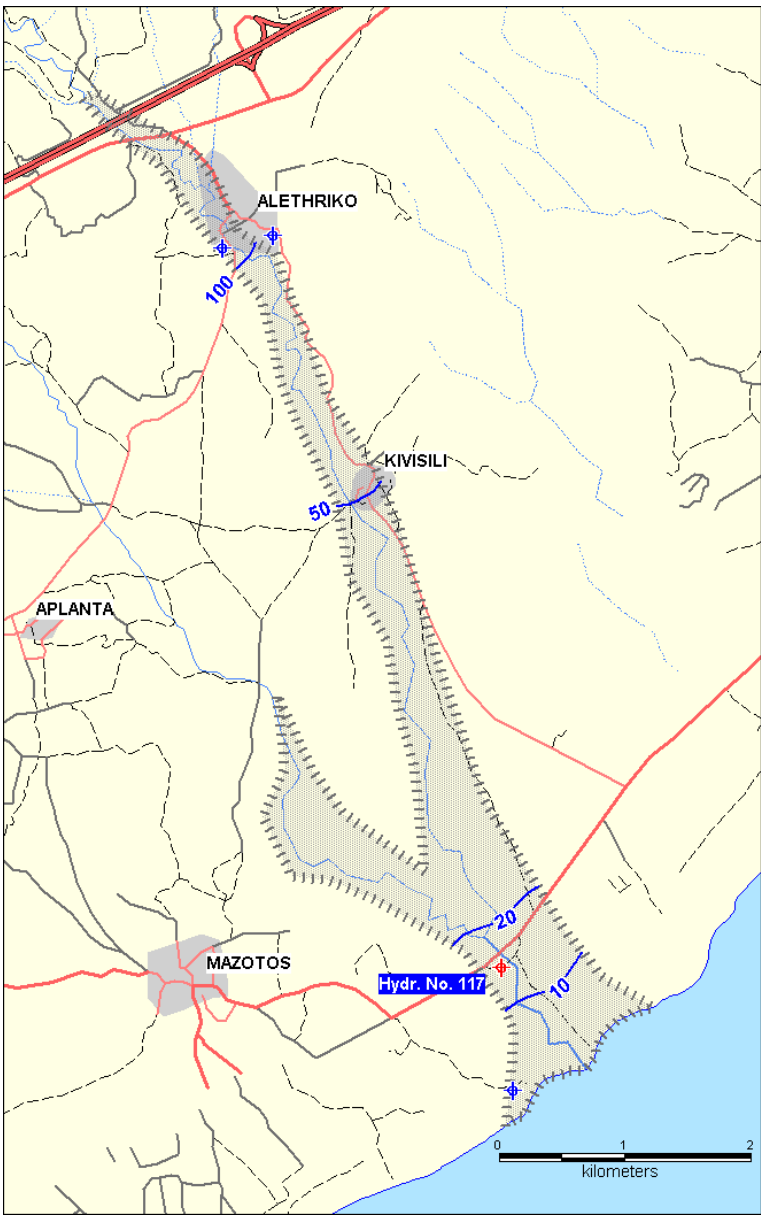
Replenishment (mcm/year)					
	Rainfall	Subsurface Inflow	Sea intrusion	Return from irrigation	Total
Average	1.5	0.0	0.1	0.1	1.7

Outflow (mcm/year)				
	Abstraction for irrigation	Subsurface outflow	Sea Outflow	Total
Average	0.4	0.0	1.3	1.7

Balance: **0** mcm/year
Increase of extraction in spring by **0.3** mcm/year is recommended. Total recommended sustainable extraction: **0.7** mcm/year

POUZIS RIVERBED AQUIFER

INTRODUCTION



Puzis Riverbed Aquifer - Location Map and Water Level (m amsl) Contour Map April 2001

Pouzis is a small alluvial aquifer situated a few kilometers west of Larnaka town and developed along the Pouzis river valley. The capacity of the aquifer is small and depends entirely on the recharge from river flow and the rainfall. The downstream, coastal part of it is the most water productive and it is included in the Southern Conveyor Project irrigation area. The delta area of the aquifer crosses the Softades-Mazotos-Alaminos-Maroni-Zygi coastal plain aquifer. It is assumed that there is a hydraulic connection between them but at this stage of the study the water interchange cannot be quantified. Generally, the aquifer is not very well studied and some of the information given in the following paragraphs is based on the author's experience.

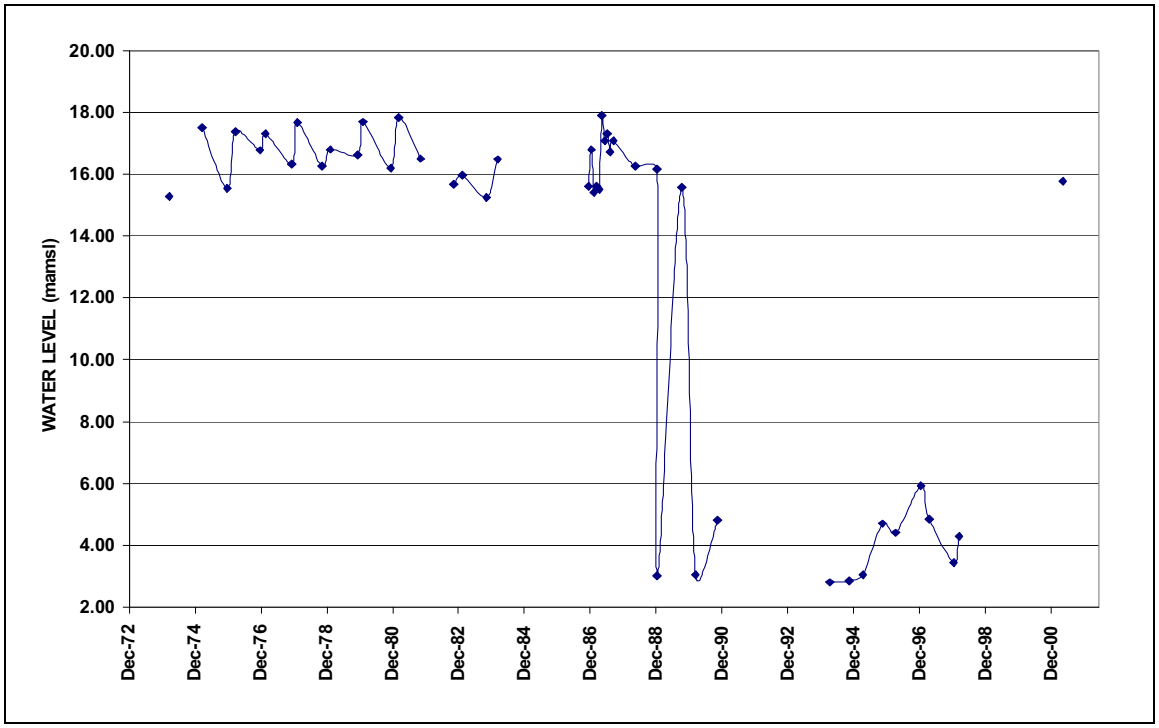
The low rainfall of the last ten years has reduced the total flow of the river and consequently the aquifer's recharge.

GEOLOGY

The impervious base of the aquifer consists of Palaeogene (Lefkara formation) and of Miocene (Pachna formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, silty gravels, silty sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 3 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, only Cl^- analysis, 1 borehole.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1985.
EXTRACTION SURVEY: Last survey in 1996.



Hydrograph of borehole Mazotos 117 (Appr. elev. 20 m amsl)

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.5 Km², WIDTH: 300m, LENGTH: 9 Km, OUTCROP: 2.5 Km².
THICKNESS: Few meters at northern end, 15 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 360 mm (1970-2000: 370 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 15 m/day (estimated).
Average S = 6% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Around forty boreholes operate in the aquifer extracting water for local irrigation. The yields of these boreholes vary from 2 to 10 m³/hour. The average extraction from the aquifer in the last ten years is estimated to be about 0.3 mcm/year. The average natural recharge for the same period is estimated to be about 0.45 mcm/year.

The aquifer is indicating a depleting trend that is a result of the reduced recharge. No problems with sea intrusion in the delta area have been reported up to now.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 2.5 km². Average rainfall: 360mm.

Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.1	0.00	0.35	0.45

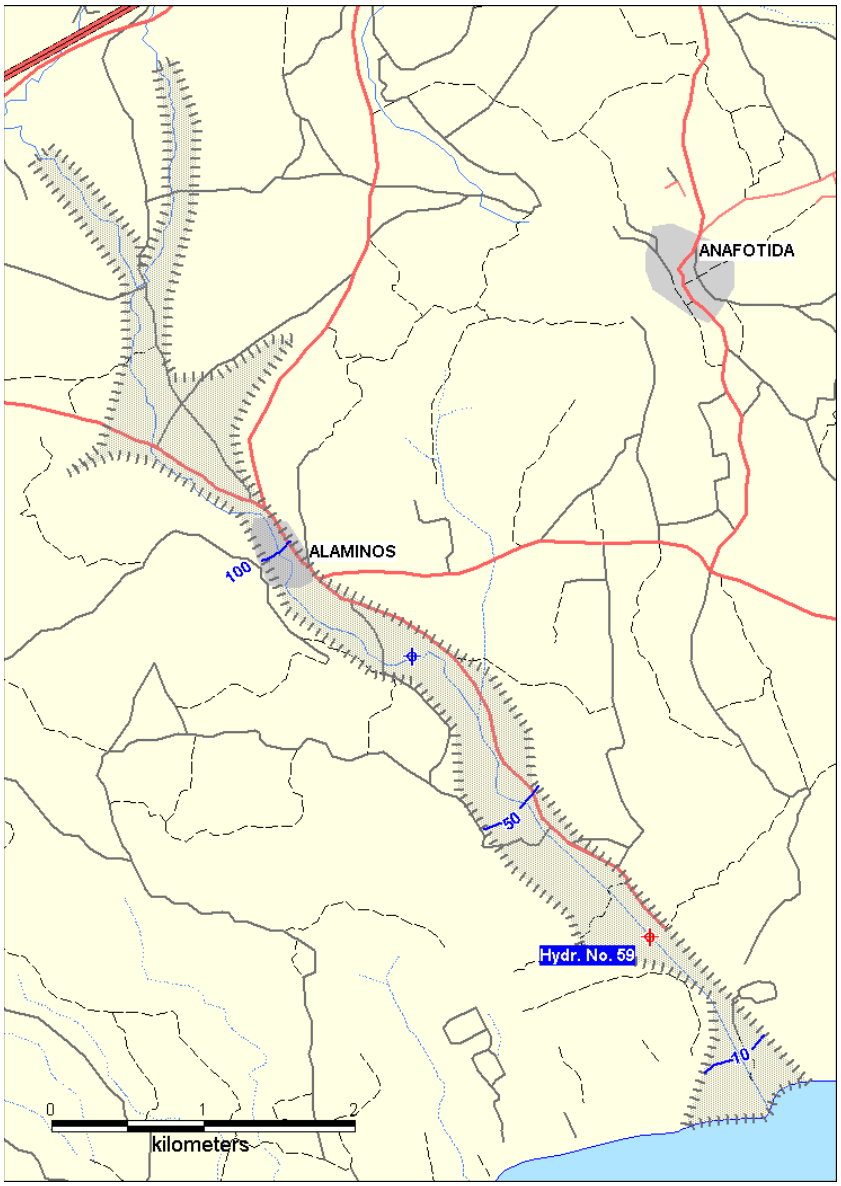
Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.3	0.2	0.5

Balance: **- 0.05** mcm/year.

Recommended sustainable extraction: **0.25** mcm/year.

XEROPOTAMOS (ALAMINOS) RIVERBED AQUIFER

INTRODUCTION



Xeropotamos (Alaminos) Riverbed Aquifer - Location Map and Water Level Contour Map
April 2001

Xeropotamos is a small alluvial aquifer situated twenty kilometers west of Larnaka town. It is developed along the Xeropotamos river valley. The capacity of the aquifer is small and depends on recharge from the river flow. Its most water productive section is the downstream, coastal part, south of Alaminos village. Part of the aquifer is included in the Southern Conveyor Project irrigation area. The delta area of the aquifer is crossing the Softades-Mazotos-Alaminos-Maroni-Zygi coastal plain aquifer. It is believed that there is a hydraulic connection between them but water interchange is not yet quantified. Generally, the aquifer is not very well studied and some of the information and parameters given in the following paragraphs are based on the author's experience.

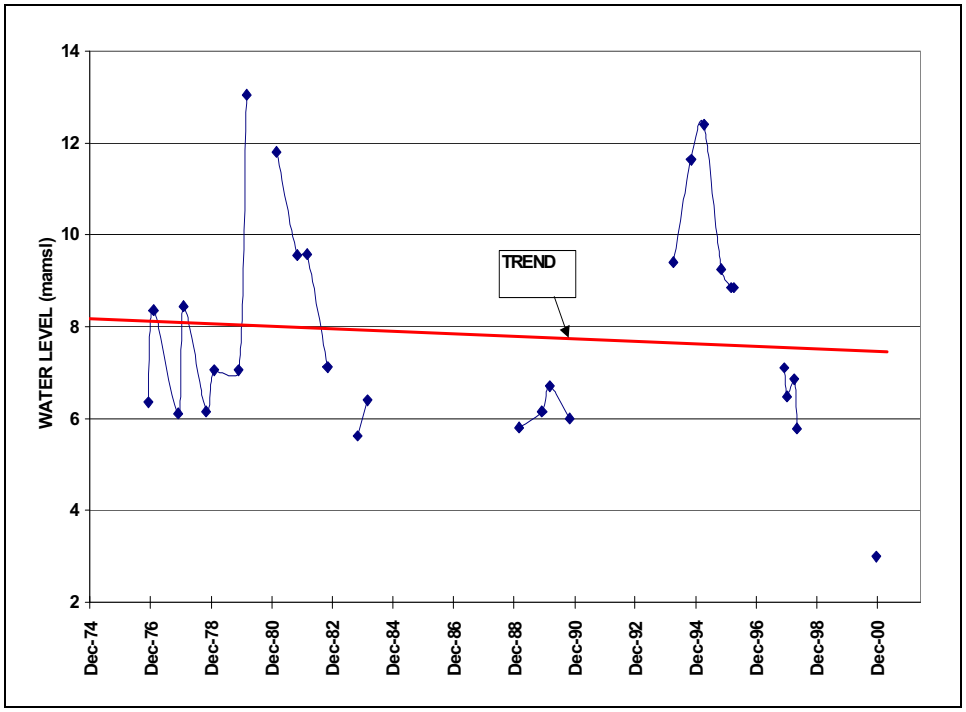
The low rainfall of the last ten years has reduced the total flow of the river and consequently the respective aquifer's recharge.

GEOLOGY

The impervious base of the aquifer consists of Palaeogene (Lefkara formation) and of Miocene (Pachna formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, silty gravels, silty sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 2 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, only Cl^- analysis, 1 borehole.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1975.
EXTRACTION SURVEY: Last survey in 1996.



Hydrograph of borehole Alaminos 59 (Appr. elev. 22 m amsl)

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.0 Km², WIDTH: 250m, LENGTH: 8 Km, OUTCROP: 2.0 Km².
THICKNESS: Few meters at northern end, 15 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 360 mm (1970-2000: 370 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day (estimate).
Average S = 7% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Around forty-five boreholes operate in the aquifer extracting water for local irrigation. The yields of these boreholes vary from 2 to 10 m³/hour. The average extraction from the aquifer in the last ten years is estimated to be about 0.5 mcm/year. The average natural recharge for the same period is estimated to be about 0.7 mcm/year.

During dry years the aquifer exhibits a depleting trend, which is a result of the reduced recharge. The aquifer recovers very quickly after normal or wet years. No problems with sea intrusion in the delta area have been reported so far.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 2.0 km².
Average rainfall: 360mm.

Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.1	0.0	0.6	0.7

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.5	0.2	0.7

Balance: **0** mcm/year.
Recommended sustainable extraction: **0.5** mcm/year.

PENTASCHOINOS RIVERBED AQUIFER

INTRODUCTION

Pentaschoinos is a river alluvial aquifer situated a few kilometers west of Larnaka town, developed along the Pentaschoinos river valley. It is the most important riverbed aquifer in the Larnaka district. The river flow and the riverbed recharge have been reduced dramatically after the construction of the Lefkara dam in 1973 and the Dipotamos dam in 1985 both on the Pentaschoinos river. Most of the area of the aquifer is included in the Vasilikos - Pentaschoinos Project irrigation area. The aquifer is not very well studied. Some of the information and parameters given in the following paragraphs are assumptions and estimates based on the author's experience.

Along a small section of the riverbed, the aquifer overlies the Agios Theodoros sandstone aquifer. There is a hydraulic connection between them but the extent of the groundwater interchange has not been studied. The predominant direction of interchange is from the alluvial to the sandstone aquifer. The delta area of the aquifer is crossing the Softades-Mazotos-Alaminos-Maroni-Zygi coastal plain aquifer. It is assumed that there is a hydraulic connection between them. The probable water interchange has not been quantified yet.

The aquifer is being overpumped for many years by the farmers in the area in their desperate attempts to maintain their plantations, mainly citrus. This phenomenon has been intensified in the last 5-6 years. Overpumping is the result of the water deficit in the area of the Vasilikos - Pentaschoinos Project; a condition reflected all over Cyprus.

GEOLOGY

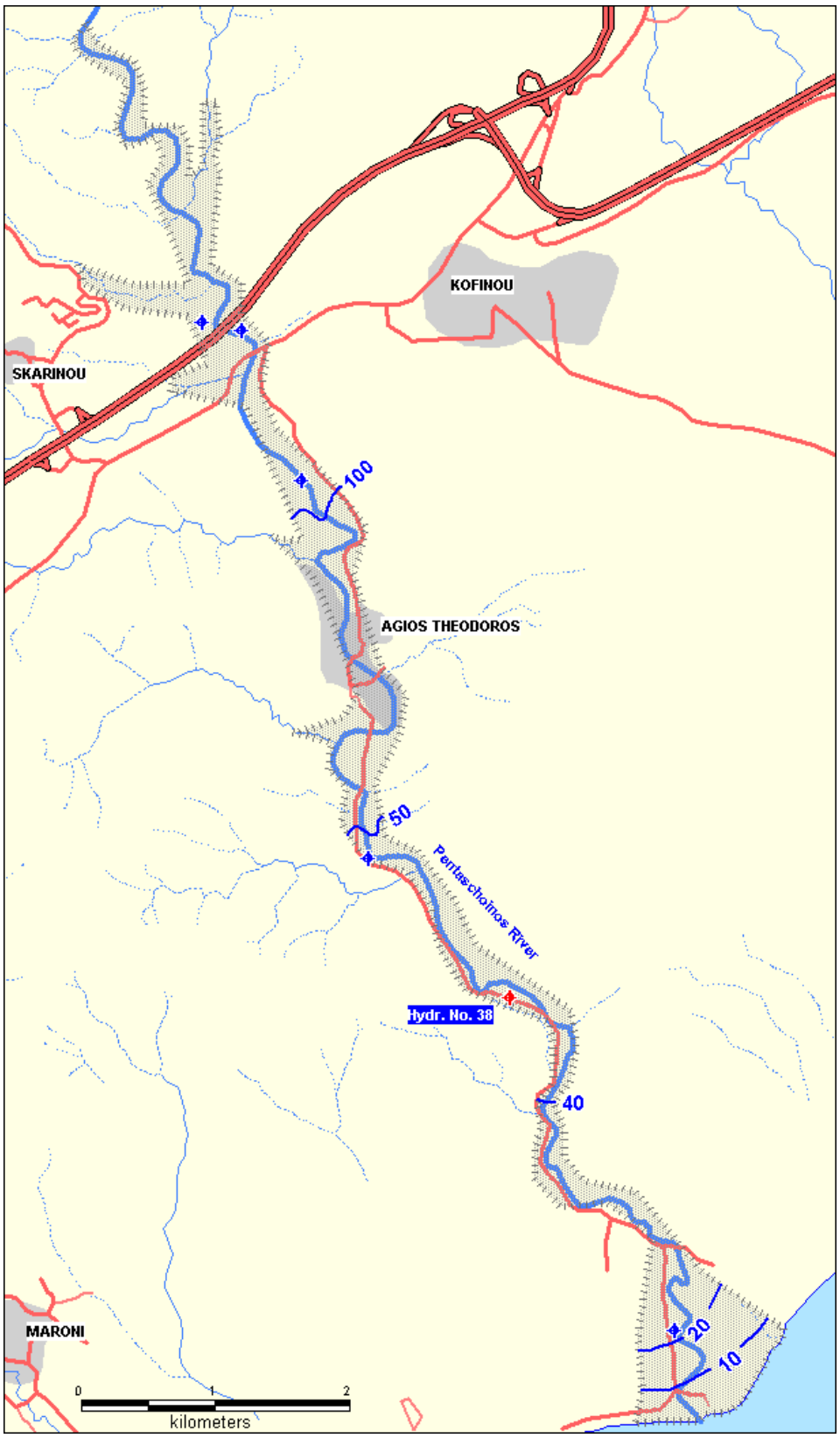
The impervious base of the aquifer consists of Miocene (Pachna formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes. Every 6 months. 8 boreholes.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1976.
EXTRACTION SURVEY: Last survey in 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.6 Km², WIDTH: 200m, LENGTH: 13 Km, OUTCROP: 2.6 Km².
THICKNESS: Few meters at northern end, 25 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (1970-2000: 420 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 25 m/day (estimated).
Average S = 10% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



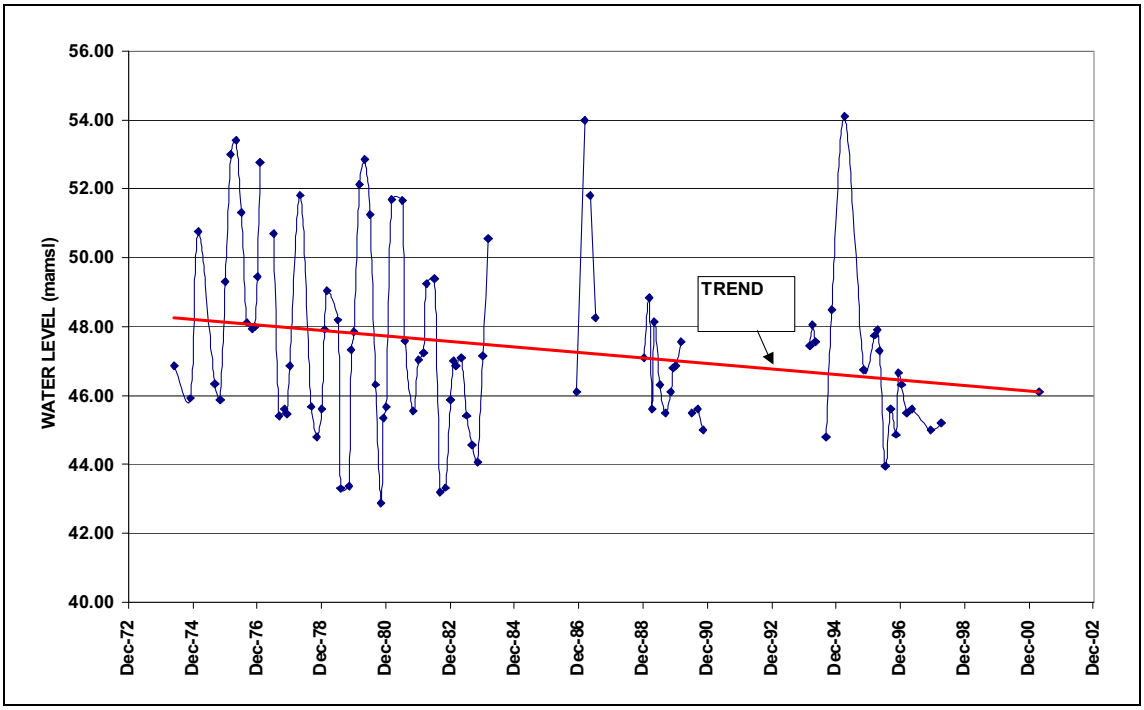
Pentaschoinos Riverbed Aquifer - Location Map and Water Level (m amsl) Contour Map April 2001

HYDROGEOLOGICAL CONDITIONS TODAY

Around 120 boreholes operate in the aquifer extracting water, mainly for local irrigation. The yields of these boreholes vary from 5 to 25 m³/hour. The extraction in the last three to four years has been gradually reduced because of propagation of sea intrusion. The

average extraction from the aquifer in the last ten years is estimated to be about 1.0 mcm/year. The average natural recharge for the same period is estimated to be about 1.2 mcm/year.

The coastal part of the aquifer has been contaminated by sea intrusion with the saline front having been propagated up to 2 km inland.



Hydrograph of borehole Agios Theodoros 38 (Appr. elev. 60 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 2.6 km².
Average rainfall: 400mm.

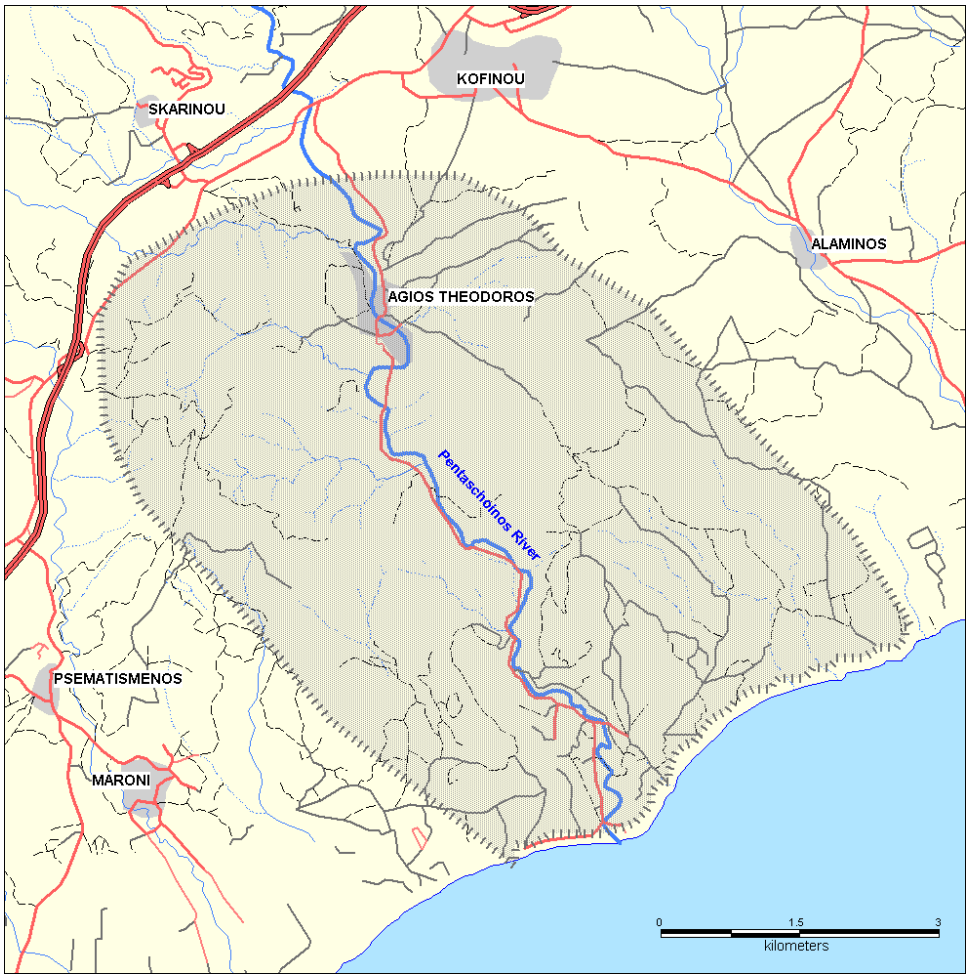
Replenishment (mcm/year)					
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Total
Average	0.2	0.2	0.6	0.2	1.2

Outflow (mcm/year)				
	Abstraction	Sea Outflow	GWT Outflow to Sandstone Aquifer	Total
Average	1.0	0.1	0.1	1.2

Balance: **0** mcm/year.
Recommended sustainable extraction: **0.7** mcm/year.

AGIOS THEODOROS SANDSTONE AQUIFER

INTRODUCTION



Agios Theodoros Sandstone Aquifer - Location Map

Agios Theodoros (Larnaka) is a semiconfined aquifer developed in sandstones of the Pachna formation. It is a very extensive artesian aquifer (more than 40 km^2) with free flowing boreholes near the coast.

The geology and hydrogeology of the aquifer is very complicated and it has yet to be studied properly. The extension, the thickness, the outcropping, the interfingering of marls and sandstones, the hydrogeological parameters, the interconnection and the water interchange with both the sea and the neighboring aquifers are not clearly defined. The fluctuation of water levels, quality and extraction are insufficiently monitored. Under these conditions it is impossible to estimate the potential yield and the water balance of this aquifer with acceptable accuracy.

The aquifer water is saline with chloride concentration exceeding 600 mg/liter. This water can only be used either for short irrigation periods or for general irrigation in mixtures with good quality water e.g. from the Vasilikos – Pentaschinos Project. Dry years and serious water deficits in the Vasilikos – Pentaschinos Project during the last decade have led to a reduction in the available amounts of good quality water to be mixed with saline aquifer water and used for irrigation. This has predictably led to reduced amounts of water extracted from the aquifer.

GEOLOGY

The aquifer is developed in Miocene (Pachna formation) sandstones. They appear in a form of layers or lenses alternating with marl. These layers are laterally changed to sandy marls and very often, in the Maroni village area, they are interfingering with the gypsum lenses. It is estimated that its total thickness is in the order of 300m. The aquifer outcrops in the Agios Theodoros and Choirokoitia village areas.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1976.
EXTRACTION SURVEY: No.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: Not defined.
AVERAGE RAINFALL: Period 1990-2000: 370 mm (1970-2000: 380 mm).
THICKNESS: Up to 300 m.
HYDROGEOLOGICAL PARAMETERS: Average K = 2 -3 m/day (estimate).
Average S = 1 % (estimate for phreatic part), 0.005 to 0.001 (estimate for confined part).
BOUNDARIES: East, West, North and South: Not clearly defined
CONFINED/UNCONFINED: semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Low.

HYDROGEOLOGICAL CONDITIONS TODAY

Neither the number of boreholes operating in this aquifer nor the amount of water extracted from it are known. Some new deep boreholes in the coastal zone have a free artesian flow indicating that the piezometric head and the groundwater reserves have not changed significantly in the last decades. The use of this water is problematic because of its inferior quality.

HISTORIC GROUNDWATER BALANCE

The only figure given, due to lack of basic data, was the rough estimate of water availability, estimated to be about 2 mcm/year (VASILIKOS – PENTASCHINOS PROJECT, Feasibility Study, Volume III – Water Resources, Nicosia July 1977). Only the western part of the aquifer has been included in this study.

GROUNDWATER BALANCE TODAY

No balance is given. The available data do not allow estimates of acceptable reliability.

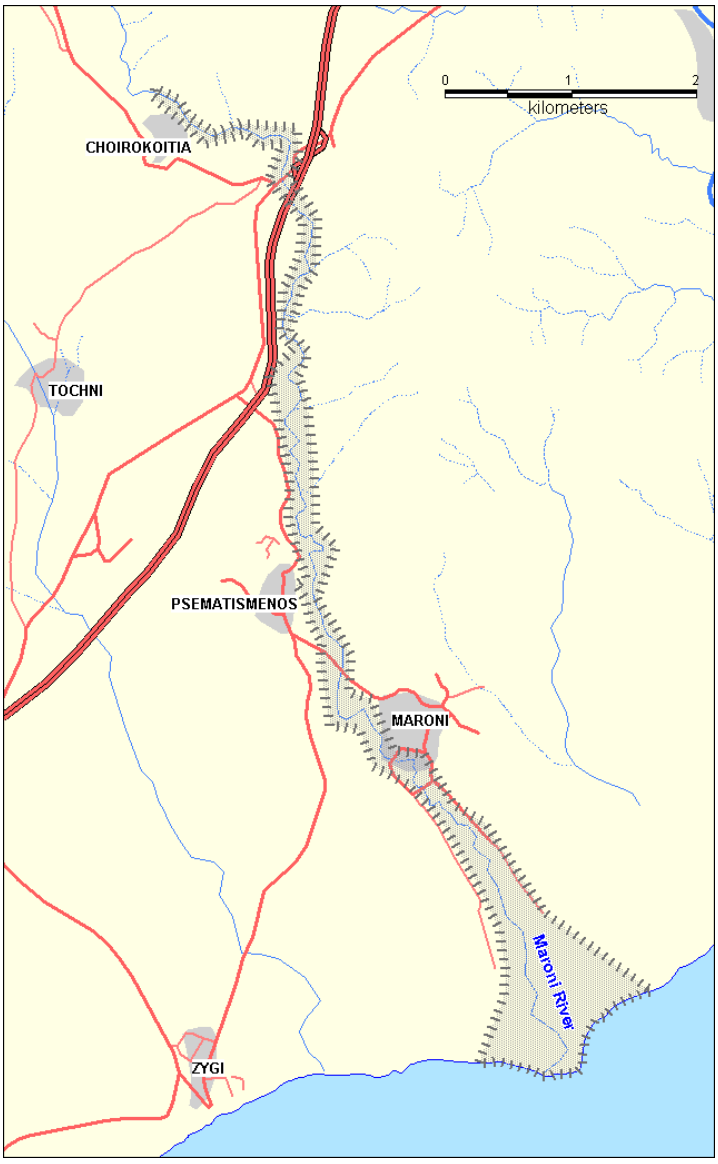
Replenishment (mcm/year)					
	Rainfall	Subsurface Inflow	Sea intrusion	Return from irrigation	Total
Average					

Outflow (mcm/year)				
	Abstraction for irrigation	Subsurface outflow	Sea Outflow	Total
Average				

Balance: -- mcm/year
Total recommended extraction -- mcm/year

MARONI RIVERBED AQUIFER

INTRODUCTION



Maroni Riverbed Aquifer - Location Map

The Maroni riverbed aquifer is a small alluvial aquifer situated thirty-two kilometers west of Larnaka town and developed along the Maroni river valley. The storage capacity of the aquifer is small and depends on river flows for recharge. Its downstream coastal part situated south of Maroni village is the most water productive. The area of Maroni is included in the Vasilikos - Pentaschoinos Project irrigation area. The aquifer has not been properly studied. Most of the information and parameters given in the following paragraphs are based on the author's experience.

The riverbed aquifer overlies the Maroni Gypsum aquifer. The two aquifers are directly connected through karstic sinkholes and other openings developed in the riverbed near the Maroni village. Groundwater infiltrates through these openings and drains the riverbed aquifer into the Gypsum aquifer thus reducing the amount of groundwater reaching the downstream part of the aquifer. The delta area of the aquifer crosses the Softades-Mazotos-Alaminos-Maroni-Zygi coastal plain aquifer. It is assumed that there is a hydraulic

connection between them but at this stage of the study there is no evidence of water interchange.

The construction of the Maroni diversion weir on the Maroni river, near Choirokoitia village, has dramatically reduced the downstream river flow and as a consequence the aquifer recharge. Rerouting of the Maroni river channel to bypass the Maroni sinkholes area resulted in an improvement of the recharge of the aquifer downstream of the sinkholes.

GEOLOGY

The impervious base of the aquifer consists of Miocene (Pachna formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1976.
EXTRACTION SURVEY: Last survey in 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 1.2 Km², WIDTH: 150m, LENGTH: 8 Km, OUTCROP: 1.2 Km².
THICKNESS: Few meters North, 12 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 370 mm, (Period 1970-2000: 390 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 15 m/day (estimated).
Average S = 8% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Around 30 boreholes operate in the aquifer extracting water for local irrigation. The yields of these boreholes vary from 2 to 5 m³/hour. Average extraction from the aquifer during the last ten years was roughly estimated to be around 0.2 mcm/year. Average natural recharge for the same period is estimated to be around 0.4 mcm/year.

Low rainfall during the last ten years has caused a reduction to river flows and as a consequence a reduction to the aquifer recharge. Sea intrusion problems have not been reported in the delta area.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 1.2 km².
Average rainfall = 370mm.

Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.1	0.0	0.3	0.4

Outflow (mcm/year)				
	Abstraction	Sea Outflow	Outflow to Gypsum Aquifer	Total
Average	0.2	0.1	0.1	0.4

Balance: **0** mcm/year.
Recommended extraction: **0.2** mcm/year.

VASILIKOS RIVERBED AQUIFER

INTRODUCTION

Vasilikos is an alluvial riverbed aquifer situated thirty-five kilometers west of Larnaka town developed along the Vasilikos river valley. It extends from the Kalavasos dam to the sea. The most water productive section of the aquifer is Its downstream, coastal part, south of Lemesos – Lefkosia motorway. Some parts of the aquifer are included in the Vasilikos - Pentaschoinos Project irrigation area.

The aquifer overlies the Maroni Gypsum aquifer. They are directly connected through karstic sinkholes and other openings developed across the riverbed 4.5 km from the sea. The groundwater of this alluvial aquifer is drained into the gypsum through these openings. For this reason the quantity of the groundwater that reaches the downstream part of the aquifer is limited. Surface water penetrates into the Maroni gypsum aquifer through the same sinkholes. The delta area of the aquifer crosses the Softades-Mazotos-Alaminos-Maroni-Zygi coastal plain aquifer. It is believed that there is a hydraulic connection between them but at this stage of the study it is not possible to evaluate the exact amount of interchange.

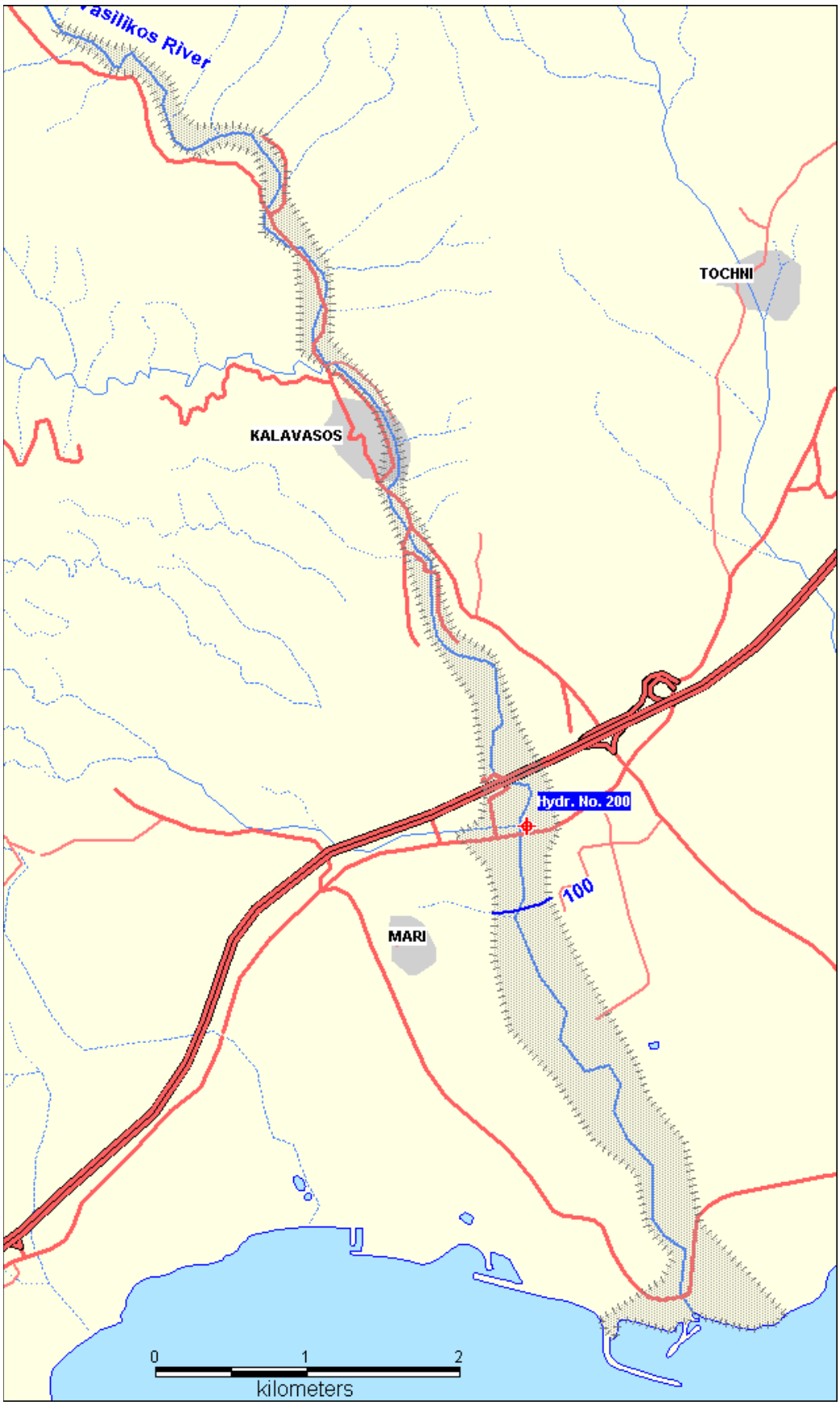
In the mid seventies a subsurface cutoff was constructed across the riverbed, 3.5 km upstream of the coast, damming the remaining groundwater flow off. The main objective was to create a subsurface dam for domestic water supply.

The construction of the 17 mcm capacity Kalavasos dam on the Vasilikos river in 1985, approximately 4 km upstream of Kalavasos village, has dramatically reduced the river flow downstream of the dam and consequently the recharge of this part of the aquifer. The natural recharge today depends on the runoff from the river catchment downstream of the dam and on the dam’s very rare spills.

The groundwater is mainly used for irrigation and for industrial purposes in the Mari village area. During the seventies and until the mid eighties there was a considerable amount of extraction for domestic supply.

GEOLOGY

The impervious base of the aquifer consists of Miocene (Pachna formation) marls, chalks and chalky marls in the downstream section, of Palaeogene (Lefkara formation) marls, chalks and chalky marls in the middle section and of igneous rocks, mainly lavas, in the upper section. The aquifer consists of alluvial deposits, gravels, sands and silts.



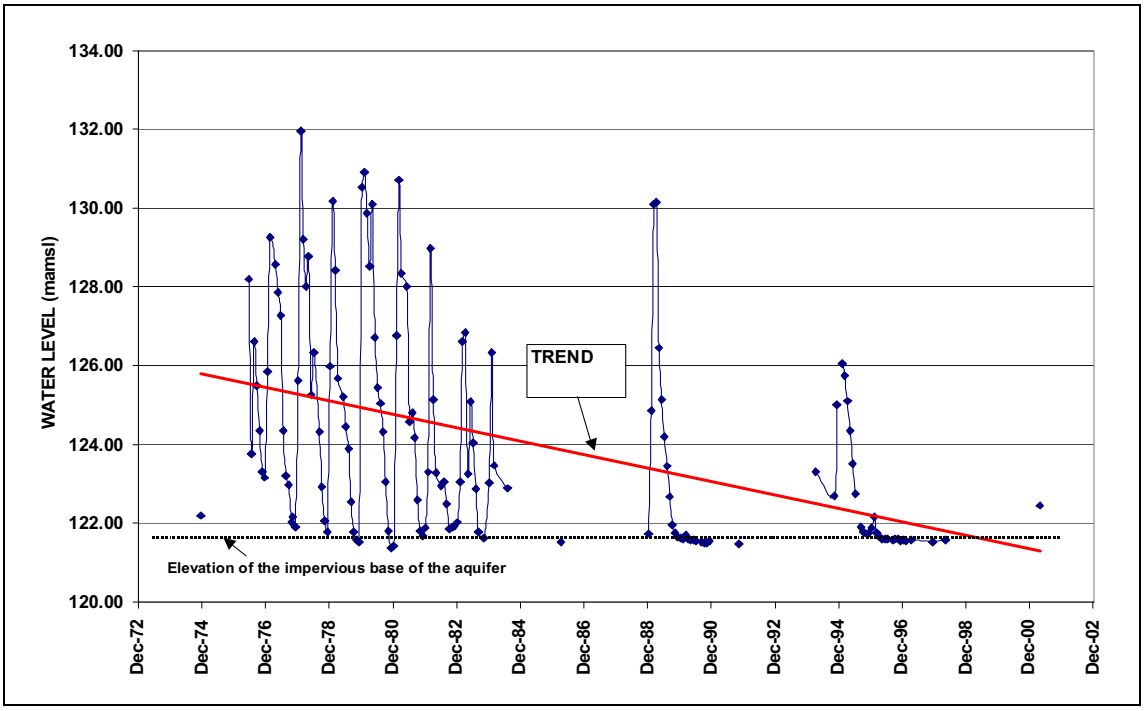
Vasilikos Riverbed Aquifer - Location Map and Water Level (m amsl) Contour Map
April 2001

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes. Every 6 months. 1 borehole.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1976.
EXTRACTION SURVEY: Last survey in 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.2 Km², WIDTH: 300m, LENGTH: 7 Km, OUTCROP: 2.2 Km².
THICKNESS: Few meters at the northern end, 30m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 390 mm (1970-2000: 410 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30 m/day (estimated).
Average S = 8% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Kalavasos 200 (Appr. elev. 138 m amsl).

HYDROGEOLOGICAL CONDITIONS TODAY

Around fifty boreholes operate in the aquifer extracting water for local irrigation and industrial purposes. Their yields vary from 5 to 15 m³/hour. The average extraction from the aquifer in the last ten years is estimated to be about 0.3 mcm/year. The average natural recharge for the same period is estimated to be about 0.6 mcm/year. The low rainfall of the last ten years has reduced the total flow of the river and the aquifer's recharge. Kalavasos dam has not spilled since1989.

The coastal part of the aquifer has been overpumped for many years. In the last five years the extraction from the aquifer has been dramatically reduced because of extensive sea intrusion.

HISTORIC GROUNDWATER BALANCE

The yearly extraction from the aquifer in 1974 and 1975 was estimated to be in the range of 0.7 to 0.9 mcm and the respective riverbed recharge in the range of 0.5 to 0.75 mcm (VASILIKOS – PENTASKINOS PROJECT, Feasibility Study, Volume III – Water Resources, Nicosia July 1977). These figures reveal overpumping as far back as 1974.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 2.2 km².
Average rainfall = 390mm.

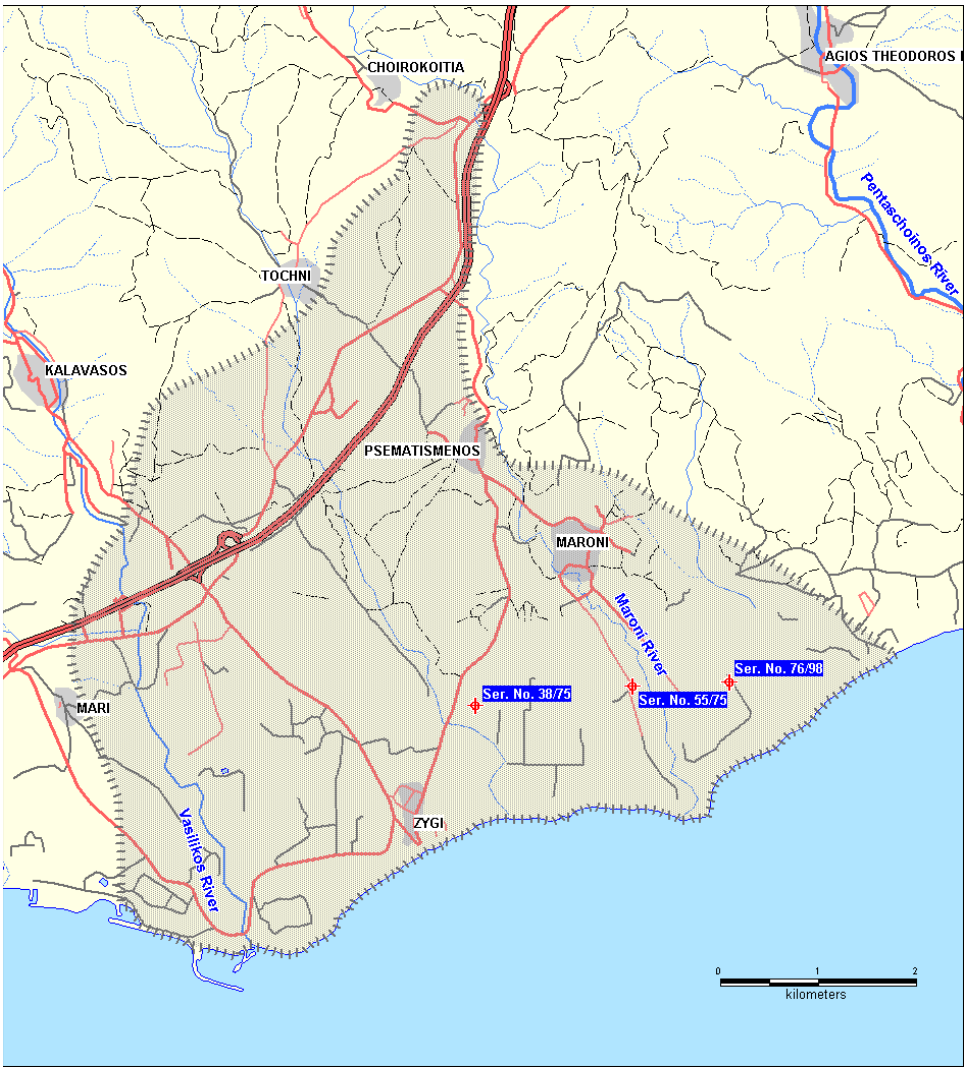
Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.1	0.1	0.4	0.6

Outflow (mcm/year)				
	Abstraction	Sea Outflow	GWT Outflow to Gypsum Aquifer	Total
Average	0.3	0.1	0.2	0.6

Balance: **0** mcm/year.
Recommended sustainable extraction: **0.3** mcm/year, concentrated mainly in the upstream section of the aquifer.

MARONI GYPSUM AQUIFER

INTRODUCTION



Maroni Gypsum Aquifer - Location Map

The Maroni Gypsum Aquifer is one of the most important aquifers in Larnaka district. The northern outcrops of the aquifer lie approximately north of the of the 45 mmsl contour line. Its Southern part is confined between impermeable marls. It is about 40m thick and dips southwards at appr. 9° inclination. At the coast, the aquifer lies 250 to 300 m below surface. The first artesian boreholes in this confined part were drilled in 1967 and were of very high yield. Until then the aquifer was discharging through springs at an elevation of about 45 m amsl in both the Maroni and Vasilikos riverbeds and most probably in the Tochni rivulet as well.

After the drilling of the first boreholes in 1967 and the lowering of the piezometric level, the already developed karstic systems around the springs functioned as sinkholes and thus river water recharged the aquifer. The main sinking area was developed in the Maroni riverbed, at the boundaries of the Maroni village. These sinkholes were operating until 1984. After this year the river was rerouted to bypass the sinkhole area, because of slope stability problems in the village. Some new recharge boreholes have been drilled in the

new riverbed, in an effort to substitute the sinkholes and the respective recharge of the aquifer.

The gypsum i.e. calcium sulfate ($CaSO_4$) is a mineral, extremely soluble in water. Groundwater in this aquifer is saturated in sulfate ions (SO_4^{--}), at levels of 1400 to 1500 mg/l.

The area of the confined aquifer is included in the Vasilikos – Pentaschoinos Project (VPP) irrigation area.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls, chalks and chalky marls of the Pachna formation.

The gypsum belongs to the Kalavasos formation of Upper Miocene age. The karstification of the Gypsum is very well developed down to an elevation of -200 to -240 m amsl. The gypsum is extended below the bottom of the sea but it is not known if it is karstified or if it contains any fresh water. It is believed that no connection exists between the aquifer and the sea. However, in the last 2 years an increase in the chloride content of groundwater pumped from depths of –150 to –130 m amsl and inexplicable rising of water levels in the aquifer are creating doubts about the “no connection” theory.

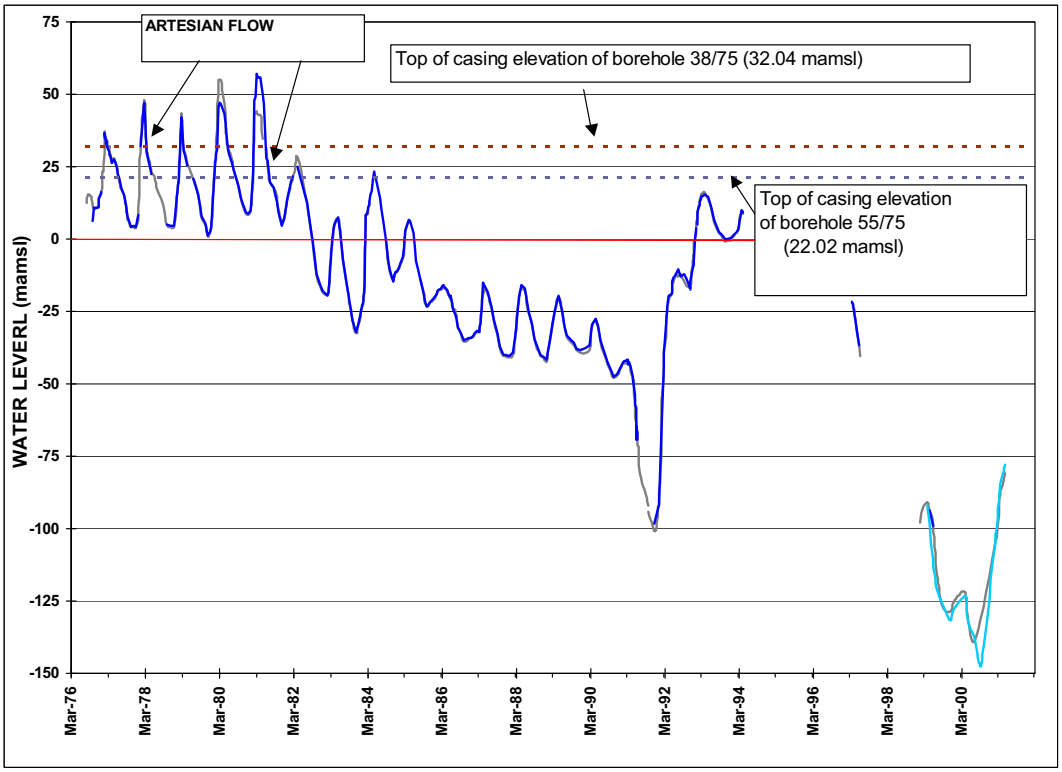
The ceiling of the confined aquifer consists of Plio/Pleistocene marls and sandy marls of the Athalassa formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, since 1975, 5 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 2 months, 4 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1976.
EXTRACTION SURVEY: Only for government boreholes (by water meters). Last general survey in 1976

AQUIFER’S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER (up to shore line): 33 Km², Width: 6 km, Length: 5 km, Accuracy of Definition: Fair, Outcrop Area: 8 Km².
AVERAGE RAINFALL: Period 1990-2000: 380 mm, (Period 1970-2000: 400 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day, from 30 to 90m/day
Average S = 0.003, from 0.002 to 0.005
BOUNDARIES: East, West and North: Impermeable. **South:** Gypsum aquifer extends into the sea.
CONFINED/UNCONFINED: Unconfined in outcrop area (North). Confined in the main aquifer area (South).
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.



Hydrograph of boreholes 38/75, 55/75 and 76/98

HYDROGEOLOGICAL CONDITIONS TODAY

The water level is uniform for the whole confined aquifer. In the spring of 2001 this water level dropped to –150 m amsl. Overpumping of the aquifer has been going on for many years. This resulted in a lowering of the water level in the aquifer, a decrease in the borehole yields, an increase in pumping costs and a further deterioration of an already inferior (because of high sulfates content) groundwater quality.

The yield of boreholes today varies between 10 to 50 m^3/hour. The water is used for irrigation (1 mcm/year) and industrial purposes (0.3 mcm/year). Part of the V.P Project irrigation demand is covered from this aquifer (0.7 – 0.8 mcm/year).

The construction of the Kalavasos dam on the Vasilikos river, the Maroni diversion weir on the Maroni river and the river rerouting away from the Maroni village sinkholes has dramatically reduced the downstream river flow and the aquifer's recharge through the sinkholes.

HISTORIC GROUNDWATER BALANCE

Rough water balance: 1975 - 76. (VPP FEASIBILITY STUDY). Average rainfall = 430mm

Replenishment (mcm/year)			
	Rainfall	River Recharge	Total
Average	0.5	2.5	3.0

Outflow (mcm/year)			
	Abstraction (irrigation)	Artesian outflow	Total
Average	1.8	1.2	3.0

Balance: **0** mcm/year

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's outcrop area: 8 km². Average rainfall: 380mm.

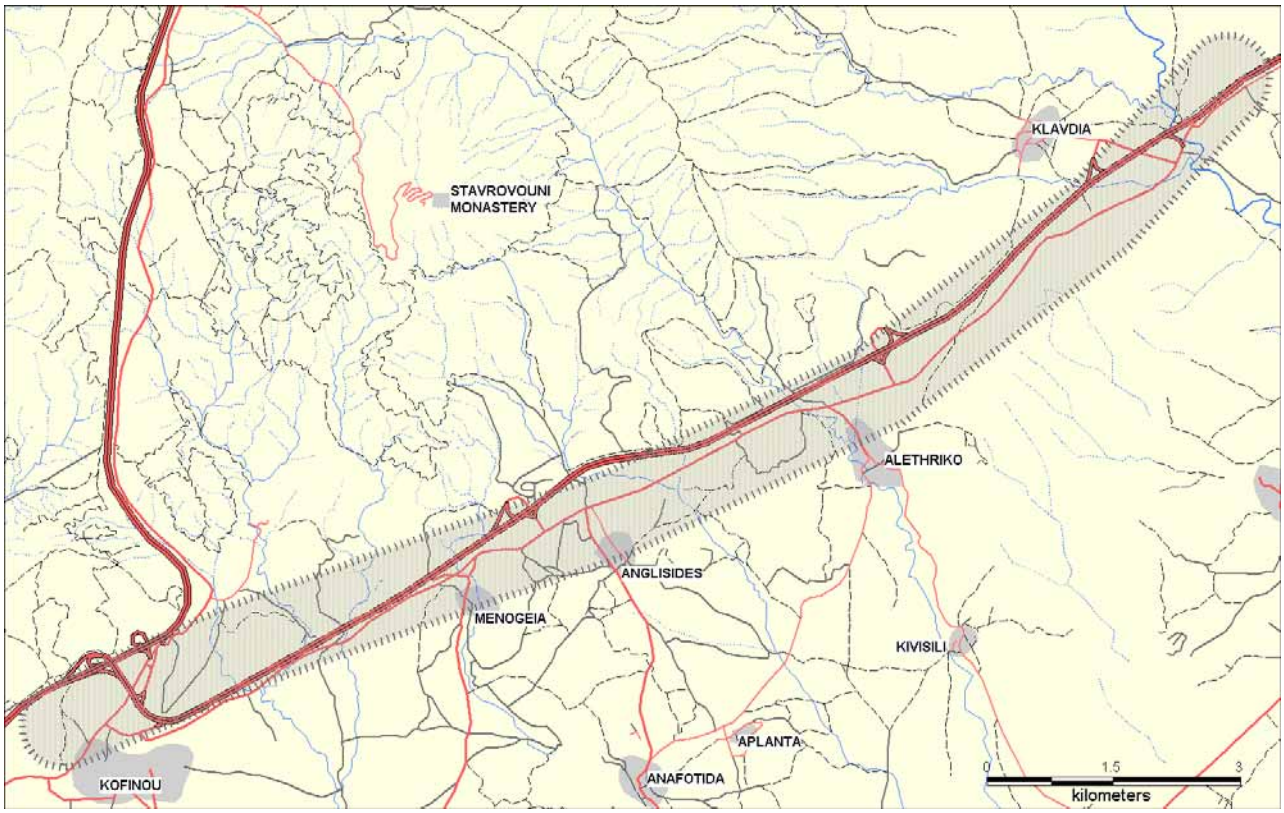
Replenishment (mcm/year)				
	Rainfall	River Recharge	Groundwater inflow	Total
Average	0.3	0.3	0.3	0.9

Outflow (mcm/year)			
	Abstraction (irrigation)	Artesian outflow	Total
Average	1.3	0	1.3

Balance: **-0.4** mcm/year
Change in storage (1991 – 2000): **- 4** mcm.
Recommended average extraction: **0.9** mcm/year.

SKARINOU – KLAVDIA FAULT ZONE AQUIFER

INTRODUCTION



Skarinou-Klavdia Fault Zone Aquifer - Location Map

Skarinou-Anglisides-Alethriko-Klavdia fault zone aquifer used to be a very important aquifer for domestic water supply for the Larnaka and Ammochostos districts and local irrigation. It is a 25 km long aquifer developed in a family of faults with a prevailing east-west direction. It is believed that some other inferred fault zones, perpendicular to this direction, e.g. the Anglisides – Anafotida fault, are hydraulically connected to the main east-west fault zone. It is therefore believed that the aquifers developed in these zones and their water regimes are interdependent. In this study these aquifers, together with the fractured zone around them, are treated as one aquifer. The width of this aquifer is not clearly defined. It is estimated to range between 0.5 to 1 km. The aquifer is neither well studied nor adequately monitored.

The aquifer is operating as a drainage channel for the aquifers developed north of it, and as a recharging boundary for the small aquifers developed in the chalks of the Lefkara formation and in fault zones south of it. An extensive section of this linear aquifer forms the contact line between the igneous and sedimentary rocks.

The aquifer has been overexploited for many years. The groundwater was distributed in the Larnaka and Ammochostos districts for domestic purposes through the Choirokoitia – Ammochostos pipeline. In places, the groundwater is saline, with chloride concentration exceeding 500 mg/liter. It can be used only in a mixture with treated surface water.

GEOLOGY

The fault zone represents a boundary between the igneous rocks, lavas and diabase and the sedimentary rocks, chalks and marls of the Lefkara formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes. Every 6 months. Few boreholes.
WATER QUALITY OBSERV. NETWORK: Yes. Only Cl. Every 6 months. Few boreholes.
ARE ALL BOREHOLES PLOTTED? : No. Last survey during the period 1975 -1983.
EXTRACTION SURVEY: Last survey in 1996.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 25 Km², WIDTH: 1 Km, LENGTH: 25 Km, OUTCROP: 25 Km².
AVERAGE RAINFALL: Period 1990-2000: 390 mm, (Period 1970-2000: 400 mm)
HYDROGEOLOGICAL PARAMETERS: Average K = 3 - 5 m/day (estimated).
Average S = 0.4 to 0.6% (estimated).
BOUNDARIES: East, West, North and South: Generally of low permeability.
CONFINED/UNCONFINED: Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Medium to high.

HYDROGEOLOGICAL CONDITIONS TODAY

The main aquifer and the small aquifers connected to it were being overpumped for many years. Overexploitation combined with low recharge in the last decade, caused the depletion of the aquifer and the abandonment of many boreholes.

The available data are not sufficient for a reliable calculation of the aquifer's water balance. The figures given in the text are based mainly on the author's rough estimations. Further study of the aquifer and collection of more reliable data are required.

It is very roughly estimated that 130 to 150 boreholes are still operating in the aquifer. The average yearly extraction in the last ten years was estimated to be between 1.2 and 1.3 mcm.

HISTORIC GROUNDWATER BALANCE

Not available

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 25 km².
Average rainfall: 390mm.

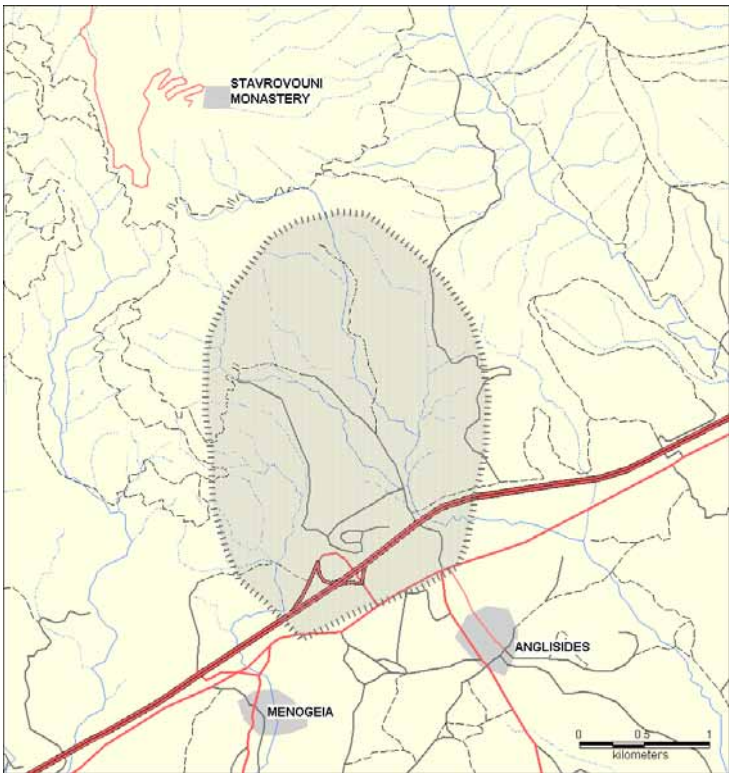
Replenishment (mcm/year)			
	Rainfall	Groundwater inflow	Total
Average	1.0	1.0	2.0

Outflow (mcm/year)			
	Abstraction	Groundwater Outflow	Total
Average	1.3	1.0	2.3

Balance: **- 0.3** mcm/year.
Recommended average extraction: **1.0** mcm/year.

ANGLISIDES LAVAS AQUIFER

INTRODUCTION



Anglisides Lavas Aquifer - Location Map

Anglisides is a small local aquifer situated in a hilly area west of Larnaka town between the mount of Stavrovouni and the Anglisides village. It is an aquifer developed in lavas and it belongs to the Troodos igneous massif (Ophiolites). It is included in this study as a typical example of one of the most common types of local aquifers developed in the Troodos massif. Anglisides is a typical small aquifer developed in igneous rocks along and around a fault zone. The aquifer has not been properly studied and it is inadequately monitored.

The sources of natural recharge of the aquifer are rainfall and groundwater inflow from surrounding igneous rocks. Low rainfall during the last decade created problems of depletion and of decreasing yields in various parts of the aquifer.

GEOLOGY

The aquifer is mainly developed in pillow lavas and in places in the Basal Group. It is formed within and around a north – south fault zone which, at its south boundary, is hydraulically connected to the east – west Skarinou – Klavdia fault zone aquifer. The position of the contact boundary line between the two aquifers has not been defined accurately.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 3 boreholes.
WATER QUALITY OBSERV. NETWORK: Occasional, only Cl^- analysis, 1 borehole.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1984.
EXTRACTION SURVEY: Yes, last one 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 6 Km², WIDTH: 2Km, LENGTH: 3 Km, OUTCROP AREA: 6 Km².
AVERAGE RAINFALL: Period 1990-2000: 400 mm, (Period 1970-2000: 410 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 3 - 5 m/day (estimated)
Average S = 0.2 - 0.5 % (estimated)
BOUNDARIES: East, West, North and South: Generally of low permeability.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Medium to High.

HYDROGEOLOGICAL CONDITIONS TODAY

Around 50 boreholes/wells operate in the aquifer today for irrigation purposes. Yields of these boreholes vary from 2 to 15 m³/hour. Average extraction from the aquifer during the last ten years varied between 0.3 to 0.4 mcm per year. Average natural recharge for the same period is estimated to be around 0.6 mcm/year.

Water level in the aquifer today is roughly 40 m lower than the level in 1995. However there is no indication of groundwater quality deterioration in the area.

HISTORIC GROUNDWATER BALANCE

Not available

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimation: Fair. Aquifer's area: 6 km².
Average rainfall: 400mm.

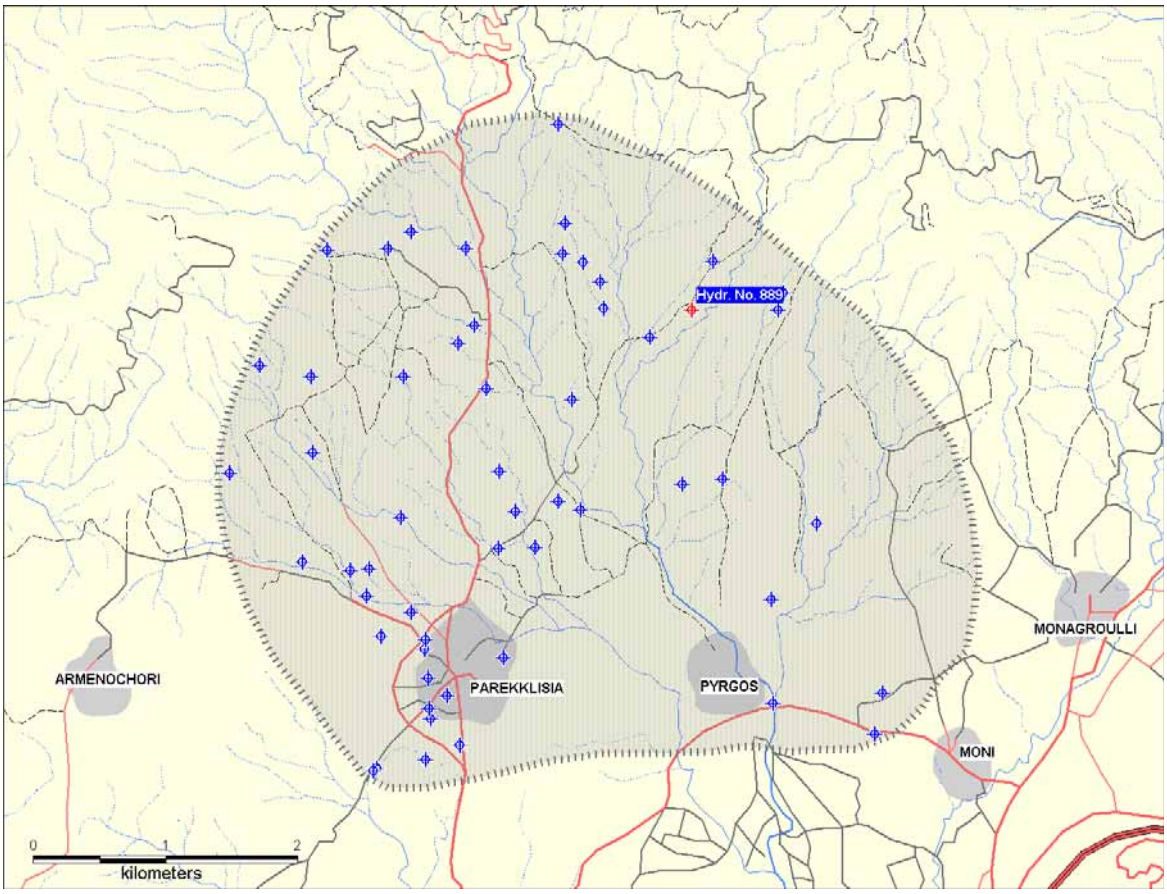
Replenishment (mcm/year)			
	Rainfall	Groundwater inflow	Total
Average	0.3	0.3	0.6

Outflow (mcm/year)			
	Abstraction	Outflow	Total
Average	0.4	0.3	0.7

Balance: **- 0.1** mcm/year.
Recommended average extraction under present conditions: **0.3** mcm/year.

PYRGOS - PAREKKLISIA AQUIFER

INTRODUCTION



Pyrgos-Parekklisia Aquifer - Location Map

Pyrgos – Parekklisia is a small local aquifer in the Limassol district, situated in a hilly area a few kilometers from the sea. It is an aquifer developed in igneous rocks and belongs to the Troodos igneous massif (Ophiolites).

Traditionally Pyrgos, Parekklisia and other surrounding villages are tomato and other vegetable producing areas. Part of the aquifer's area is included in the Southern Conveyor Project (SCP) irrigation area. The idea of replacing this water (SCP) with water from the Limassol town sewage treatment plant is under consideration.

The natural recharge of the aquifer is based mainly on rainfall and groundwater inflow from igneous rocks along its northern boundary. Low rainfall during the last decade caused depletion, which resulted in lower yields in various parts of the aquifer.

GEOLOGY

The aquifer is developed mainly in pillow lavas and in places in the Basal Group. Its upper, phreatic part is generally formed in the weathered and highly fractured surface zone. This section of the aquifer is very poor and it dries up very quickly after the wet period. The main, lower part of the aquifer is semiconfined. It is formed at depths of 130 to 150 meters and its thickness varies between 15 and 20 meters. Most probably this zone represents

the conduct between older, already fractured and weathered lavas and a younger lava flow.

The northern boundary of the aquifer, which is controlled by a fault, is in contact with Gabbros and represents a recharge boundary. The South and Southeastern boundaries consist of impermeable Mamonia and Moni Formation bentonitic clays. The eastern and western boundaries are treated as having low to zero permeability. They consist mainly of diabase. In general the boundaries of the aquifer are not clearly defined.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 50 boreholes.
WATER QUALITY OBSERV. NETWORK: Occasional, only Cl^- analysis, 20 boreholes.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: Yes, last survey in 1995.

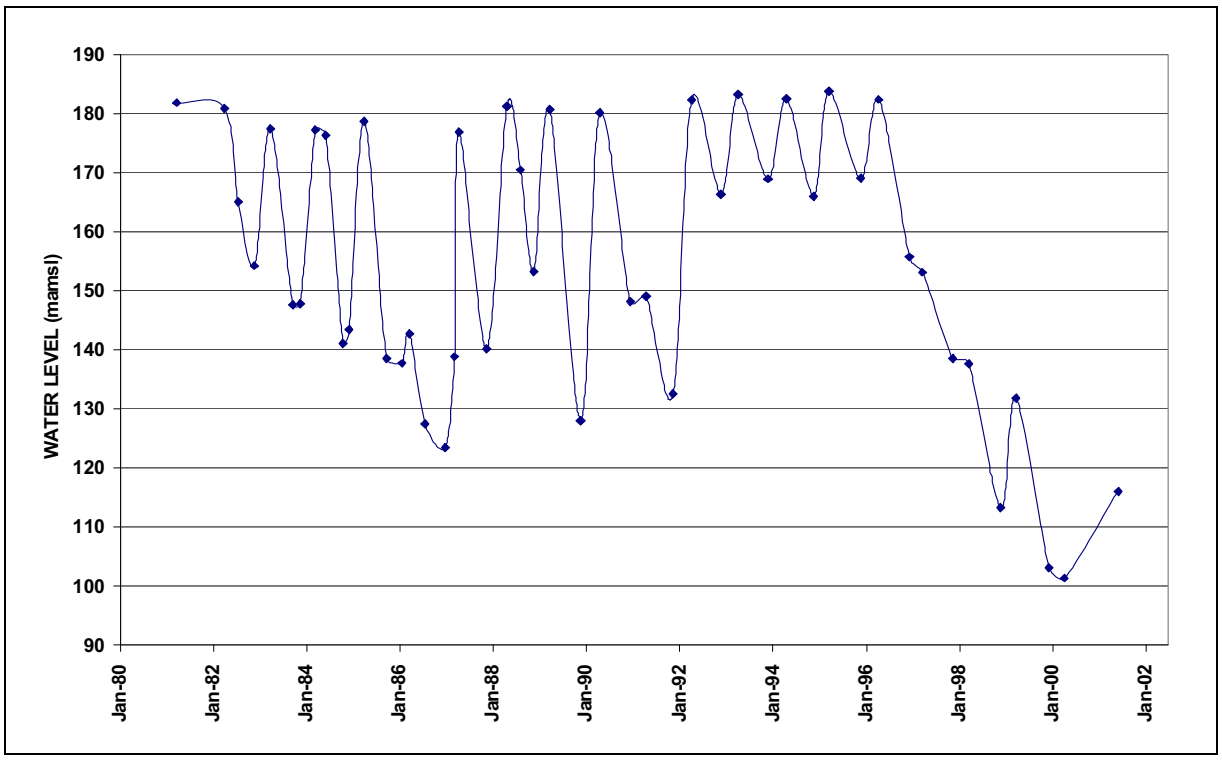
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS (Main aquifer)

AREA OF THE AQUIFER: 20 Km², WIDTH: 5Km, LENGTH: 5 Km, OUTCROP: 20 Km².
THICKNESS: 10 – 15 m.
AVERAGE RAINFALL: 1990-2000: 410 mm, 1970-2000: 430 mm.
HYDROGEOLOGICAL PARAMETERS: Average K = 5-6 m/day (estimated)
Average S = 0.2 – 0.5 % (estimated)
BOUNDARIES: North: Permeable (Inflow)**, East and West:** Semipermeable (Negligible inflow), **South**: Impermeable.
CONFINED/UNCONFINED: Confined in places.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Medium to High.

HYDROGEOLOGICAL CONDITIONS TODAY

Around 200 boreholes operate in the aquifer for irrigation purposes. The yields of these boreholes vary from 5 to 20 m³/hour. The average extraction from the aquifer in the last ten years is estimated to vary between 1.5 to 2.2 mcm per year. The average natural recharge for the same period is estimated to be about 1.5 mcm/year.

The water level of the aquifer is approximately 30 m lower than in 1990. In spite of this there is no indication of groundwater quality deterioration in the area. In general the aquifer recovers very quickly after an average hydrometeorological year.



Hydrograph of borehole Parekklisia 889 (Elev. 198.57 m amsl).

HISTORIC GROUNDWATER BALANCE

Not available

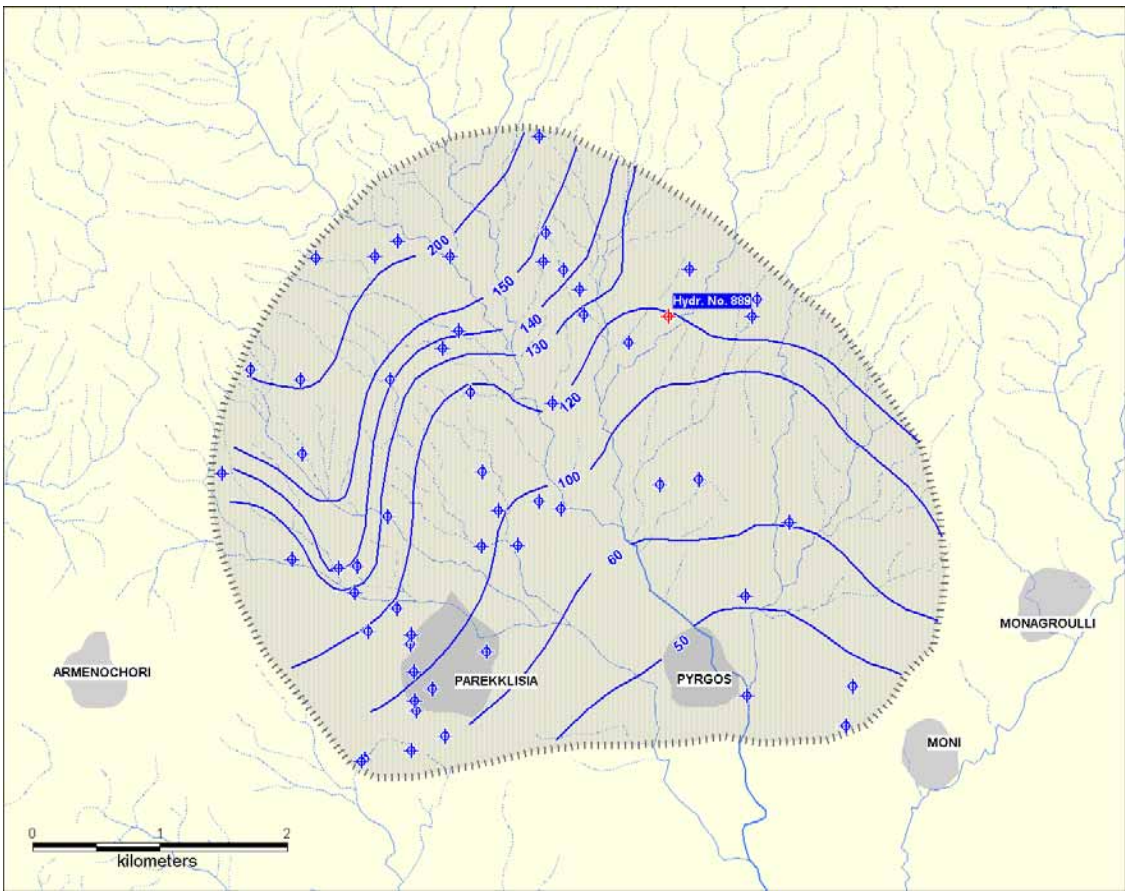
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 20 km².
Average rainfall = 410mm.

Replenishment (mcm/year)					
	Rainfall	Groundwater inflow	Return from Irrigation	Riverbed	Total
Average	0.80	0.60	0.05	0.05	1.50

Outflow (mcm/year)			
	Abstraction	Outflow	Total
Average	1.8	0.00	1.80

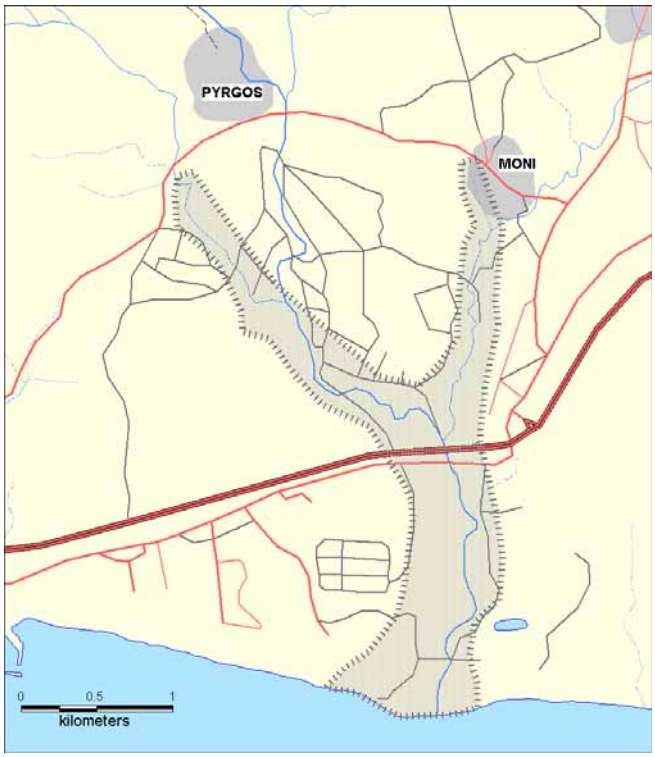
Balance: **- 0.3** mcm/year.
Recommended yield under the present conditions: **1.4** mcm/year.



Pyrgos-Parekklisia Aquifer – Water Level (m amsl) Contour Map May 2001

MONI RIVERBED AQUIFER

INTRODUCTION



Moni Riverbed Aquifer - Location Map

Moni is a small riverbed alluvial aquifer situated a few kilometers east of Lemesos town and developed along the Moni river valley. The capacity of the aquifer is small and depends on recharge from the rainfall and the occasional river flows. Even though the aquifer is still not properly studied its monitoring program has been abandoned 5 years ago. Much of the information given in the following paragraphs is a result of the author's experience.

The low rainfall of the last ten years caused a reduction to the total recharge of the aquifer.

GEOLOGY

The impervious base of the aquifer consists mainly of Palaeogene (Lefkara formation) marls, chalks and chalky marls. The base of the aquifer's upstream section consists of Cretaceous (Moni formation) bentonitic clays. The aquifer consists of alluvial deposits, silty gravels, silty sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No. Last survey before 1995.
EXTRACTION SURVEY: Last survey before 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2 Km², WIDTH: 500m, LENGTH: 4 Km, OUTCROP: 2 Km².
THICKNESS: Few meters at the northern end, 10 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 380 mm, (Period 1970-2000: 390 mm.)
HYDROGEOLOGICAL PARAMETERS: Average K = 6 - 8 m/day (estimated).
Average S = 4 -6% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Only few wells are in operational condition today. The low recharge in the last ten years has diminished the yield of the aquifer and as a consequence that of individual wells. The unreliability of the source caused by repeated dry periods is forcing farmers to abandon most of these wells. The yields of these boreholes vary from 0.5 to 2 m³/hour. The average extraction from the aquifer in the last ten years is roughly estimated to be about 0.1 mcm/year. The average natural recharge for the same period is estimated to be about 0.15 mcm/year.

No problems with sea intrusion in the delta area have been reported so far.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 2.0 km².
Average rainfall = 380mm.

Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.1	0.00	0.05	0.15

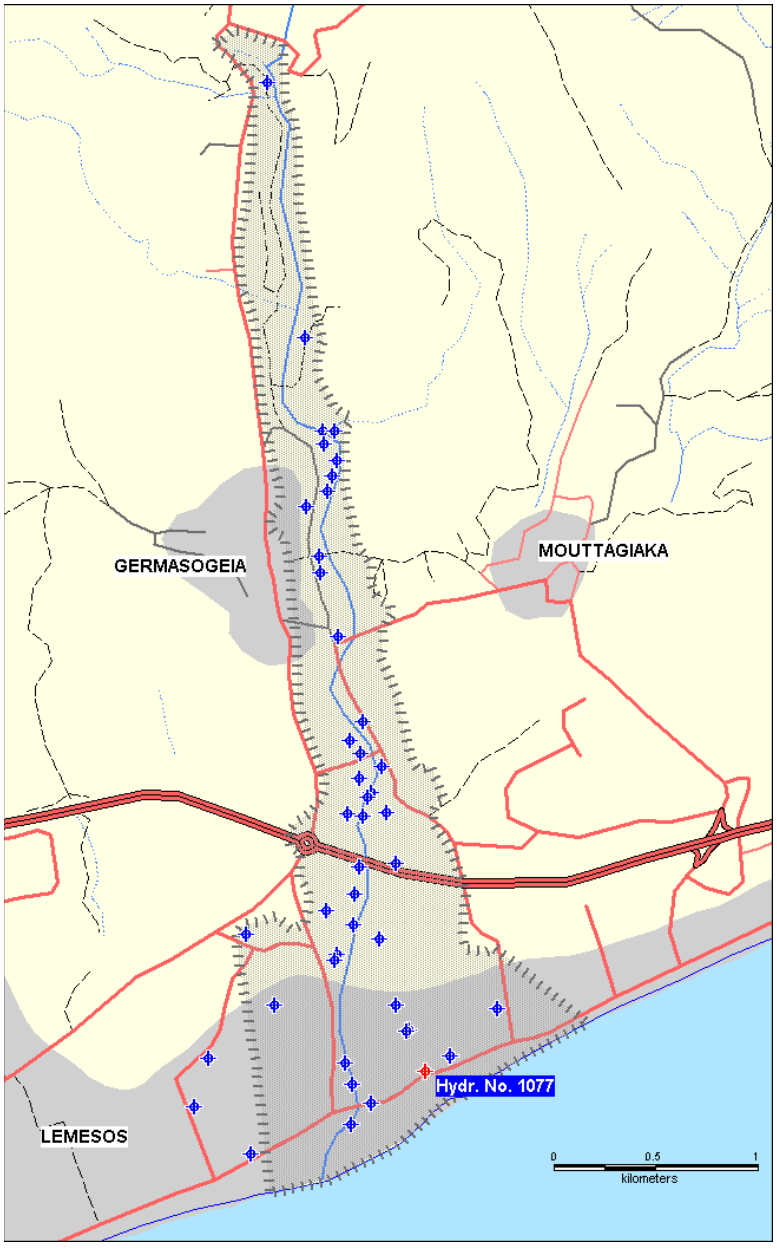
Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.1	0.05	0.15

Balance: **0** mcm/year.
Recommended extraction: **0.1** mcm/year.

GERMASOGEIA RIVERBED AQUIFER

INTRODUCTION

Germasogeia is a typical river alluvial aquifer in Cyprus developed along the Germasogeia river valley extending between the Germasogeia dam and the coast. Since the construction of the dam in 1969 the recharge of the aquifer depends on controlled releases from the dam and its spills. During the last ten years the dam spilled only twice, once in 1993 and once in 1995.



Germasogeia Riverbed Aquifer - Location Map

Germasogeia was the first aquifer in Cyprus used as a natural water treatment plant. Surface water from the Germasogeia and Kouris dams is being released in the riverbed since 1982 for recharge of the aquifer. After natural purification (SAT - Soil Aquifer Treatment), the “treated” groundwater is pumped for the domestic water supply of

Limassol town, the surrounding villages, and the tourist zone. This aquifer is the only source of domestic water supply of the surrounding villages and the tourist zone.

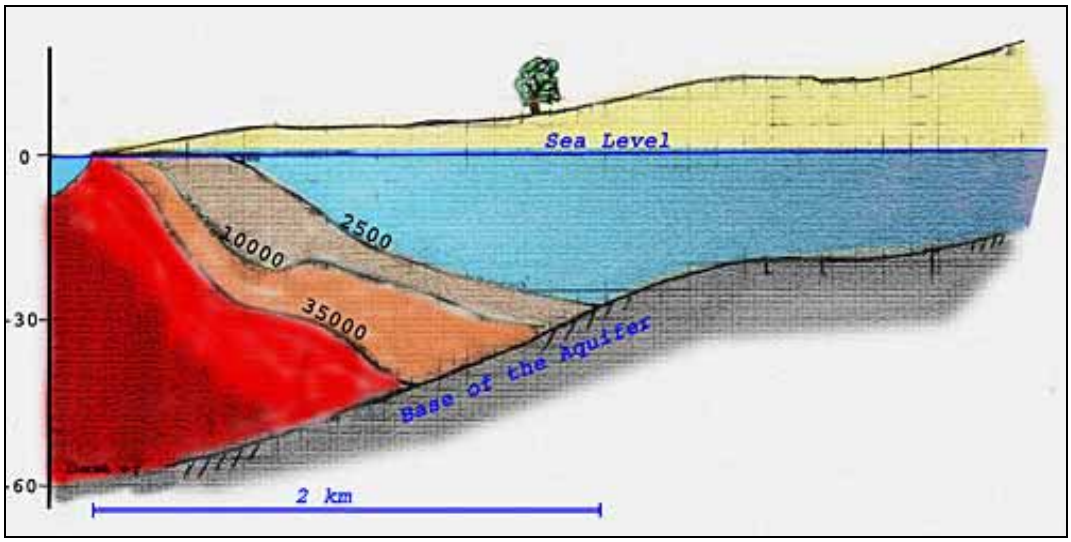
Germasogeia is the most intensively exploited aquifer in Cyprus. In 1996 up to 9 mcm of groundwater were extracted from this small aquifer, whose area is only 3 km^2 and its total fresh water capacity (based on average water level) is in the order of only 3.5 mcm.

Fast urbanization and tourist development in the area are causing rapid deterioration of this highly susceptible aquifer thus seriously endangering its future.

GEOLOGY

The impervious base of the aquifer consists mainly of the Miocene (Pakhna formation) marls, chalks and chalky marls.

The upstream part of the river alluvial aquifer i.e. the part near the dam consists of gravel and coarse sand. The permeability in this section is very high. The permeability gradually reduces downstream because of an increase in the content of fine materials such as fine sands and silts.



Germasogeia Aquifer - Electrical Conductivity (μS/cm) Cross Section
(Graphical Presentation: O. Christou)

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 15 days, 46 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, conductivity logs of 10 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, every month, by water meters.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

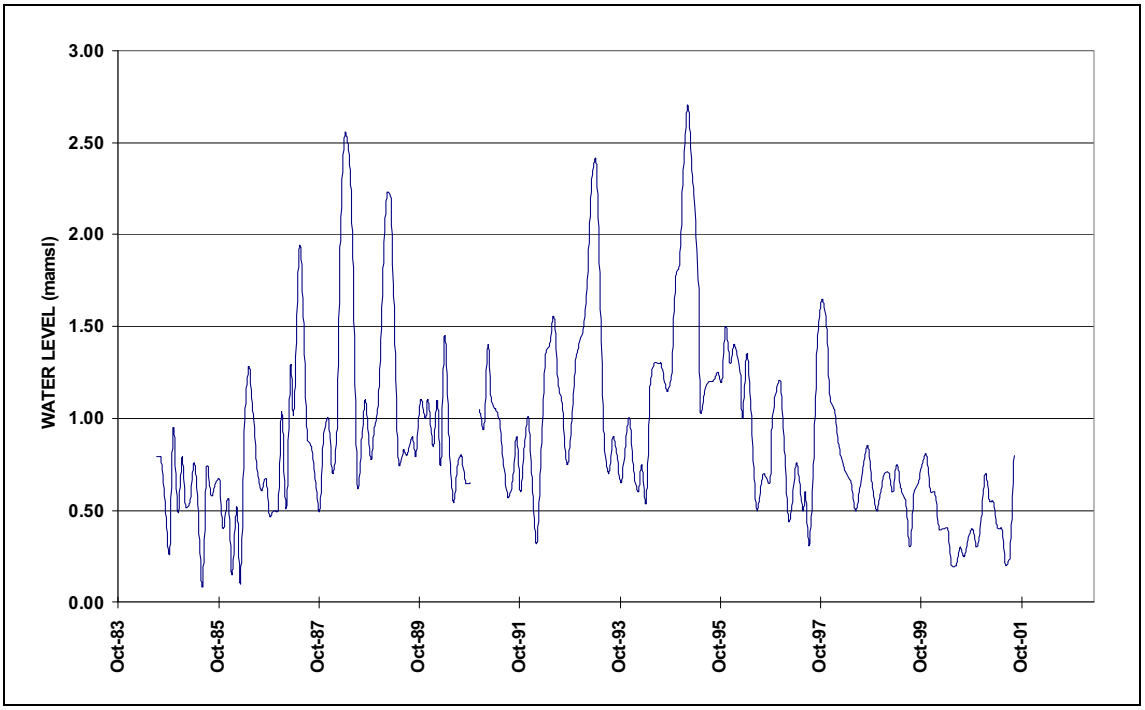
AREA OF THE AQUIFER: 3.0 Km², WIDTH: 500m (150-800m), LENGTH: 5.5 km, OUTCROP AREA: 3 Km².
THICKNESS: 30m at the dam, 55m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 410 mm, (Period 1970-2000: 450 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 130 m/day, from 80 to 350m/day
Average S = 18 %, from 14 to 22
BOUNDARIES: East and West: impermeable. **South**: Permeable, Sea. **North**: Leaking dam.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The hydrogeological regime and the water balance of the aquifer are "regulated" by controlled releases from the dam into the river valley to meet the expected demand for domestic water supply. The main targets of the aquifer's "regulation" are: a) to cover water demand with groundwater of acceptable quality, b) to protect the aquifer from sea intrusion, and c) to minimize groundwater losses to the sea.

Around 23 boreholes operate in the aquifer today for domestic water supply. Yields of these boreholes vary from 50 to 200 m³/hour. Average extraction from the aquifer over the last ten years was 6.4 mcm/year, ranging from 3.9 mcm in 1999 to 9 in 1996. The average artificial recharge for the same period, coming from Kouris and Germasogeia dam, is 5.1 mcm/year, increasing from 1.6 mcm in 1999 to 8.8 in 1992.

The aquifer is crossed by the Limassol – Nicosia highway, by locally important roads, the main SCP pipeline, the main pipeline and the irrigation network of the Germasogeia dam, the main pipelines of the Limassol –Amathous raw and treated sewage, the local sewage system, etc. It is obvious that the aquifer is under constant threat of contamination.



Hydrograph of borehole Germasogeia 1077 (Elev. 4.98 m amsl)

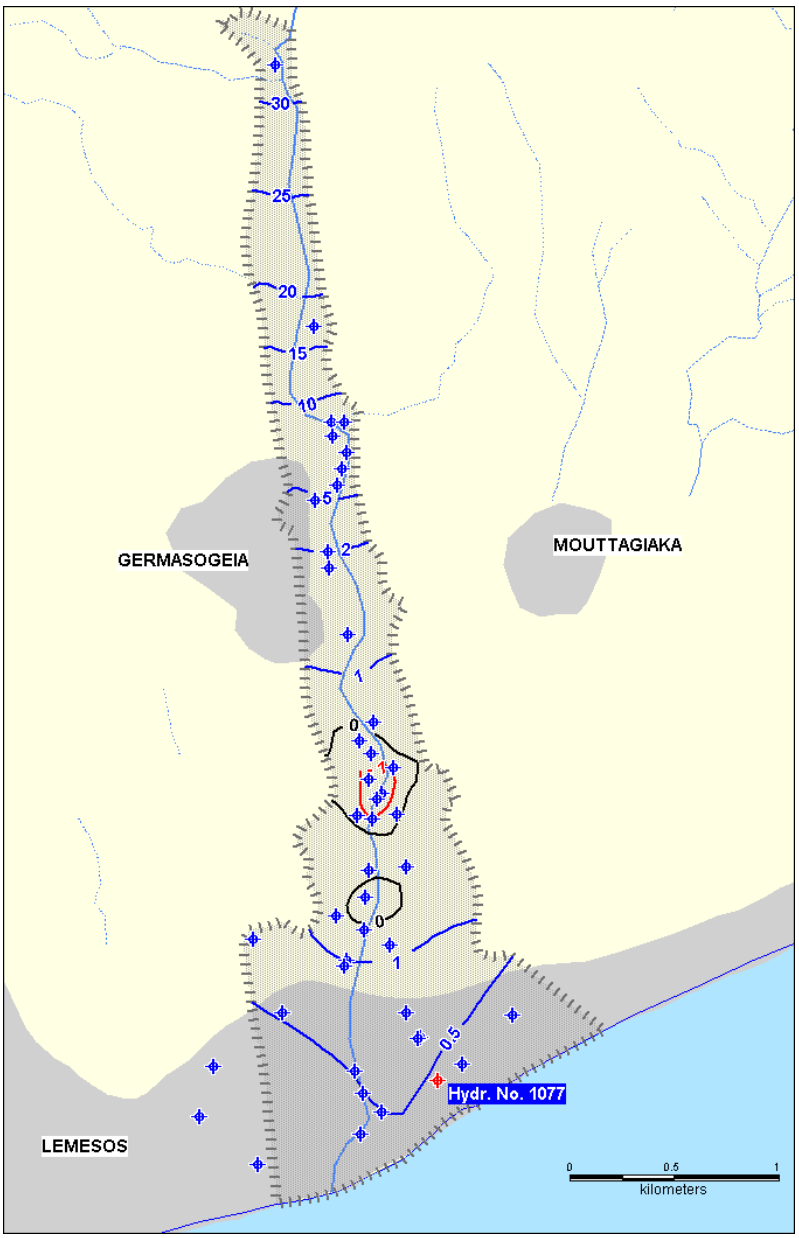
HISTORIC GROUNDWATER BALANCE

Average water balance1982– 1987 (6 years), (A. Christodoulides), result of a mathematical model. Average rainfall = 430mm

Replenishment (mcm/year)					
	Rainfall+ Return from Irrigation/Domestic	Riverbed Recharge (Runoff)	Dam Leakage	Artificial Recharge	Total
Average	0.4	0.5	1.8	3.6	6.3

Outflow (mcm/year)			
	Abstraction (domestic)	Sea Outflow	Total
Average	5.6	0.7	6.3

Balance: **0** mcm/year



Germasogeia Riverbed Aquifer - Water Level (m amsl) Contour Map November 2001

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Very Good. Aquifer's area: 3 km². Average rainfall: 400mm.

Replenishment (mcm/year)						
	Rainfall + Runoff	Dam Leakage	Sea intrusion	Return Irrig. + Domestics	Artificial Recharge.	Total
Average	0.3	1.0	0.1	0.2	5.1	6.7

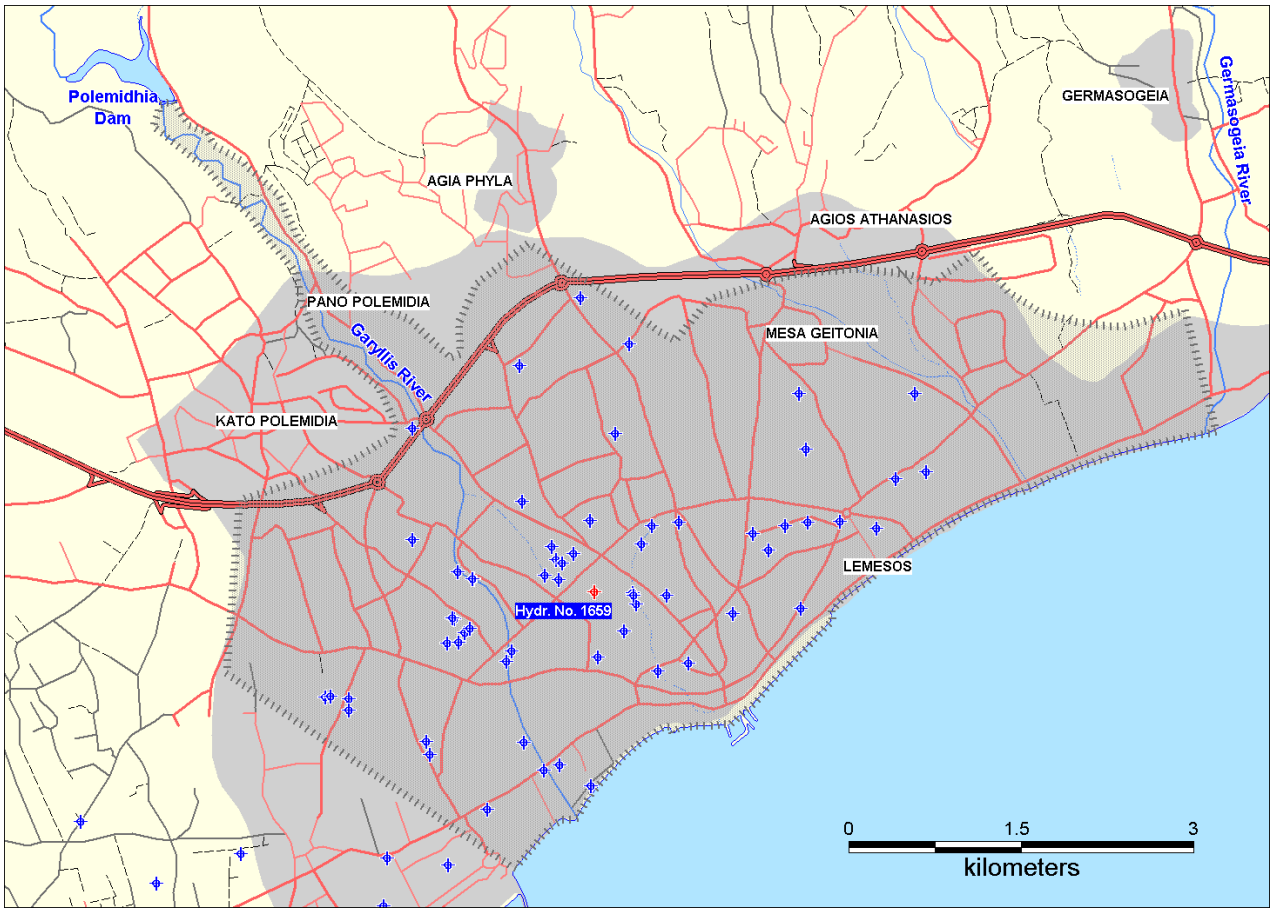
Outflow (mcm/year)			
	Abstraction (domestic)	Sea Outflow	Total
Average	6.4	0.3	6.7

Balance: **0** mcm/year
Sustainable extraction under natural conditions i.e. with no artificial recharge of the aquifer: **1.4** mcm/year (the dam leakages are included).

LEMESOS TOWN (GARYLLIS) AQUIFER

INTRODUCTION

Lemesos Town is a coastal alluvial aquifer and it used to be one of the most important aquifers in Cyprus. Together with the Akrotiri and Germasogeia aquifers they form the main groundwater resources for the Lemesos district. This aquifer, also known as the Garyllis aquifer, is a natural continuation of the Akrotiri aquifer to the east. Its separation from the Akrotiri was decided upon for practical reasons and not because of the presence of any physical separation. The entire aquifer is developed in the Lemesos Town area.



Lemesos Town (Garyllis) Aquifer - Location Map

The first boreholes in the aquifer were drilled in the early sixties by the Lemesos Water Board for domestic use. These boreholes were drilled along or near the Garyllis riverbed outside the inhabited area of Lemesos. Operation of these boreholes during the last 5 years has been irregular. When in operation extraction from them varies from 1 to 3 mcm/year. A systematic exploitation of the aquifer for irrigation in the Akrotiri area started in 1990 after a series of dry years and serious water shortages.

Up to 1995 sewage effluent absorption wells dug for each house in Lemesos Town constituted one of the two major sources of water for recharge of the aquifer. Fast urbanization of the area and direct sewage disposal in the aquifer gradually deteriorated groundwater quality. Nitrate ion concentration now exceeds 100 mg/lit. Many water supply boreholes have been abandoned because of water quality deterioration. In 1995 the first

houses were connected to the newly constructed Lemesos- Amathous central sewage system. This is gradually expanding. Today it covers around 20% to 25% of the Town area and the Tourist Zone east of Lemesos. The creation and expansion of the central sewage system resulted in a serious reduction in the contribution of sewage to the aquifer's recharge. This contribution is expected to diminish to only 10% to 15% of its original value by the mid 2010's.

After the construction of the Polemidia dam in 1965 on Garyllis river, river flows were greatly reduced and the aquifer were deprived of the second major part of its recharge. Aquifer recharge through the riverbed now depends entirely on rare spills from the dam. In the last ten years the dam has spilled only twice, once in 1993 and once in 1995.

The aquifer was seriously overpumped in the last ten and especially in the last five years in a struggle to keep the citrus plantations of the Akrotiri area alive, always expecting that next year's rainfall will be high enough to repair the adverse results of this overexploitation. Overpumping and reduction of recharge resulted in a serious deficit in the water balance of the aquifer. In the last years the general water level in the aquifer has stabilized below sea level and the inland progression of the fresh water/sea water interface has greatly increased.

GEOLOGY

The impervious base of the aquifer mainly consists of Middle Miocene marls, chalks and chalky marls, of the Pachna formation.

The sediments of the aquifer belong to Pleistocene Terrace deposits and sea or river Alluvium formations. They consist of gravels, conglomerates and sandy gravels and some silt. The thickness of the aquifer varies from few meters at its Northern impervious boundary to 60-70 meters at the coast.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, established in 1990, 30 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 1 to 2 months, 20 boreholes.
ARE ALL BOREHOLES PLOTTED? : No
EXTRACTION SURVEY: Monthly, only of public boreholes, by water meters.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

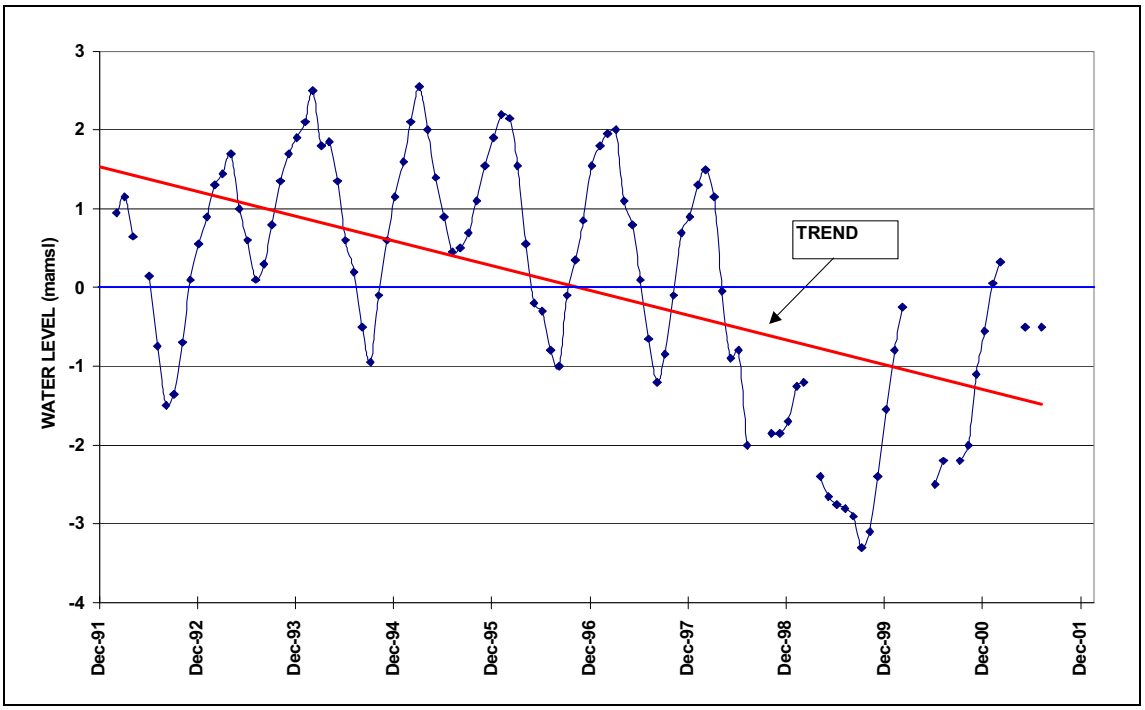
AREA OF THE AQUIFER: 20 Km², WIDTH: 3 km, LENGTH: 7 km, OUTCROP AREA: 20 Km².
AVERAGE RAINFALL: Period 1990-2000: 390 mm, (Period 1970-2000: 420 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 60 m/day, increasing from 30 m/day to 150 m/day at the west.
Average S = 8 %, from 5% to 20%
BOUNDARIES: East and North: Impermeable, some groundwater inflow.
West: Permeable, Akrotiri aquifer (no flow).
South: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Extensive overpumping of the aquifer and dramatic reduction in the recharge resulted in the contamination by sea intrusion of the most productive part of the aquifer, a 1.5 to 2 km wide coastal zone. In this zone the Chloride ion concentration exceeds 300 mg/lit and at places it reaches values up to 1800 mg/lit. Nitrate ion concentration is in excess of 100 mg/lit.

The water level in the aquifer during the last 5 years was very often near or even below mean sea level. In the early nineties there was no sea intrusion in the aquifer and it is estimated that the groundwater outflow to the sea was about 6 mcm/year. Today, this outflow does not exceed 1.5 mcm/year and the sea intrusion is estimated to be of the order of 2.5 mcm/year.

Today, only 6 to 7 government boreholes pump for irrigation of the Akrotiri area. 11 boreholes of the Lemesos Water Board and 17 or 18 government boreholes are presently not in operation because of a general deterioration in groundwater quality. The yield of boreholes in this aquifer varies from 30 to 250 m³/hour. Average extraction over the last 10 years (1991-2000) was estimated to be 6.8 mcm/year, 1.5 mcm/year being used for domestic water supply and 5.3 mcm/year being used for irrigation. The demand on these boreholes for domestic water supply varies from 0 mcm in 1997 to 3.1 mcm in 1994 while the demand for irrigation increased from 2.8 in 1993 to 8 in 1998. Private extraction for industrial use and garden irrigation is estimated to be about 1.1 mcm/year.



Hydrograph of borehole Lemesos 1659 (Elev. 22.6 m amsl)

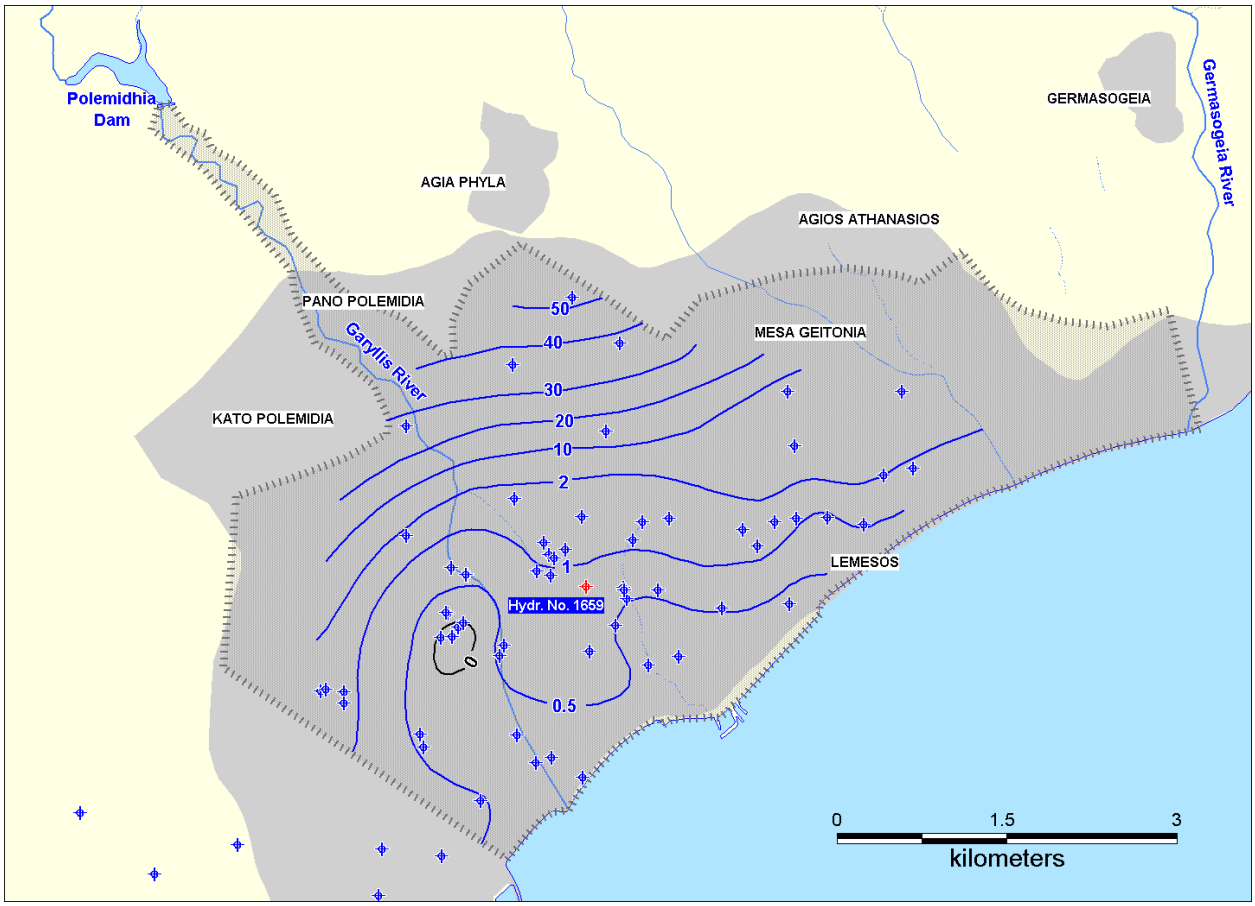
HISTORIC GROUNDWATER BALANCE

Average water balance : 1987– 1997 (11 years). (Hydrogeological Services International (HIS) – J.A. Theophilou/ Water Board of Lemesos, GARYLLIS AQUIFER STUDY, Final Report, March 1999). Result of a mathematical model applied in an area of 34.3 km². Average rainfall: 390mm

Replenishment (mcm/year)							
	Rainfall	Absorption Pits	Subsurface Inflow	Sea intrusion	W. S. network losses	Sewers losses	Total
Average	2.76	4.59	0.45	0.04	0.92	0.02	8.78

Outflow (mcm/year)			
	Abstraction irrig/dom.	Sea Outflow	Total
Average	5.57	3.22	8.79

Balance: **- 0.09** mcm/year



Lemesos Town (Garyllis) Aquifer - Water Level (m amsl) Contour Map April 2001

GROUNDWATER BALANCE TODAY

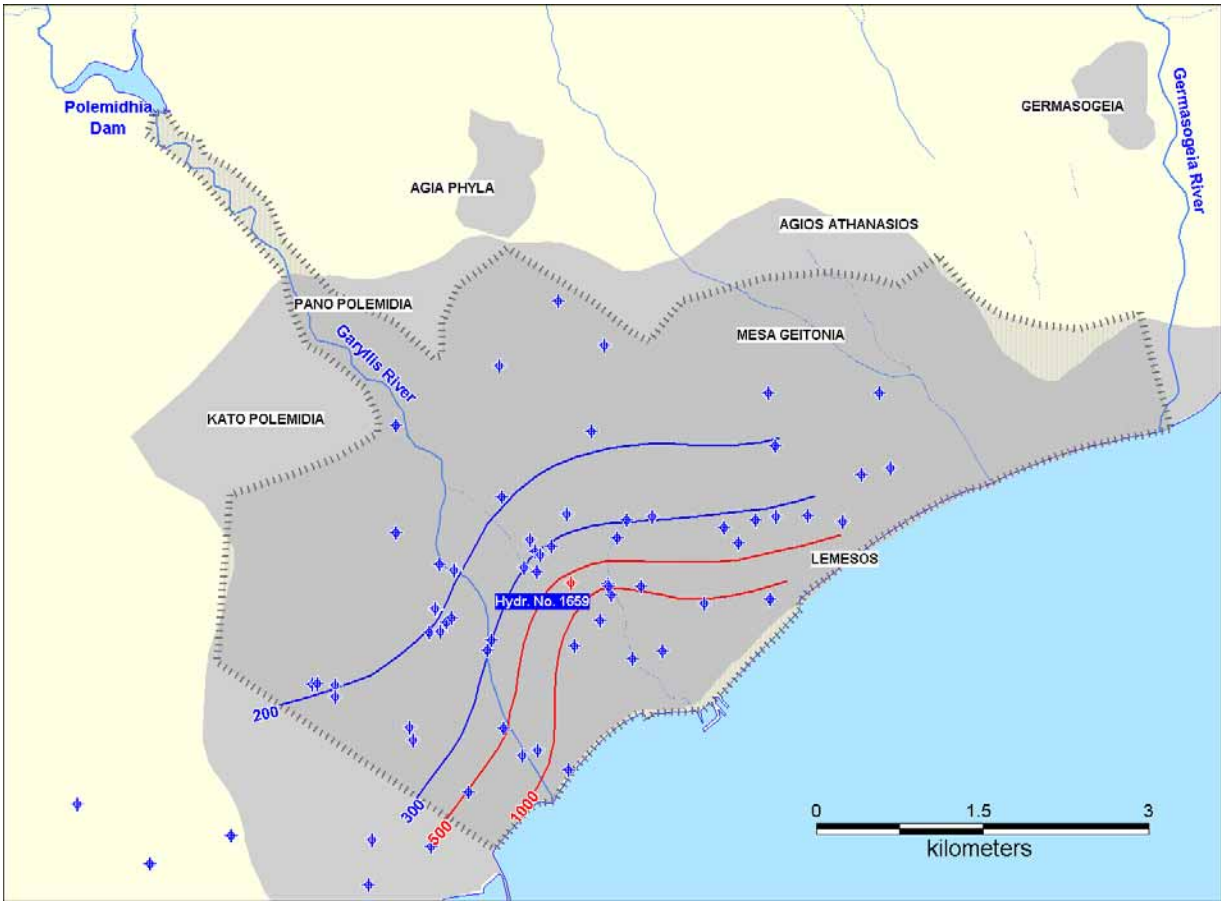
Period 1991 – 2000. Accuracy of estimations: Very Good. Aquifer's area: 20 km². Average rainfall: 390mm.

Replenishment (mcm/year)							
	Rainfall	Riverbed Recharge	Subsurface Inflow	Domestic effluent	Sea intrusion	WS network losses	Total
Average	0.4	0.2	0.4	6.5	1.5	1.4	10.4

Outflow (mcm/year)			
	Abstraction irrig/dom.	Sea Outflow	Total
Average	7.9	3.0	10.9

Fresh water balance: **-2** mcm/year
General Balance: **-0.5** mcm/year
Change in storage (1991 – 2000): **- 5** mcm (based on water level changes)
Recommended extraction until the aquifer's recovery: **0** mcm/year.

It should be noted that, when sea intrusion is taken into consideration, the real deficit in fresh water in the aquifer is greater than 2 mcm/year.
To rehabilitate the aquifer, levels of extraction and artificial recharge should be such that fresh water balance turns positive to values well above zero.

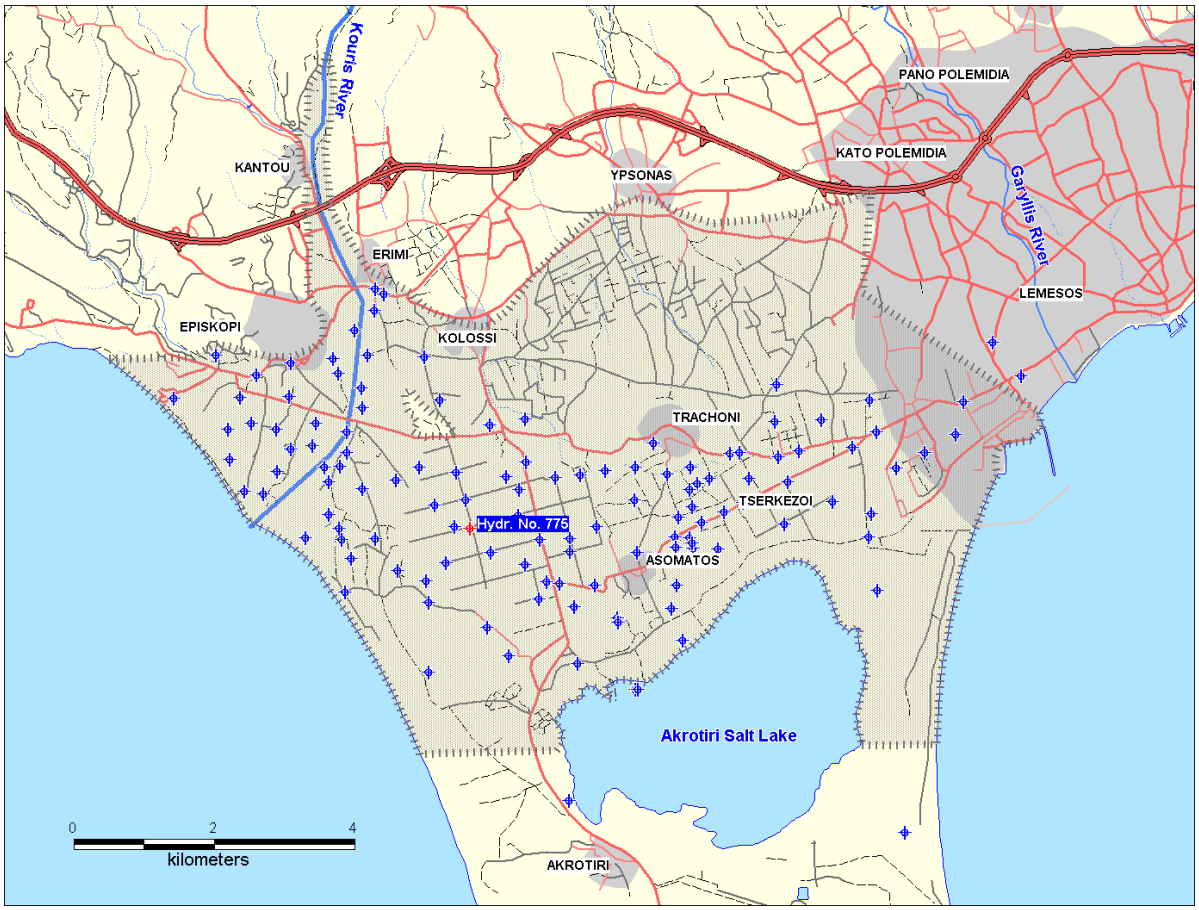


Lemesos Town (Garyllis) Aquifer – Isochlorides (ppm) Contour Map April 2001

AKROTIRI AQUIFER

INTRODUCTION

Akrotiri is the third largest aquifer in Cyprus. It is a coastal deltaic alluvial aquifer located a few kilometers west of town. The main source of its natural recharge is the Garyllis river flows in the east and the Kouris river in the west. However after the construction of Polemidia dam in 1965 on Garyllis river and the construction of the Kouris dam in 1987 on Kouris river the recharge regime changed dramatically. It now depends entirely on the rare reservoir spills and controlled releases from these dams. Kouris, the biggest dam in Cyprus, has never spilled.



Akrotiri Aquifer - Location Map

The low rainfall of the last decade has caused a decrease of water inflows to the dams. The artificial recharge of the aquifer has been interrupted because of the general water deficit in the country. Controlled recharge is achieved through releases of water from the Kouris and Yermasoyia dam in specially constructed recharge ponds. Occasionally limited quantities of water pumped from the Garyllis aquifer were also used for this purpose.

The dramatic reduction in recharge resulted in a serious deficit in the water balance of the aquifer. In the last years the general water level of in the aquifer has stabilized below sea level and the inland progression of the fresh water/sea water interface has greatly increased.

The Akrotiri region is a part of the irrigation area of the Southern Conveyor Project. During the last years, tertiary treated water from the Lemesos Sewage System was transferred to the area for direct irrigation. This water is planned to be used for aquifer artificial recharge.

GEOLOGY

The impervious base of the aquifer consists mainly of Miocene marls, chalks and chalky marls.

The sediments of the aquifer consist of Pleistocene deposits, mainly sandstones (Athalassa Formation), overlaid by river alluvial deposits. The Kouris river alluvial deposits, in the western part of the aquifer are much coarser than the Garyllis river deposits in the eastern part. The thickness of the aquifer, at its deepest sections, is 130 to 140m.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, since 1960, 150 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, last sampling in 2000, 85 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes, last update in 2000
EXTRACTION SURVEY: Yes, every month, by water meters.

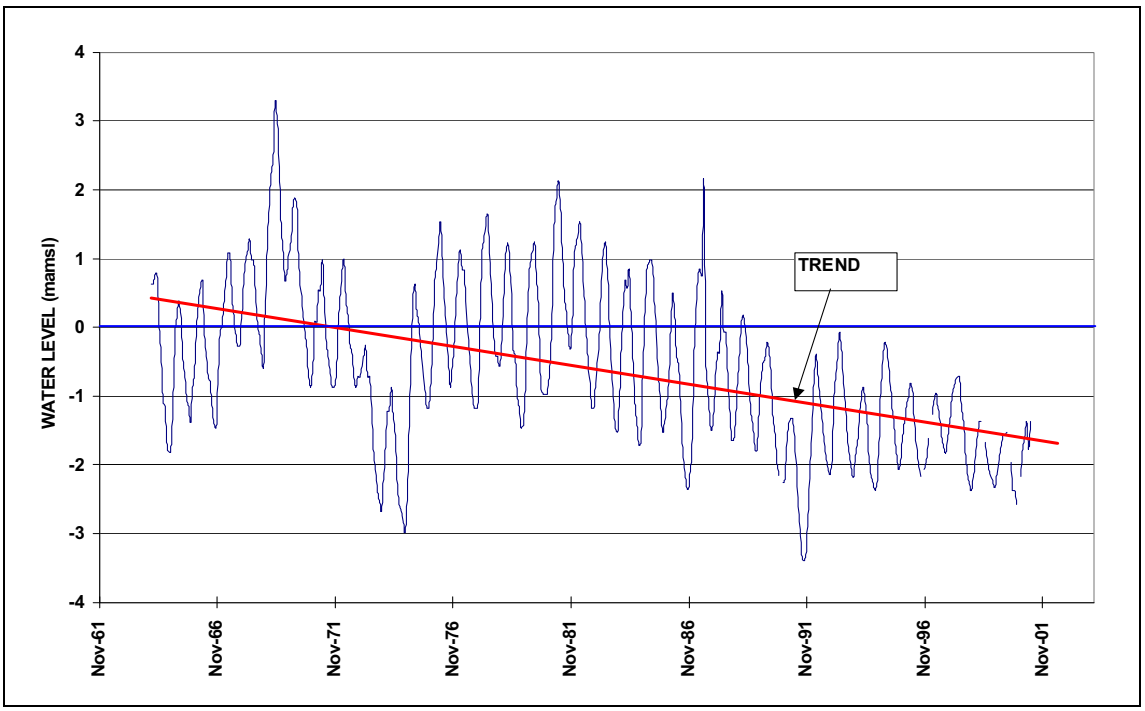
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 53 Km², WIDTH: 10 km, LENGTH: 5 km, OUTCROP AREA: 53 Km².
AVERAGE RAINFALL: 1990-2000: 380 mm, 1970-2000: 430 mm.
HYDROGEOLOGICAL PARAMETERS: Average K = 100 m/day, ranging from 30 to 300 (west).
Average S = 15 %, ranging from 8 to 20
BOUNDARIES: **East:** Permeable, Garyllis aquifer (no flow).
South: Permeable, Sea and Salt Lake.
West and North: Impermeable in places: some groundwater inflow.
CONFINED/UNCONFINED: Unconfined, locally semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

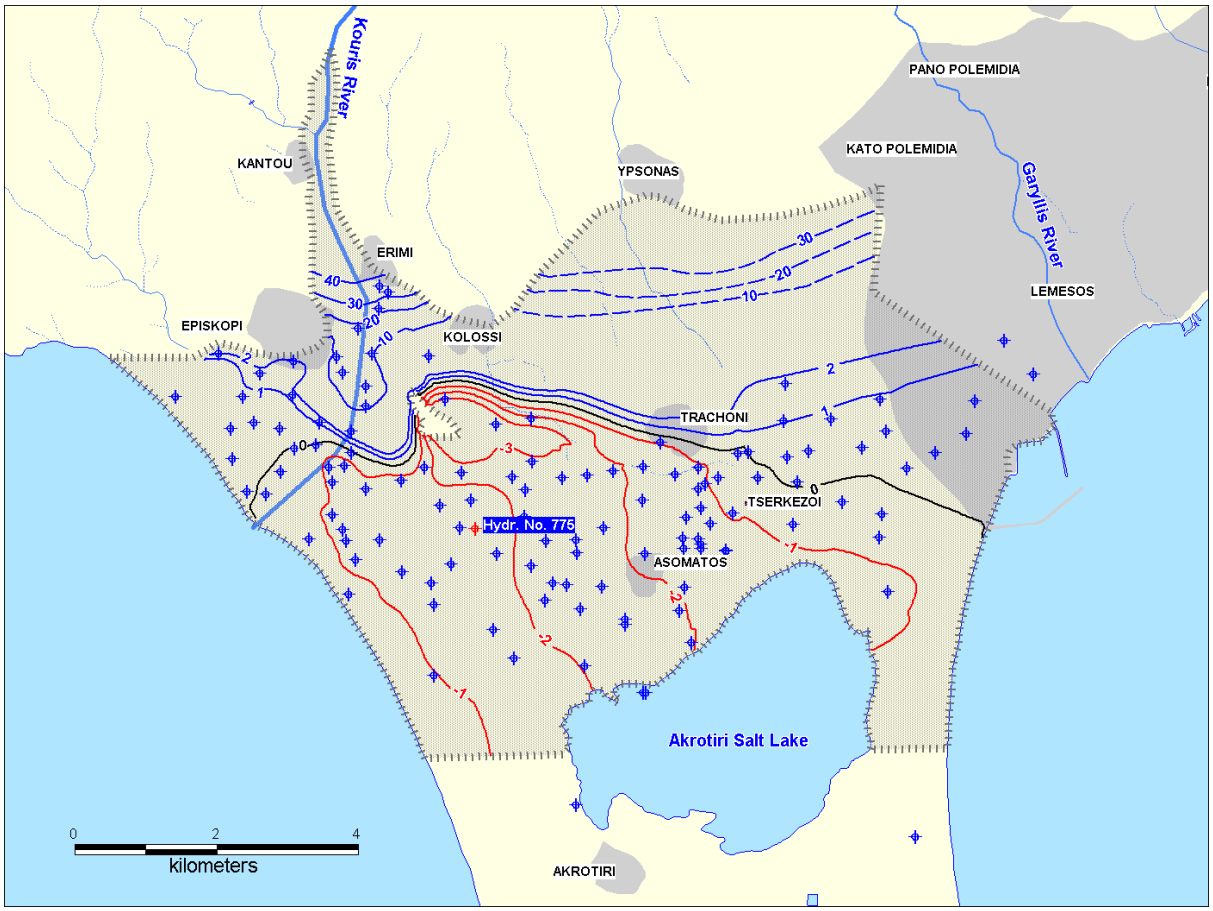
HYDROGEOLOGICAL CONDITIONS TODAY

The coastal parts of the aquifer, where the thickness exceeds 100m, have been sea intruded during the last five years due to low recharge and illegal overpumping of the aquifer. The intensive use of fertilizers in agriculture resulted to nitrate contamination of the aquifer. The concentration of nitrate ion in the eastern part of the aquifer is in excess of 200 mg/lit.

It is estimated that today, around 400 boreholes operate in the area. Yields of these boreholes range from 20 to 200 m³/hour. The average extraction in the last ten years is 10.8 mcm/year, decreasing from16 mcm in 1991 down to 5.8 mcm in 2000. The average artificial recharge for the same period is 3.3 mcm/year, ranging from 5.4 mcm in 1993 to 0.4 mcm in 2000.



Hydrograph of borehole Akrotiri 775 (Elev. 15.63 m amsl)



Akrotiri Aquifer - Water Level (m amsl) Contour Map March 2001

HISTORIC GROUNDWATER BALANCE

Average water balance: 1967/68 – 1976/77 (10 years). (SCP FEASIBILITY STUDY), result of a mathematical model applied in an area of 40 km². Average rainfall: 395 mm

Replenishment (mcm/year)							
	Rainfall	Riverbed Recharge	Subsurf. Inflow	Sea intrusion (Sea/S. Lake)	Return abstract	Return imp./Diver	Total
Average	5.9	15.4	4.2	0.7	4.5	3.5	34.2

Outflow (mcm/year)					
	Abstraction irrig/dom.	Evapotrans	Rising water	Sea/Lake Outflow	Total
Average	14.5	2.5	2.2	16.0	35.2

Balance: **- 1** mcm/year
Change in storage 1967/68 – 1976/77 (10 years): **- 9.6** mcm

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Very Good. Aquifer's area: 53 km². Average rainfall: 380mm.

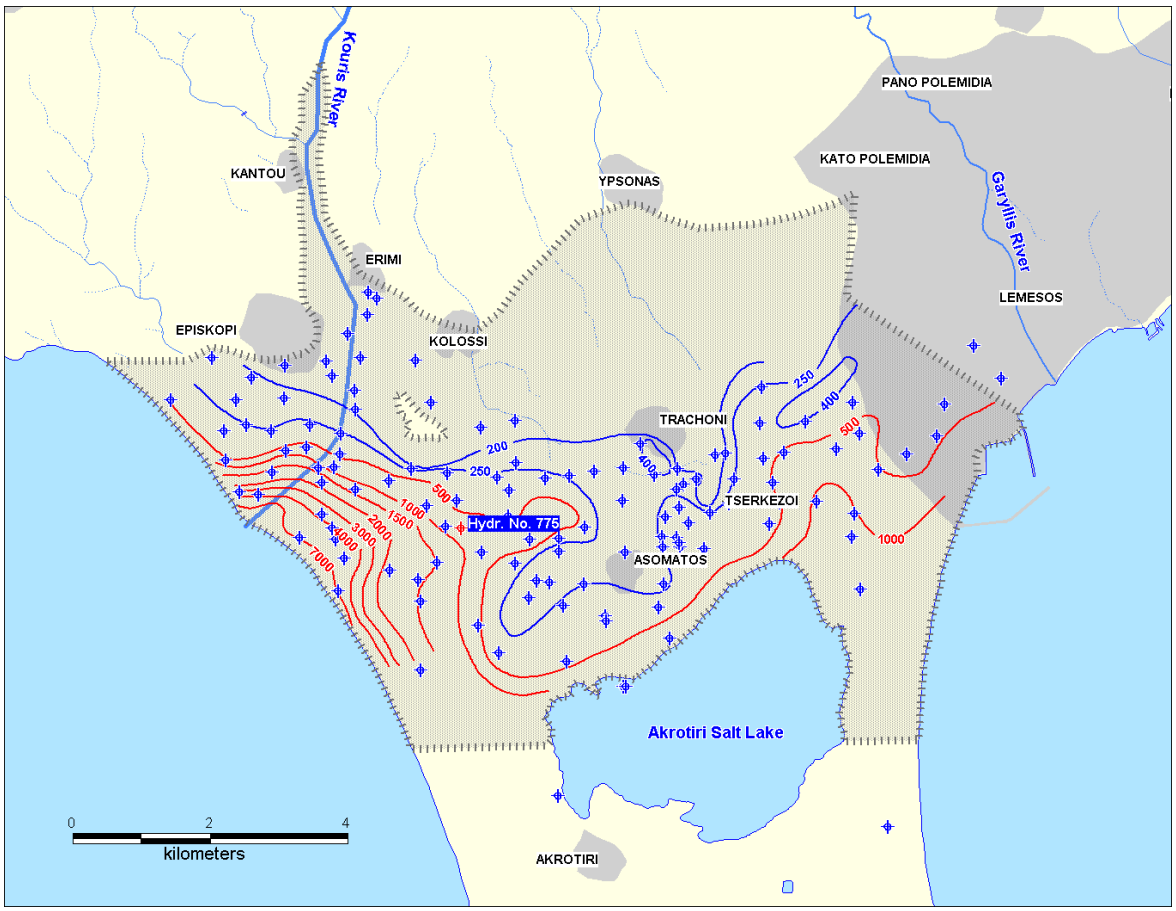
Replenishment (mcm/year)								
	Rainfall	Riverbed Recharg.	Subsurf. Inflow	Sea/lake intrusion	Return abstract.	Return Import.	Artificial Rechar.	Total
Aver.	4.2	0.5	0.2	**3.0**	1.1	0.7	3.3	13

Outflow (mcm/year)					
	Abstraction irrig/dom.	Evapotran.	Rising water	Sea/Lake Outflow	Total
Average	10.8	2.4	0.3	0.5	14

Fresh water balance: **- 4** mcm/year
General Balance: **-1** mcm/year
Change in storage (1991 – 2000): **-10** mcm (based on water level changes)
Recommended extraction until the aquifer's recovery: **0** mcm/year.

It should be noted that, when sea intrusion is taken into consideration, the real deficit in fresh water in the aquifer is greater than 4 mcm/year.

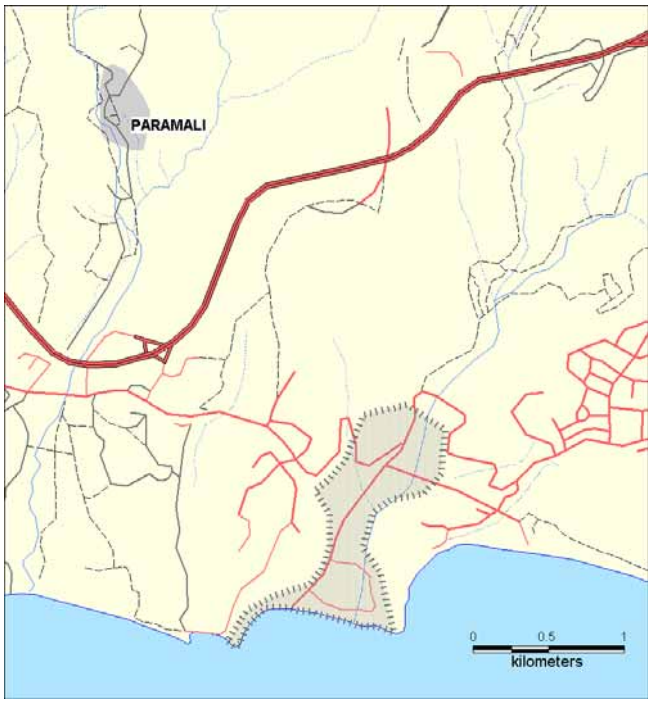
In order to stop further deterioration of groundwater and bring about rehabilitation of the aquifer, levels of extraction and artificial recharge should be such that fresh water balance turns positive to values well above zero.



Akrotiri Aquifer - Isochloride (ppm) Contour Map April 2001

SYMVOULOS RIVERBED AQUIFER

INTRODUCTION



Symvoulos Riverbed Aquifer - Location Map

Symvoulos is a small alluvial aquifer situated a few kilometers west of Lemesos town and developed along the Symvoulos river valley. It is situated within the British Sovereign Bases and it extends from Symvoulos dam to the sea. The aquifer capacity is small and its recharge depends entirely on rainfall. After the construction of the dam, by British, at the end of the eighties and grouting carried out in the mid nineties to suppress very high reservoir losses through karstic channels, recharge from river water has drastically diminished. The dam has never spilled. Groundwater as well as recycled water was used for the irrigation of several playgrounds in the valley. The delta area is aquifer's most water productive part. Even though the aquifer is not properly studied it is not monitored. Much of the information given in the following paragraphs is based on the author's experience and some old information.

GEOLOGY

The impervious base of the aquifer consists mainly of Miocene (Pachna formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, silty gravels, silty sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0.5 Km², WIDTH: 250 m, LENGTH: 2.0 Km, OUTCROP: 0.5 Km².
THICKNESS: Few meters at the northern end, 10 - 15 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 380 mm, (Period 1970-2000: 390 mm)
HYDROGEOLOGICAL PARAMETERS: Average K = 6 - 8 m/day (estimated).
Average S = 4 -6% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Only few wells have been drilled in the aquifer. They have been constructed for the British Bases and according to the latest information they are not in use today. Low aquifer recharge in the last years caused a reduction to the aquifer yield and the yield of the boreholes. The average natural recharge for the same period is estimated to be about 0.15 mcm/year.

No problems with sea intrusion in the delta area have been reported in the last few years.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 0.5 km².
Average rainfall: 380mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.03	0.00	0.00	0.02	0.05	0.10

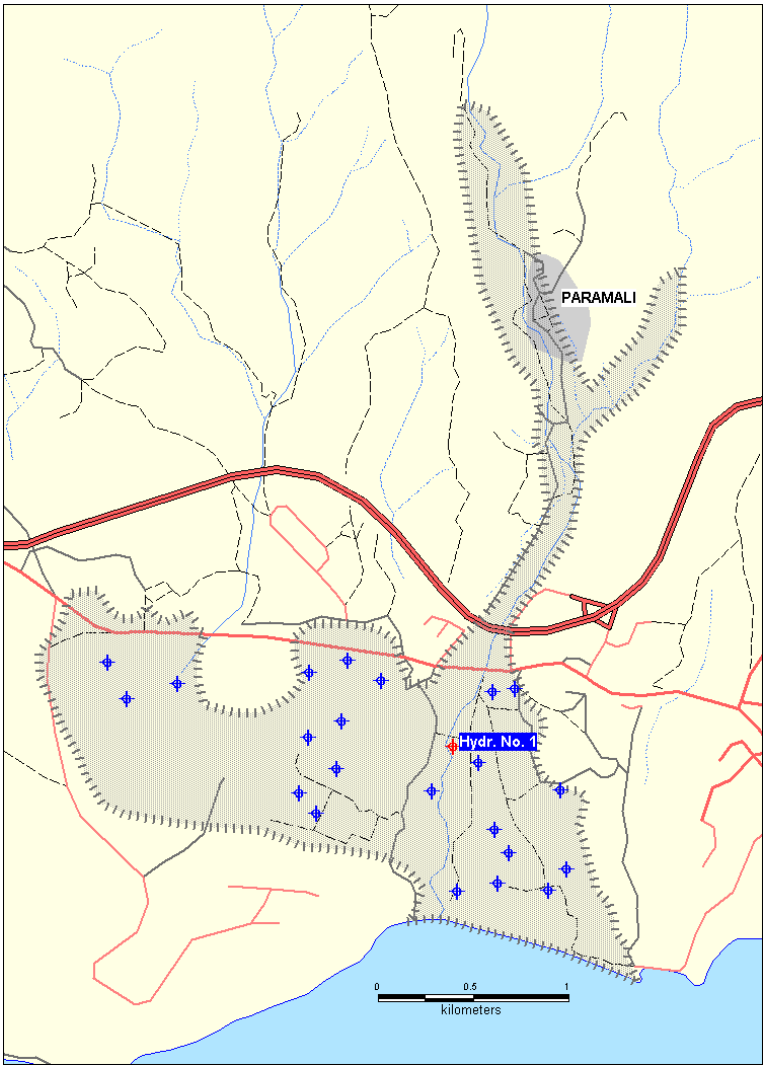
Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.0	0.10	0.10

Balance: **0** mcm/year.
Recommended average extraction: **0.07** mcm/year.

PARAMALI AQUIFER

INTRODUCTION

Paramali is a small coastal alluvial aquifer situated twenty-five kilometers west of Lemesos town. Paramali used to be a traditional vineyards area. In the last decade the irrigated area has been doubled, mainly by expansion of citrus plantations.



Paramali Aquifer - Location Map

After the construction of a diversion weir on the Shapanis river, in the early eighties, the recharge of the aquifer has been reduced dramatically. Now the recharge depends almost entirely on local rainfall and the occasional short time weir overflows. During the last years the weir overflowed only a few times. The purpose of this diversion weir was to cover the vineyards irrigation demand in the villages Paramali and Avdimou. For the same purpose some quantities of water are being diverted from Kryos river, a Kouris river tributary, to Shapanis riverbed. The total amount of water that could be diverted by the weir on Shapanis river was estimated to vary between 1.5 to 2 mcm per year.

Low rainfall in the last decade resulted in lower river flows and consequently in lower diverted quantities which are used for irrigation only in the Avdimou area. Pumping from

the Paramali aquifer covers the demand for irrigation in the Paramali area. The reduction of the natural recharge of the aquifer in conjunction with overpumping resulted in the contamination of the aquifer by sea intrusion.

GEOLOGY

The eastern and most water productive part of the aquifer is developed in the Shapanis river delta area. Some of the sediments of its western part were most probably developed under conditions of slow circulating water. This part of the aquifer is less productive and the groundwater here is of high salinity with Chloride ion concentration exceeding 500 mg/lit.

The impervious base of the aquifer consists mainly of Miocene (Pachna formation) marls, chalks and chalky marls. The eastern part of the aquifer consists of alluvial deposits, gravels sands with some silty lenses and its western part of Plio/Pleistocene silts, silty sands, gravels and sandstones of the Nicosia/Athalassa formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 15boreholes.
WATER QUALITY OBSERV. NETWORK: Occasional, only Cl^- analysis, 17 boreholes.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: Occasional, last survey 2001.

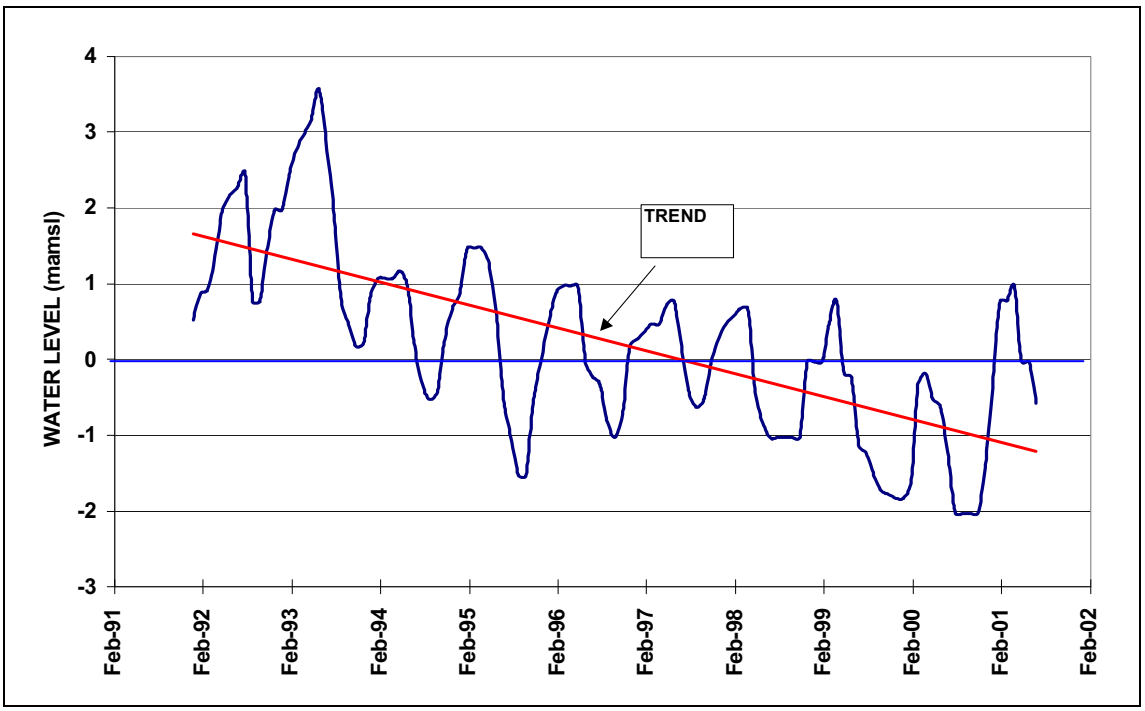
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.5 Km², WIDTH: 1Km, LENGTH: 2.5 Km, OUTCROP: 2.5 Km².
THICKNESS: 10m at the western part, 45m along the coast at the eastern part.
AVERAGE RAINFALL: Period 1990-2000: 390 mm, (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30 m/day, from 10 to 40m/day
Average S = 8 %, from 4 to 15
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Coastal, phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Forty-one boreholes operate in the aquifer: three are used for domestic water supply (two for the British Bases) and thirty-eight for local irrigation. Some of them are illegal. Their yields vary from 5 to 50 m³/hour. The average extraction from the aquifer in the last ten years is about 0.6 mcm/year. A quantity of 0.45 mcm/year is used for irrigation and 0.15 mcm/year is used for domestic water supply. The average natural recharge for the same period is estimated to be about 0.25 mcm/year.

Water levels in the greater part of the aquifer are below mean sea level resulting in very fast inland propagation of the sea front. The most productive part of the aquifer is already contaminated by seawater. The concentration of chloride ions in the groundwater varies from 250 to 3500 mg/lit (April 2001).



Hydrograph of borehole Paramali 1 (Elev. 15.97 m amsl)

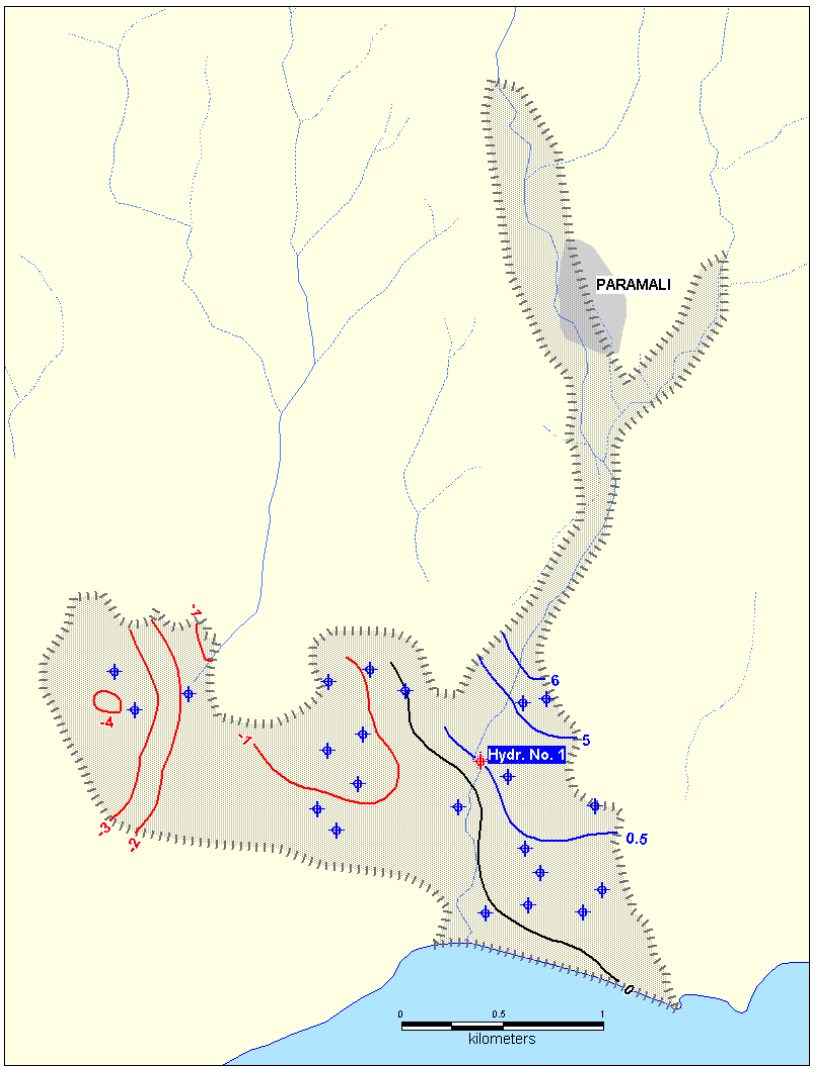
HISTORIC GROUNDWATER BALANCE

Water balance of the year 1979 (SCP Feasibility Study, Volume 3, Groundwater Resources). Average rainfall = 430mm

Replenishment (mcm/year)		
	Rainfall+ Return from Irrigation/Domestic+ Riverbed + Groundwater inflow	Total
	0.64	0.64

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.42	0.29	0.71

Balance: **- 0.07** mcm/year



Paramali Aquifer - Water Level (m amsl) Contour Map April 2001

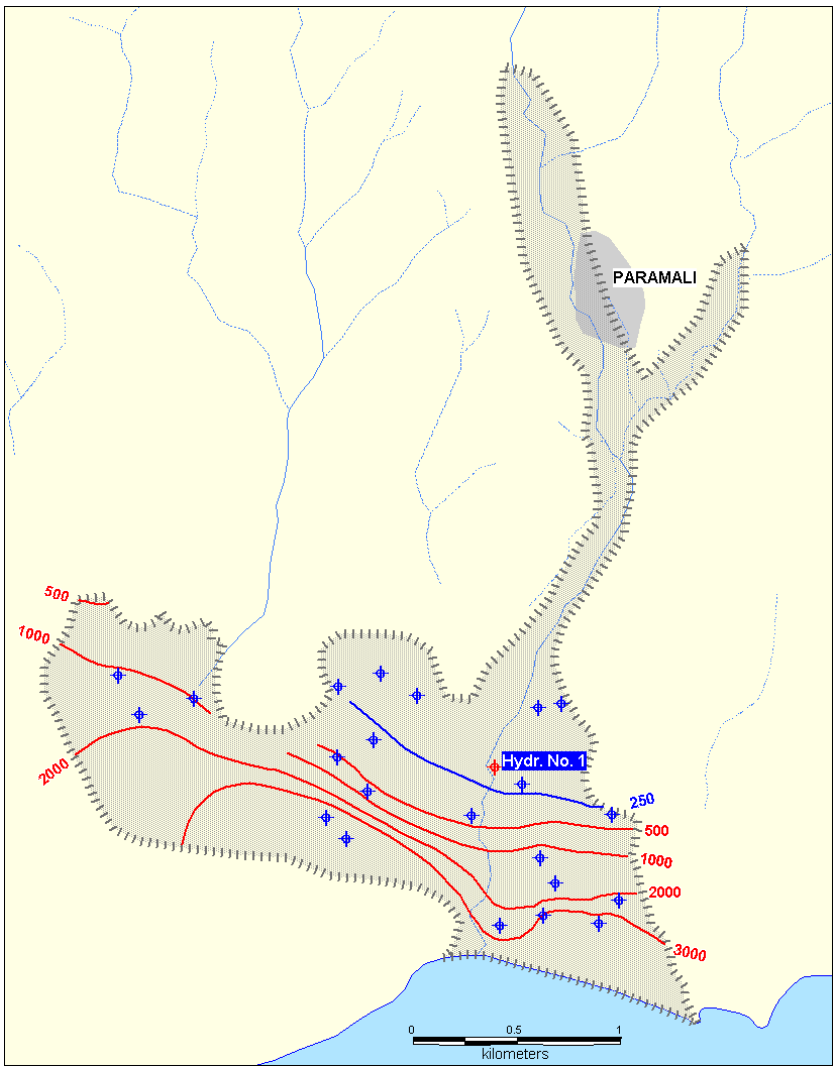
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 2.5 km².
Average rainfall: 390mm.

Replenishment (mcm/year)						
	Rainfall	Groundwater inflow	Sea intrusion	Return from Irrigation	Riverbed	Total
Average	0.12	0.05	0.36	0.03	0.05	0.61

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.6	0.02	0.62

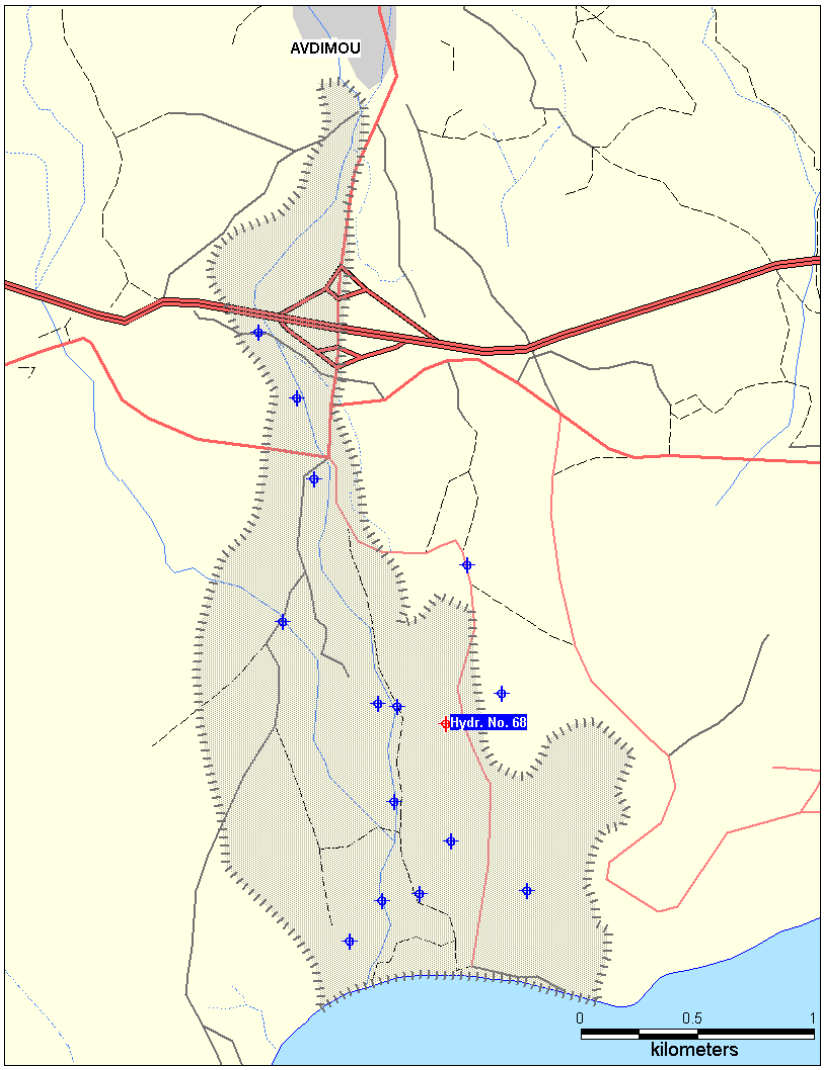
Balance: **- 0.1** mcm/year.
Recommended extraction under the present conditions: **0** mcm/year. After the aquifer is allowed to recover the long duration extraction may rise to: **0.15** mcm/year.



Paramali Aquifer - Isochloride (ppm) Contour Map April 2001

AVDIMOU AQUIFER

INTRODUCTION



Avdimou Aquifer - Location Map

Avdimou is a small coastal alluvial aquifer situated twenty-eight kilometers west of Lemesos town and developed along the Avdimou river valley, a traditional vineyards area. The aquifer is relentlessly overpumped since the late seventies. As a consequence the greater part of its productive section has been sea intruded.

Part of the irrigation demand, in the aquifer area, is covered by the diversion project of Shapanis (Paramali) river.

Low rainfall during the last ten years reduced the total flow of the Avdimou river. Consequently, riverbed recharge has been considerably reduced.

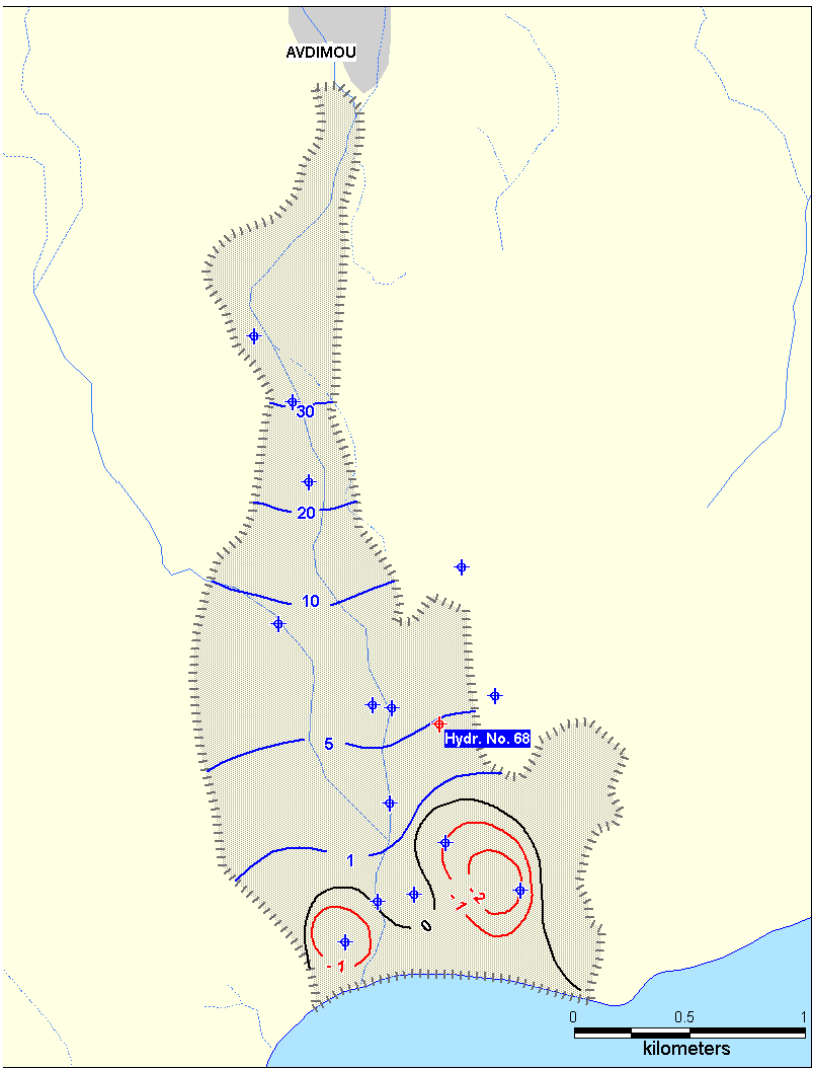
GEOLOGY

The impervious base of the aquifer consists mainly of the Miocene (Pakhna formation) marls, chalks and chalky marls. The part of the aquifer that runs along the riverbed consists of recent alluvial deposits, gravels and sands with some silty lenses. The other

part of the aquifer, in the valley, consists of Plio/Pleistocene silts, silty sands, gravels and sandstones of the Nicosia/Athalassa formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 11 boreholes.
WATER QUALITY OBSERV. NETWORK: Occasional, only Cl^- analysis, 9 boreholes.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: Occasional, last one in 2001.



Avdimou Aquifer - Water Level (m amsl) Contour Map April 2001

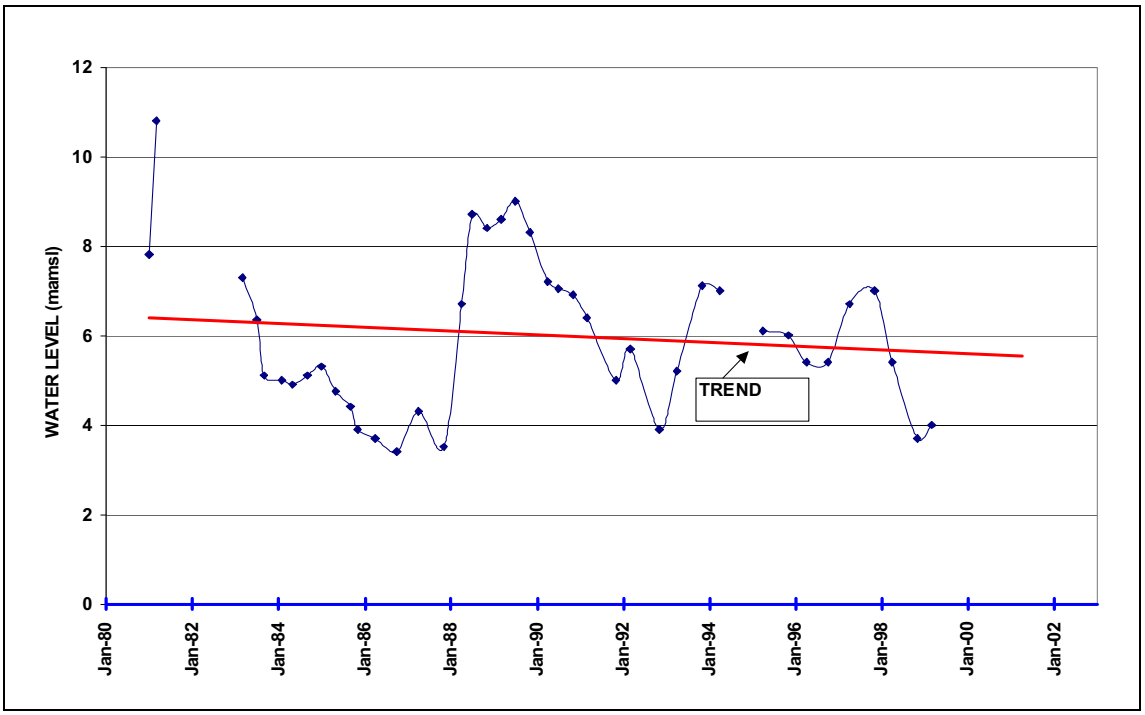
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.5 Km², WIDTH: 800m, LENGTH: 3 Km, OUTCROP: 2.5 Km².
THICKNESS: 10m at the Northern end, 25m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 390 mm, (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day, from 10 to 30m/day
Average S = 4 %, from 1 to 10
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Coastal, phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Around 60 boreholes are in operation in the aquifer today. These extract water for local irrigation. The yields of these boreholes vary from 5 to 15 m³/hour. Average extraction from the aquifer during the last ten years is roughly estimated to be 0.33 mcm/year. Average natural recharge for the same period is estimated to be roughly 0.2 mcm/year.

In the 500 m wide coastal zone of the aquifer the water levels are below mean sea level and almost the entire aquifer is contaminated by sea intrusion. The concentration of chloride ion varies from 250 to 2000 mg/lit (April 2001).



Hydrograph of boreholes Avdimou 68 (Elev. 15.41 m amsl)

HISTORIC GROUNDWATER BALANCE

Water balance: 1979 (SCP Feasibility Study, Volume 3, Groundwater Resources).
Average rainfall: 430mm

Replenishment (mcm/year)		
	Rainfall+ Return from Irrigation/Domestic+ Riverbed + Groundwater inflow	Total
	0.41	0.41

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
	0.52	0.0	0.52

Balance: **- 0.11** mcm/year (Sea intrusion is not taken into account)

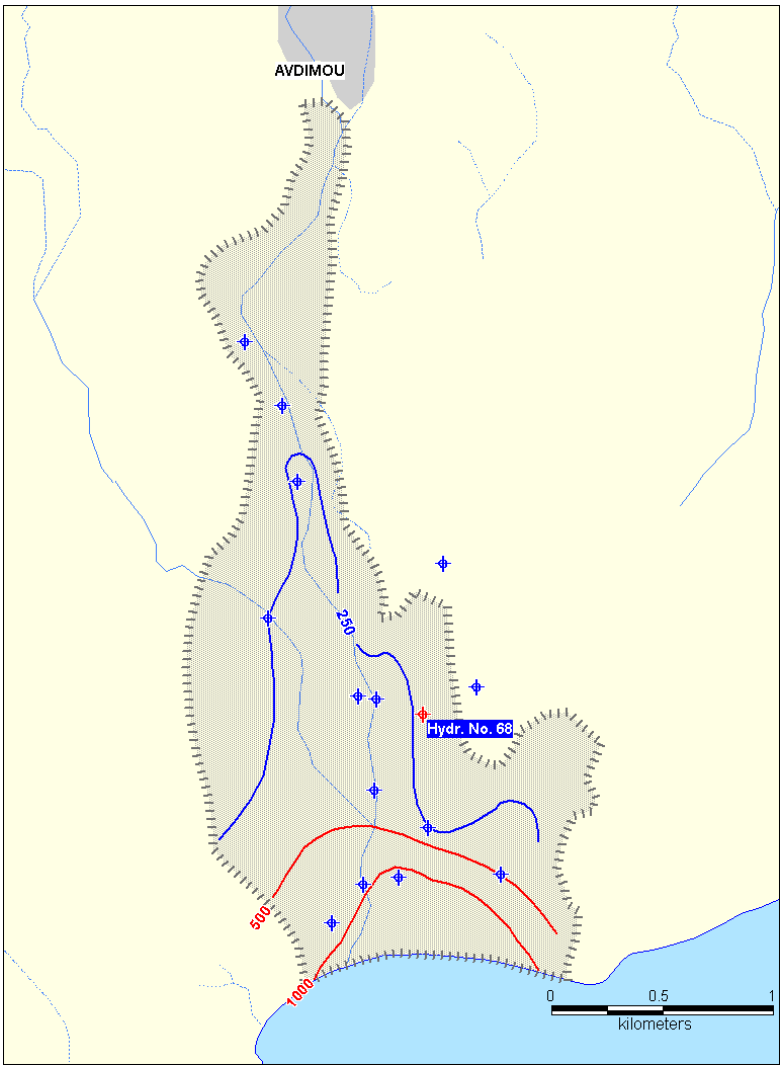
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 2.5 km².
Average rainfall: 390 mm.

Replenishment (mcm/year)						
	Rainfall	Groundwater inflow	Sea intrusion	Return from Irrigation	Riverbed	Total
Average	0.12	0.01	0.15	0.02	0.05	0.35

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.33	0.02	0.35

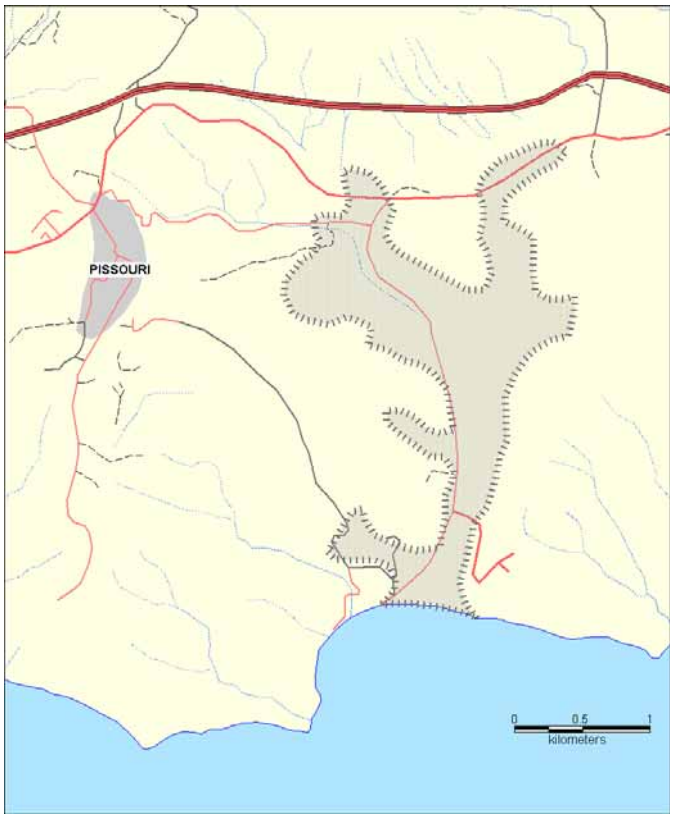
Balance: **- 0.0** mcm/year.
Recommended yield under present conditions: **0** mcm/year. If the aquifer is allowed to recover the recommended long-term average extraction rises to: **0.15** mcm/year.



Avdimou Aquifer - Isochloride (ppm) Contour Map April 2001

PISSOURI RIVERBED AQUIFER

INTRODUCTION



Pissouri Riverbed Aquifer - Location Map

Pissouri is a small alluvial aquifer situated a few kilometers west of Lemesos town and developed along the Pissouri river valley. Pissouri is a traditional early table grape producing area. Up to 1989, 0.2 to 0.3 mcm of groundwater per year was pumped from this aquifer to irrigate vineyards. The capacity of the aquifer is small. Its recharge depends on rainfall and the rare river flows. It is not an important aquifer and it has been practically abandoned in the last years. The aquifer has not been studied properly and during the last years is not being monitored. Much of the information given in the following paragraphs is based on the author's experience and on some old information.

At its northern part it overlies the Pissouri East Gypsum aquifer. There is a hydraulic connection and groundwater interchange between the two aquifers. The total recharge of the aquifer has been significantly reduced due to droughts in the last ten years.

GEOLOGY

The impervious base of the aquifer consists mainly of Miocene (Pachna formation) and in places of Pliocene (Nicosia formation) marls, chalks and chalky marls. The aquifer consists of alluvial deposits, silty gravels, silty sands and silts. In few places older sandstones of Athalassa formation appear.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 3 Km², WIDTH: 1 Km, LENGTH: 3 Km, OUTCROP: 3 Km².
THICKNESS: Few meters at the Northern end, 10 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 380 mm, (Period 1970-2000: 390 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 6 - 8 m/day (estimated).
Average S = 4 - 6% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Only few wells are in operational condition today. Low recharge in the last ten years has diminished the yield of both the aquifer and the individual wells. All the wells have been abandoned due to repeated dry periods and unreliable yields. For this reason farmers today use the high yielding gypsum aquifer instead. The average natural recharge of the aquifer is estimated to be about 0.25 mcm/year.

No problems with sea intrusion in the delta area have been reported.

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Poor. Aquifer's area: 3.0 km².
Average rainfall: 380mm.

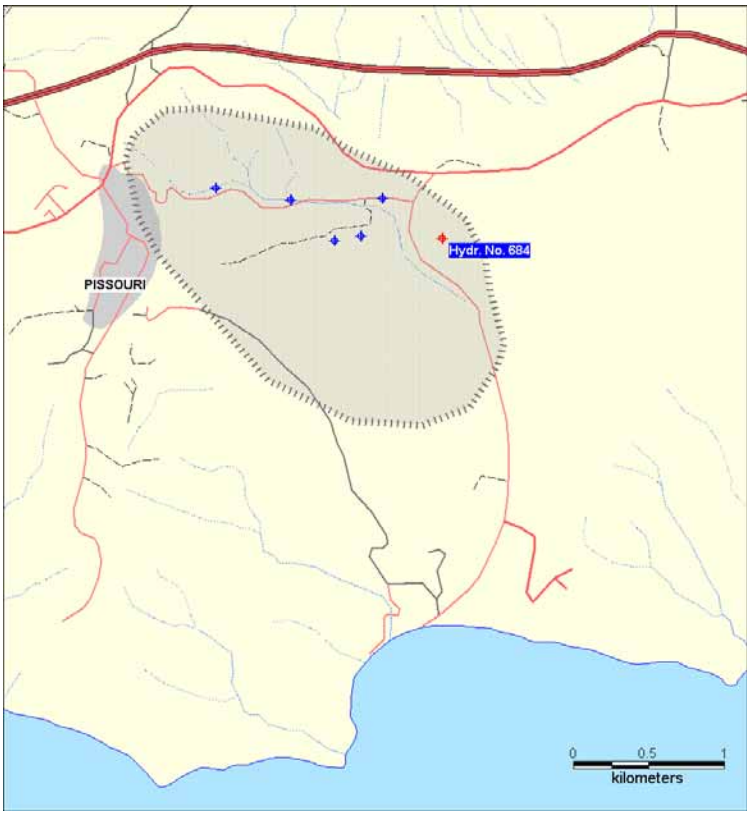
Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.15	0.00	0.05	0.05	0.05	0.30

Outflow (mcm/year)				
	Abstraction	Sea Outflow	Groundwater outflow	Total
Average	0.0	0.25	0.05	0.30

Balance: **0** mcm/year.
Recommended average extraction: **0.20** mcm/year.

PISSOURI EAST GYPSUM AQUIFER

INTRODUCTION



Pissouri East Gypsum Aquifer - Location Map

Pissouri East Gypsum aquifer is an important local aquifer. It is situated west of Lemesos town. The groundwater is used for irrigation of early table grapes plantations that are the traditional crop of the Pissouri village area. The vineyards of the area are mainly irrigated by surface water diverted from Chapotami river. During the last few years the aquifer has gained more importance because of reduction in the diverted quantities of this water. The aquifer is outcropping in its northwestern part. Its southeastern part is confined where a free artesian flow occasionally appears. It is up to 100 - 120 meters thick and it is dipping southeastwards.

The recharge of the aquifer depends on rainfall and partly on return flow from irrigation. Irrigation water surpluses are occasionally overflowing from a concrete reservoir thus artificially recharging the aquifer through a karstic sinkhole. In its eastern part the aquifer is overlaid by the Pissouri riverbed aquifer. There is a hydraulic connection and groundwater interchange between them.

Gypsum i.e. calcium sulfate ($CaSO_4$) is a mineral highly soluble in water. The groundwater in this aquifer is supposed to always be saturated in sulfate ions (SO_4^{--}) the concentration of which ranges between 1400 and 1500 mg/l.

The aquifer is not very well studied.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls and chalky marls of the Pachna formation. Its ceiling consists of Pliocene (Nicosia formation) marls and sandy marls.

The gypsum belongs to a formation known as Kalavasos formation of Upper Miocene age. The karstification, which is well developed, appears mainly in the deeper sections of the aquifer.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 10 boreholes.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1976.
EXTRACTION SURVEY: Occasionally.

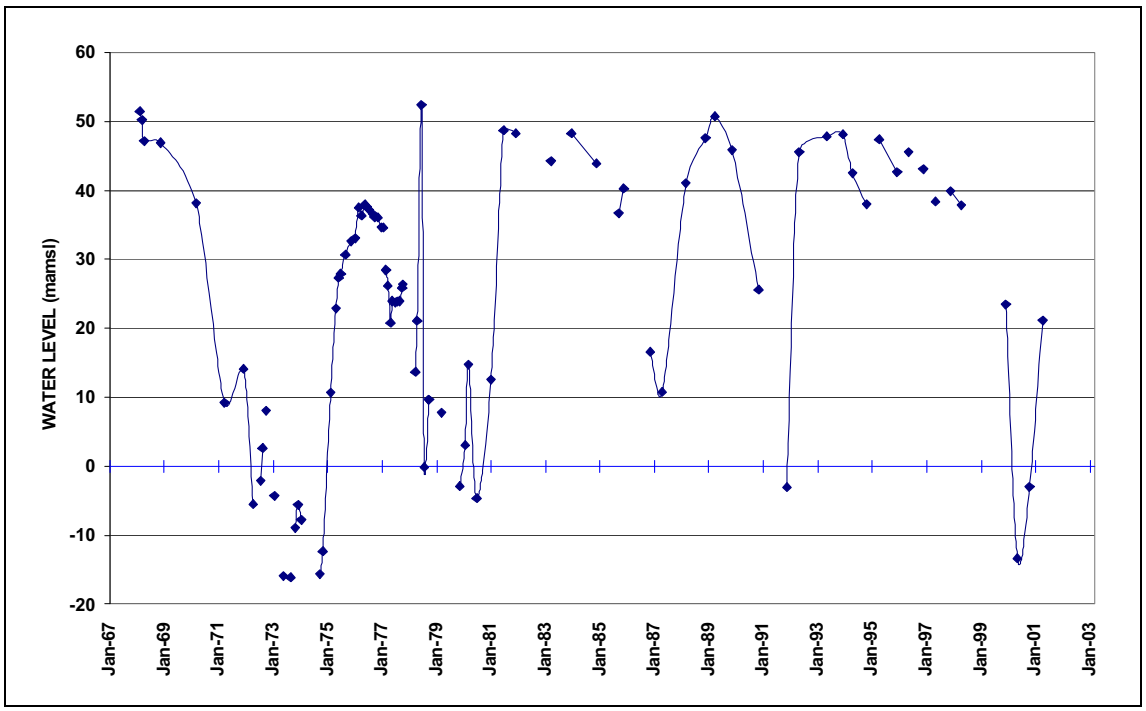
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 3.5 Km², Width: 1.2 km, Length: 3 km, Accuracy of Definition: Fair, Outcrop Area: 2 Km².
AVERAGE RAINFALL: Period 1990-2000: 380 mm, (Period 1970-2000: 390 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 40 m/day (estimated).
Average S = 0.007 from 0.003 (confined) to 0.01(estimated).
BOUNDARIES: East, West, North and South: impermeable
CONFINED/UNCONFINED: Unconfined in the outcrop area (Northwest), Confined (Southeast).
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The aquifer has been overexploited in the last 7 years. Overpumping has intensified in the last five dry years in order to counteract the reduction in the surface water supply. The phenomenon of overexploitation of the aquifer also appeared during the dry period of 1972 – 1974. The aquifer was not exploited to its full capacity during the time separating these two dry periods.

Only 3 to 4 boreholes are operating in the aquifer. The yield of these boreholes varies between 20 to 50 m^3/hour. Total extraction increased from about 20000 before 1993 to about 130000 m^3/year today. The recharge of the aquifer is estimated to be about 0.15 mcm/year.



Hydrograph of borehole Pissouri 684 (Elev. 52.36 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1995 – 2000. Accuracy of estimations: Good. Outcrop area: 2 km². Average rainfall: 380mm.

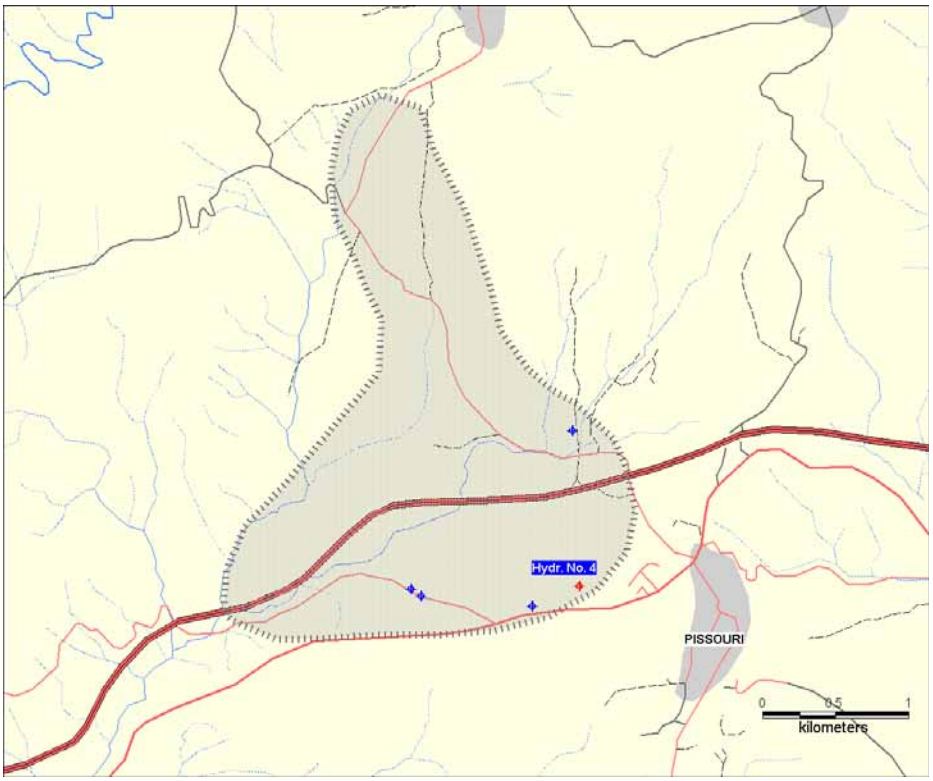
Replenishment (mcm/year)				
	Rainfall	Groundwater inflow	Return from irrigation + artificial recharge	Total
Average	0.08	0.05	0.02	0.15

Outflow (mcm/year)				
	Abstraction (irrigation)	Artesian outflow	Groundwater outflow	Total
Average	0.12	0.00	0.05	0.17

Balance: **-0.02** mcm/year
Change in storage (1995 – 2000): **0.1** mcm.
Recommended average extraction: **0.1** mcm/year.

PISSOURI WEST GYPSUM AQUIFER

INTRODUCTION



Pissouri West Gypsum Aquifer - Location Map

Pissouri West Gypsum aquifer is an important local aquifer which is situated in the west of Lemesos town. It extends from the old Lemesos – Pafos road, in the area of Pissouri village, to Alektora village. The groundwater is used for irrigation of early table grapes plantations that are the traditional crop of the area. The vineyards are mainly irrigated by surface water diverted from Chapotami river. In the last few years, the aquifer has gained more importance because of the reduction in the diverted quantities of surface water. The aquifer is outcropping in several places. The recharge depends on rainfall and at a lesser degree on return flow from irrigation. The aquifer has yet to be studied in depth.

Gypsum i.e. calcium sulfate ($CaSO_4$) is a mineral highly soluble in water. The groundwater in this aquifer is supposed to always be saturated in sulfate ions (SO_4^{--}) the concentration of which ranges between 1400 and 1500 mg/l.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls and chalky marls of the Pachna formation.

The gypsum belongs to the Kalavasos formation, of Upper Miocene age. Its thickness is estimated to average between 50 to 60 meters. In places it reaches depths of 250 meters. It appears in layers or lenses intercalated with marls, chalky marls and sandstones. The karstification which is well developed appears mainly in the deeper sections of the aquifer. The gypsum formation of the Alektora village is included in this aquifer although there are some doubts about their hydraulic connection.

The aquifer is partly covered by Pliocene (Nicosia formation) marls, sandy marls and sandstones. It is assumed that there is a hydraulic connection between sandstones and the gypsum.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 10 boreholes.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1976.
EXTRACTION SURVEY: Occasionally.

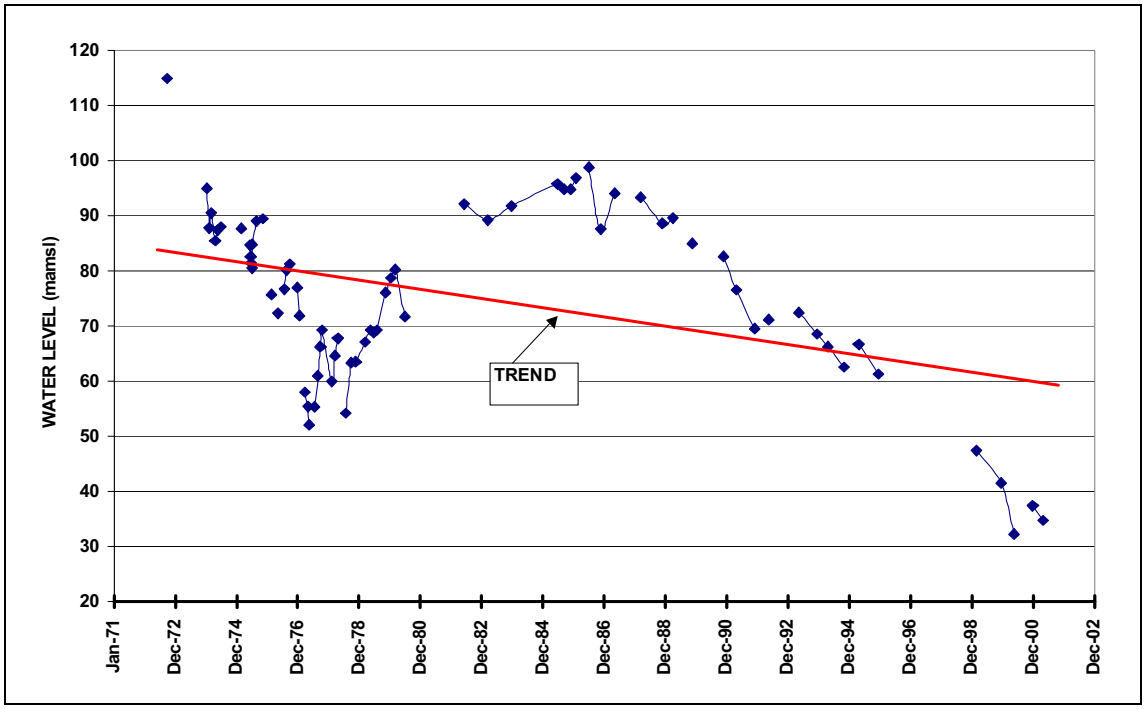
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 5 Km², Width: 1.2 km, Length: 4 km, Outcrop Area: 3 Km².
AVERAGE RAINFALL: Period 1990-2000: 410 mm, (Period 1970-2000: 440 mm).
HYDROGEOLOGICAL PARAMETERS: Average K =40 m/day (estimated)
Average S = 0.01(estimated).
BOUNDARIES: East, West, North and South: impermeable
CONFINED/UNCONFINED: Unconfined to semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The aquifer was overpumped for many years. Overpumping has intensified in the last five dry years in order to counteract the reduction of the surface water supply.

Around twenty-five boreholes operate in the aquifer today. The yield of boreholes varies between 10 to 50 m^3/hour. The total extraction increased from about 0.4 before 1993 to about 0.7 mcm/year today. The recharge of the aquifer is estimated to be about 0.4 mcm/year.



Hydrograph of borehole Pissouri 4 (Elev. 149.72 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1995 – 2000. Accuracy of estimations: Good. Outcrop area: 3 km². Average rainfall: 410mm.

Replenishment (mcm/year)				
	Rainfall	Groundwater inflow	Return from irrigation	Total
Average	0.2	0.1	0.1	0.4

Outflow (mcm/year)				
	Abstraction (irrigation)	Artesian outflow	Groundwater outflow	Total
Average	0.7	0.00	0.00	0.7

Balance: **-0.3** mcm/year
Recommended average extraction: **0.4** mcm/year.

PAFOS COASTAL PLAIN AQUIFER

INTRODUCTION

The Pafos Coastal Plain aquifer is developed along a 35 km long coastal strip, stretching from the Chapotami river at the east to the Aspros river, in the Pegeia village area. Its average width is about 3.5 km. The area of this aquifer coincides almost completely with the Pafos Irrigation Project area.
The southeastern part of the aquifer which extends south - southeast of Pafos town is crossed by the alluvial deltas of Diarizos, Xeropotamos and Ezousa rivers. There is underground hydraulic connection and groundwater interchanges between these riverbed aquifers and the coastal plain aquifer. There are no rivers in the northeastern part of the aquifer and, in places, the aquiferous layers disappear.

Intensive agriculture and the use of fertilizers in the area are endangering the groundwater quality. There are indications of increasing nitrate concentration and problems of sea intrusion appear in a few coastal zones. A dense highway network is under development in the area.

GEOLOGY

The impervious base of the aquifer in the southeastern part of the aquifer consists mainly of Miocene (Pachna formation) marls, chalks and chalky marls. In the northwest part the base of the aquifer consists of Palaeogene (Lefkara formation) marls, chalks and chalky marls and of Triassic/Cretaceous (Mamonia formation) clays, siltstones, mudstones, sandstones, diabase, serpentinites etc. The elevation of the impervious base of the aquifer is generally above mean sea level. In few places where the elevation of the impervious base is below sea level sea intrusion problems appeared.

The aquifer is mainly developed in the calcarenites of the Pleistocene Athalassa formation. These layers alternate with marls of the same formation. The lateral interfingering between them is very common. Some pockets of silty, sandy gravels are also present. The average thickness of the calcarenites is about 10 meters, varying from 5 to 15 and they appear down to a depth of 30 m. Pleistocene Terrace deposits which are few meters thick and consist of gravels and sands, overlie the sediments of the Athalassa formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 3 months, 58 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 2 to 4 times per year, only Chloride analyses, 17 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last survey in 1967.
EXTRACTION SURVEY: Last survey in 1995.

Pafos Coastal Plain Aquifer - Location Map

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

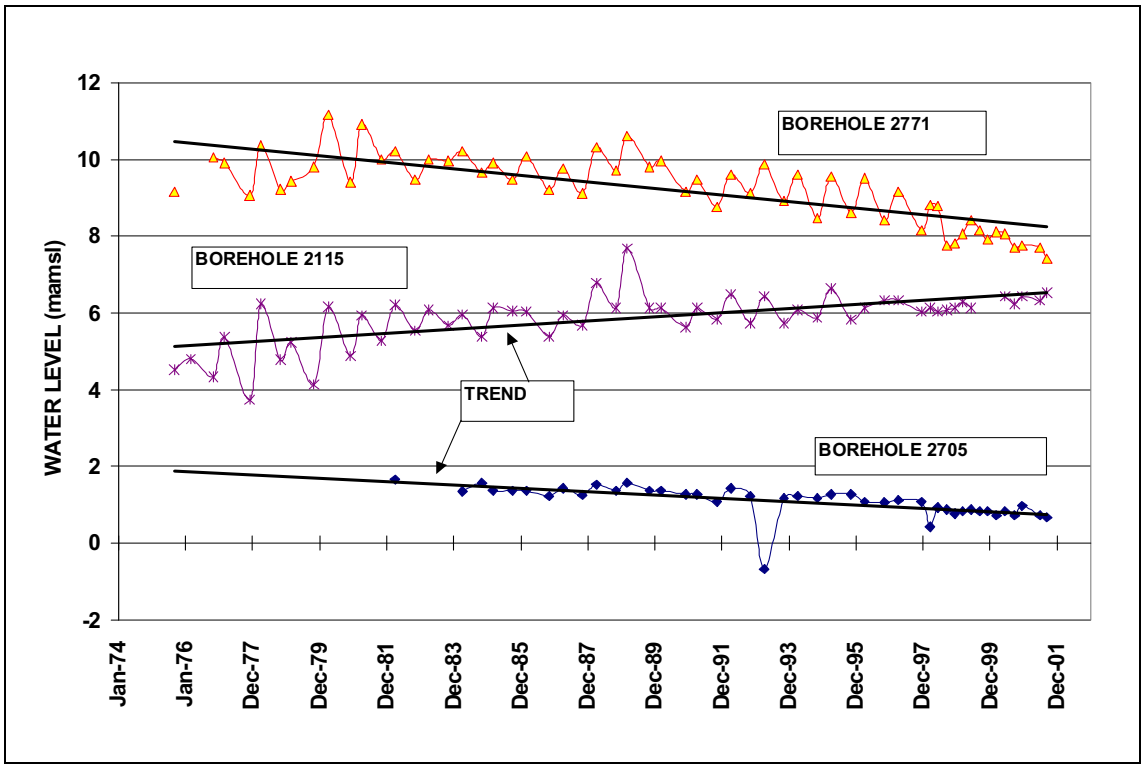
AREA OF THE AQUIFER: 110 Km², WIDTH: 3 km, LENGTH: 35km, OUTCROP: 110 Km².
AVERAGE RAINFALL: Period 1990-2000: 370 mm, (Period 1970-2000: 400 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 3-4 m/day, from 1 to 50(Gravels).
Average S = 1-2 %, from 0.5 to 10
BOUNDARIES: East, West and North: Impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Moderate to high.

HYDROGEOLOGICAL CONDITIONS TODAY

Coastal parts of the aquifer, where the impervious base of the aquifer is below sea level, have been sea intruded since the beginning of the seventies.

It is estimated that around 750 private boreholes and wells operate in the area today and their yield ranges from 1 to 20 m³/hour. Many of these boreholes have been drilled in the last ten years. Dry years and water deficits in the last ten years forced extraction to

increase from 2.3 mcm in 1990 to 4.7 in 1995. Average extraction during the last decade was 4.5 mcm/year.



Hydrograph of boreholes Mandria 2705 and 2771 (Elev. 5.27 and 12.61m amsl) and Kato Pafos 2115 (Elev. 12.33 m amsl)

A considerable part of the aquifer's recharge comes from the individual sewage effluent absorption wells, dug for each house in Pafos Town and villages in the area. The Pafos central sewage system is under construction and the first house connections are expected in the first months of 2002. The implementation of the central sewage system will result in a gradual decrease of the recharge to the aquifer.

HISTORIC GROUNDWATER BALANCE

Not available for the entire area.

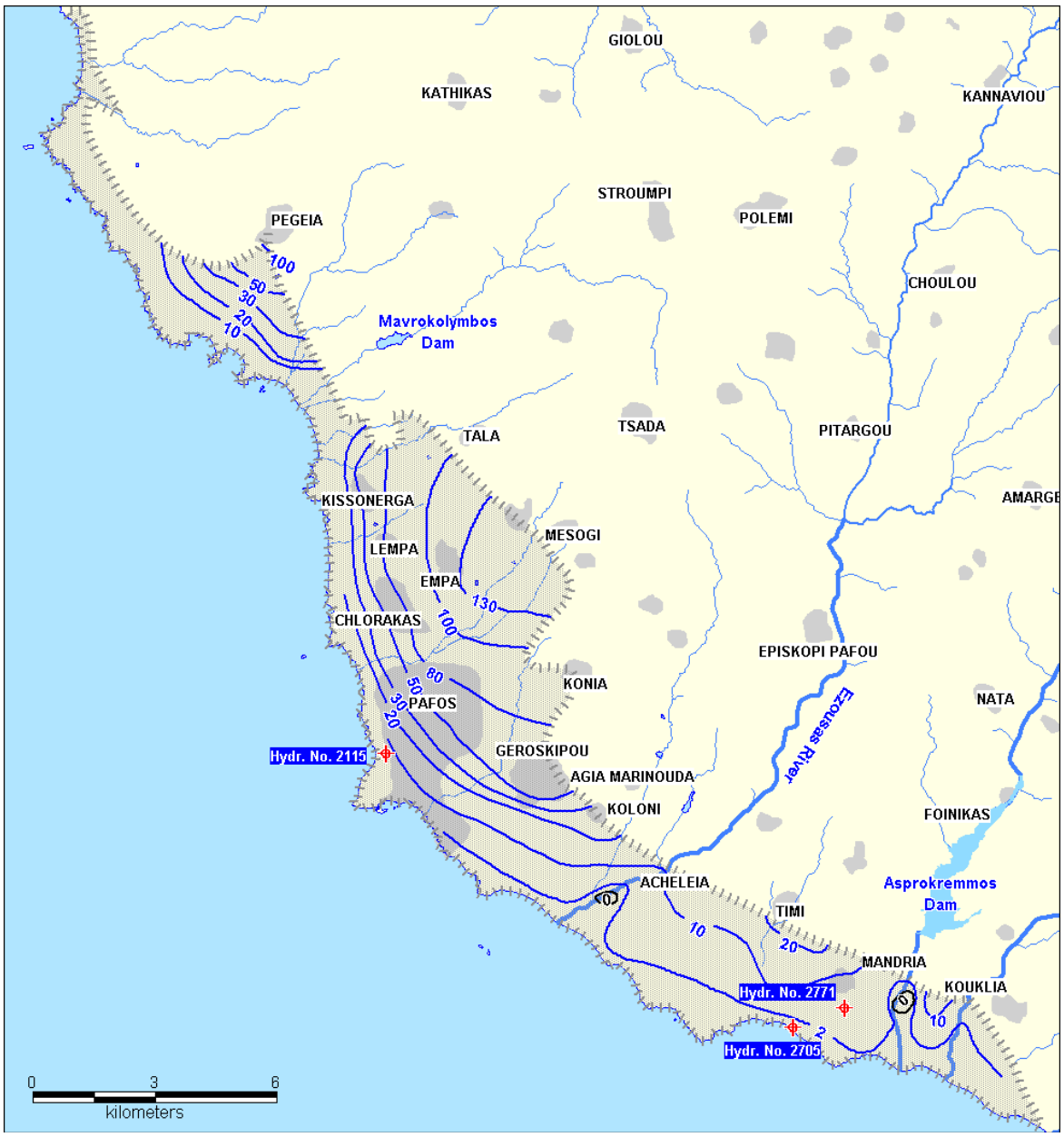
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 110 km².
Average rainfall: 370mm.

Replenishment (mcm/year)						
	Rainfall	Subsurface Inflow	Sea intrusion	Return from irrigation and network losses	Return from domestic	Total
Average	4.8	0.4	0.1	0.9	3.5	9.7

Outflow (mcm/year)				
	Abstraction for irrigation	Subsurface outflow	Sea Outflow	Total
Average	4.5	0.1	5.1	9.7

Balance: **0** mcm/year
An increase in extraction, especially in spring, of 1.5 to 2 mcm/year is recommended.
Recommended total extraction: **6** mcm/year.

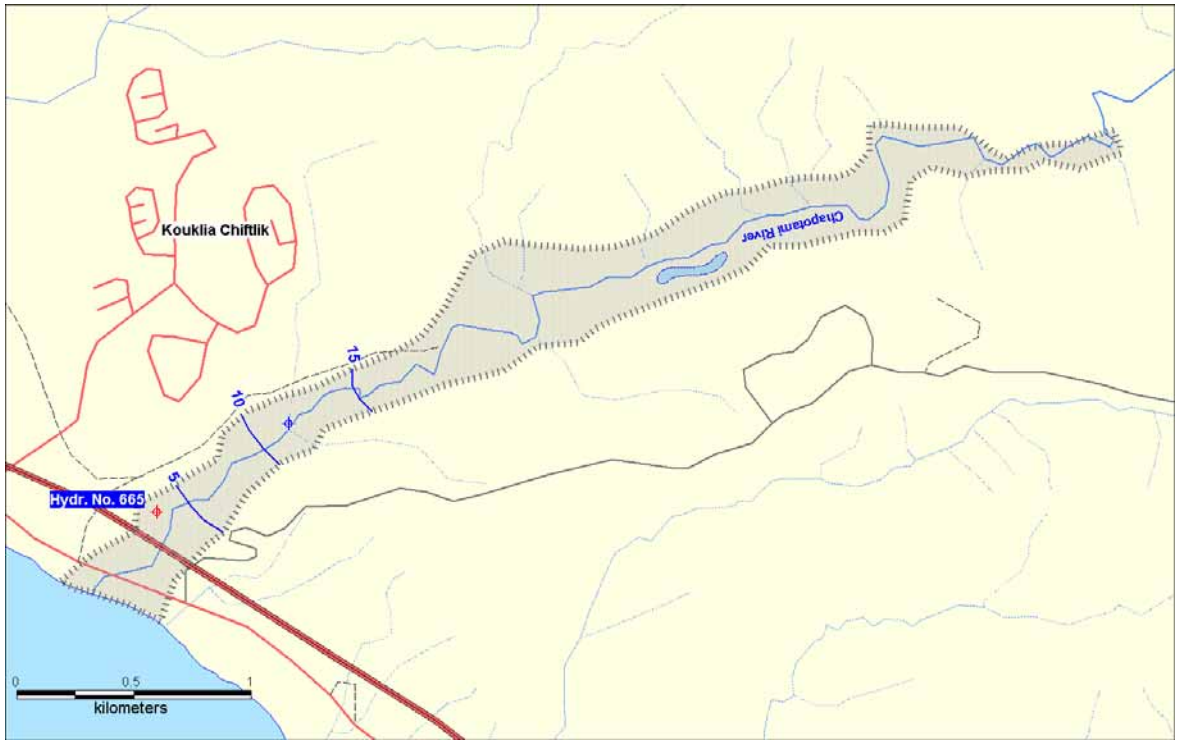


Pafos Coastal Plain Aquifer - Water Level (m amsl) Contour Map September 2001

CHAPOTAMI RIVERBED AQUIFER

INTRODUCTION

Chapotami is a small alluvial aquifer situated twenty kilometers east of Pafos town and developed along the Chapotami river valley. The storativity of the aquifer is small. Its upstream sections are drying up very fast after the wet months. Only its downstream, coastal part can be successfully exploited. The aquifer has not been properly studied. Part of the information given in the following paragraphs is based on the author's experience.



Chapotami Riverbed Aquifer - Location Map and Water Level Contour Map September 2001

Low rainfall during the last ten years resulted in reduced river flows. Diversion of significant quantities of river water to Kouris dam through a shaft and a tunnel further deteriorated recharge conditions in the aquifer.

GEOLOGY

The impervious base of the aquifer consists mainly of the Miocene (Pakhna formation) marls, chalks and chalky marls and of Triassic and Cretaceous (Mamonia formation) siltstones, mudstones, clays, sandstones, serpentines, lavas etc. The aquifer consists of recent alluvial deposits, gravels, sands, silts and clays.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every month, 2 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, only Cl^- analysis, 2 boreholes.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1967.
EXTRACTION SURVEY: Last survey in 1995.

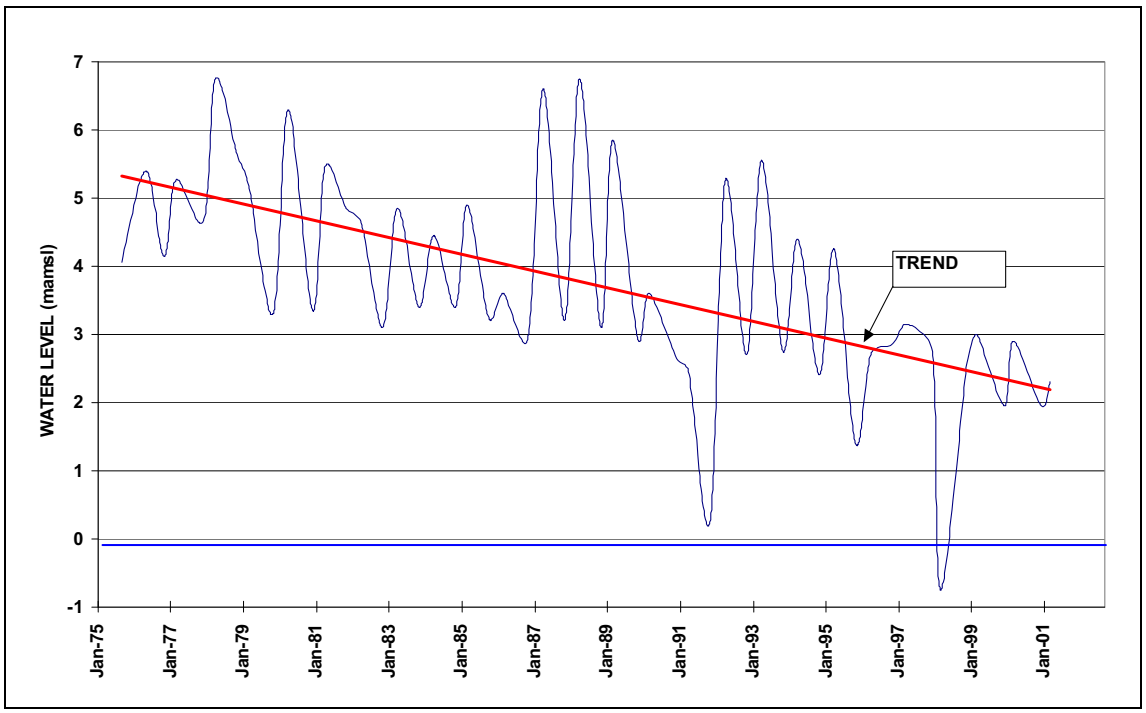
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 1 Km², WIDTH: 200m, LENGTH: 5 Km, OUTCROP: 1 Km².
THICKNESS: 2 m at the Northern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm, (Period 1970-2000: 420 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30 m/day (estimated).
Average S = 8% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Coastal, phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Only 3 boreholes operate in the aquifer. These extract water for local irrigation. The yields of these boreholes vary from 5 to 20 m³/hour. Average extraction from the aquifer during the last ten years was about 0.03 mcm/year. Average natural recharge for the same period is estimated to be around 0.37 mcm/year.

The aquifer shows a depleting trend caused by reduced aquifer recharge. No evidence of significant sea intrusion has been registered.



Hydrograph of borehole Kouklia 665 (Elev. 10.4 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 1 km².
Average rainfall: 400 mm.

Replenishment (mcm/year)				
	Rainfall	Sea intrusion	Riverbed recharge	Total
Average	0.05	0.07	0.25	0.37

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.03	0.37	0.4

Balance: **- 0.03** mcm/year.
Extraction can be increased to **0.13** mcm/year. It is recommended that any increase be carried out during the spring months.

DIARIZOS RIVERBED AQUIFER

INTRODUCTION

Diarizos is a typical river alluvial aquifer developed along the Diarizos river valley, in the Pafos District. Diarizos river is the second largest river in Cyprus in terms of flow. The 4.6mcm capacity Arminou dam was constructed in 2000 on this river, 29 km upstream of the coast. The dam is the upstream end of the aquifer. The purpose of the dam is to cover part of the local irrigation demand but mainly to divert significant quantities of water to the Kouris dam through a 14.5 km long tunnel. Kouris reservoir is the main impounding reservoir of the Southern Conveyor Project. Local irrigation demand will be covered partly by direct supply of water through pipelines from Arminou dam and partly indirectly by controled releases in the riverbed which recharge the aquifer.

The southern part of the aquifer which is approximately 8 km long, is one of the water sources of the Pafos Irrigation Project (PIP). The average quantity of groundwater pumped for this project during the last ten years was in the order of 4.5 mcm/year. In the last few years, some quantities of groundwater were pumped from this part of the aquifer for the domestic water supply of Pafos Town.

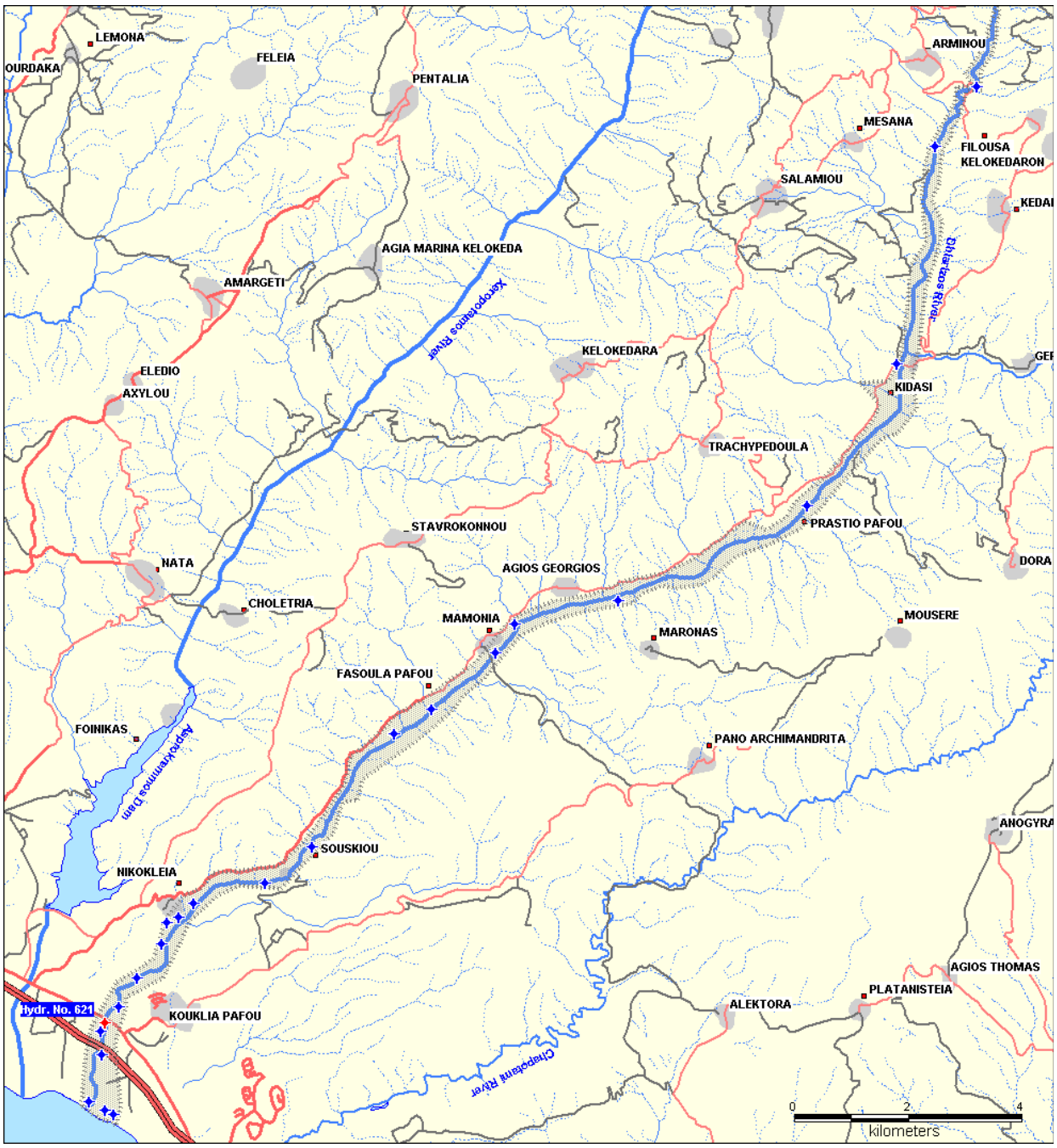
GEOLOGY

The impervious base of the lower part of the aquifer which stretches for 10 km inland from the coast consists of Miocene (Pachna formation) marls, chalks and chalky marls. The allochthonous Mamonia formation which consists of a mixture of sedimentary and igneous rocks, clays, sandstones, mudstones, pillow lavas, serpentinite etc forms the middle part of the impervious base. The upper part of the base at the upstream end of the valley consists of palaeogene (Lefkara formation) marls, chalks, chalky marls and cherts and the most upstream part, near the Arminou dam, of the igneous rocks, Lavas and Diabase.

The river alluvial aquifer consists of gravel and sand at the upstream and middle sections where the permeability is very high. Permeability at the downstream sections of the aquifer gradually reduces with an increase in the amount of fine sediments especially in clays originating from the Mamonia formation.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, 22 boreholes.
WATER QUALITY OBSERV. NETWORK: No, occasional collection of samples for monitoring and control of sea intrusion.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Last survey in 1995.



Dhiarizos Riverbed Aquifer - Location Map

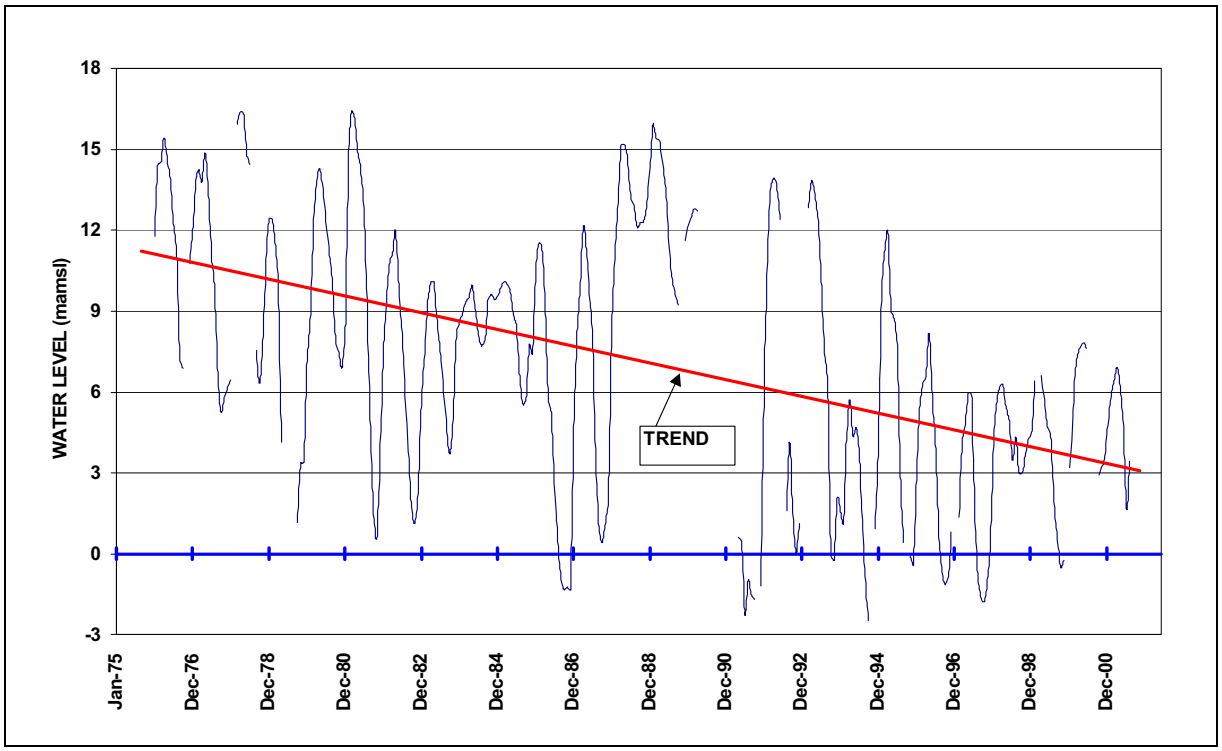
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 9 Km², WIDTH: 300m (50-600m), LENGTH: 29 km, OUTCROP AREA: 9 Km².
THICKNESS: Few meters in the upper part increasing to 50m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 480 mm, (Period 1970-2000: 500 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 60 m/day, from 10 to 200 m/day
Average S = 10%, from 3 to 20%
BOUNDARIES: East and West: impermeable. **South**: Permeable, Sea. **North**: dam.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

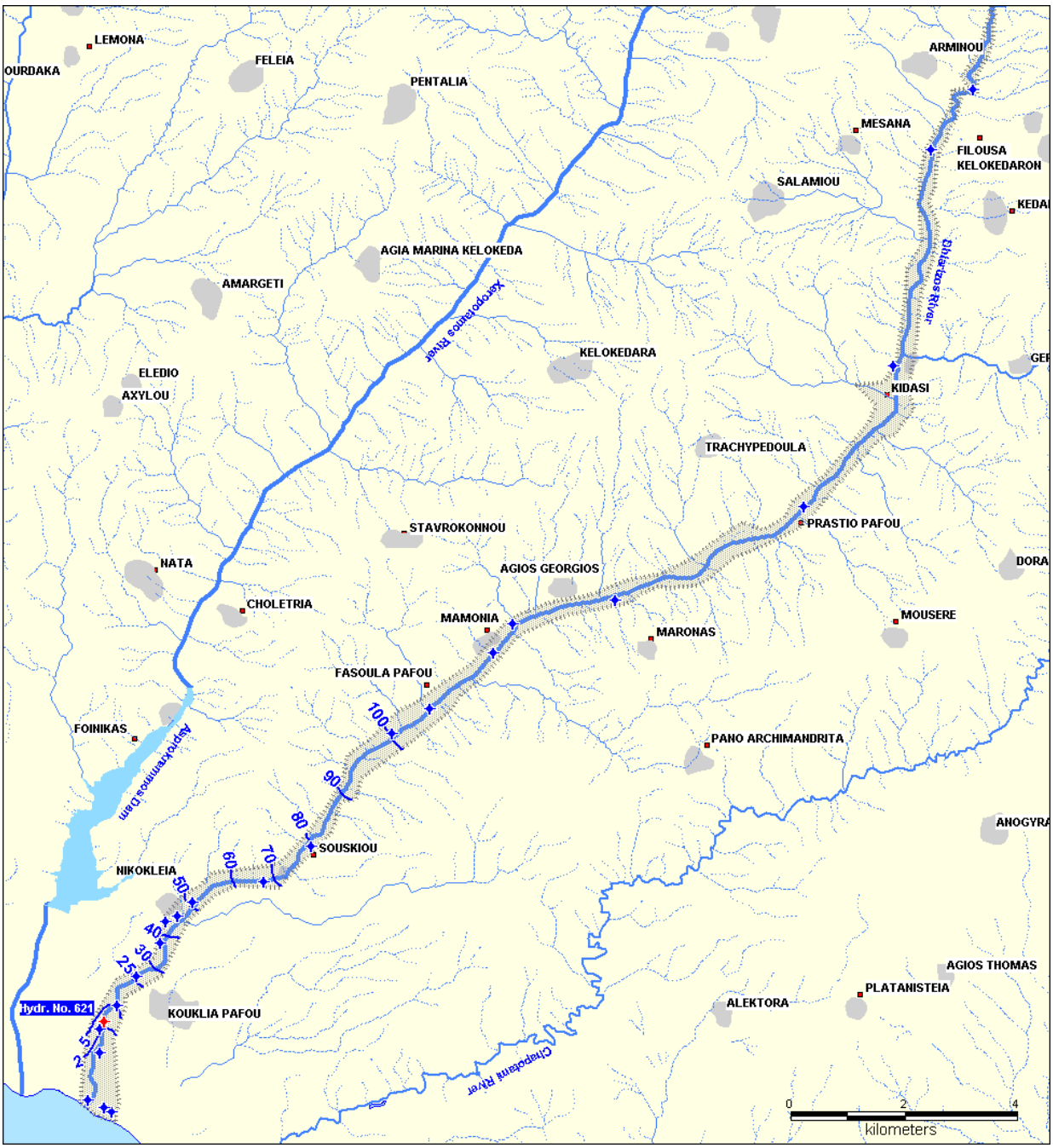
HYDROGEOLOGICAL CONDITIONS TODAY

The main source of recharge to the aquifer is river water. During normal hydrometeorological years the aquifer is fully replenished. Under these condition total aquifer reserves are estimated to be approximately 15 mcm. Natural river flows were significantly reduced and recharge conditions changed after the construction of the Arminou dam. Aquifer recharge now depends on runoff from the catchment downstream the dam and on occasional releases from the dam. During the hydrological year 2000/2001, roughly 1 mcm of water was released in the riverbed from the dam for recharge.

Around 60 boreholes operate today mainly for irrigation purposes. Yields of these boreholes range from 10 to 200 m³/hour. Average extraction from the aquifer in the last ten years is appr. 7 mcm/year, varying from 6 to 8 mcm. About 2.5 mcm/year is extracted for local irrigation and 4.5 mcm for irrigation in PIP and for Pafos domestic water supply. The water level in the aquifer today is amongst the lowest in the last 20 years.



Hydrograph of borehole Kouklia 621 (Elev. 21.42 m amsl).



Dhiarizos Riverbed Aquifer - Water Level (m amsl) Contour Map September 2001

HISTORIC GROUNDWATER BALANCE

Average water balance: 1976/77– 1977/78 (2 years), (SCP Feasibility Study, Groundwater Resources), result of a mathematical model applied on a river length of 4.2 km only.
Average rainfall: 500 mm

Replenishment (mcm/year)			
	Riverbed Recharge (Runoff)	Subsurface inflow	Total
Average	2.1	1.4	3.5

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	1.7	1.9	3.6

Balance: - **0.1** mcm/year

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 9 km².
Average rainfall: 480mm.

Replenishment (mcm/year)					
	Rainfall	Riverbed	Sea intrusion	Return Irrig. + Domestics	Total
Average	0.6	7.5	0.1	0.4	8.6

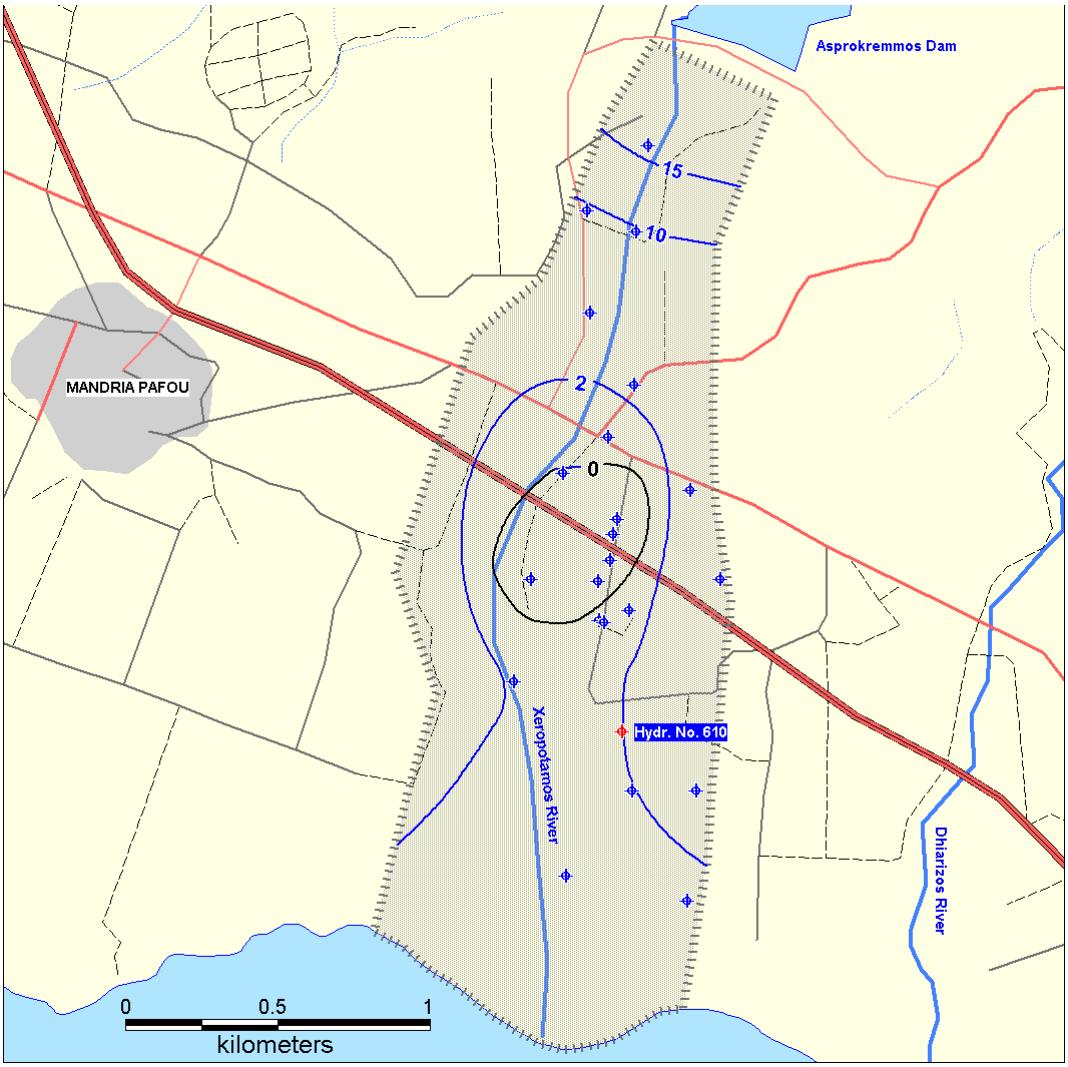
Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	7	1.6	8.6

Balance: **0** mcm/year
The recommended sustainable groundwater extraction under natural conditions i.e. with no artificial recharge of the aquifer is estimated to vary between **4** and **6** mcm/year.
Recommended average extraction under natural conditions: **5** mcm/year.

XEROPOTAMOS DOWNSTREAM AQUIFER

INTRODUCTION

Xeropotamos is another typical river alluvial aquifer in Cyprus. It is developed along the Xeropotamos river valley, in Pafos District. The Xeropotamos Downstream aquifer is the downstream section of this aquifer, extending between the Asprokremmos dam and the seacoast. Since 1982 when Asprokremmos dam was constructed aquifer recharge mainly depends on controlled releases from the dam and occasional dam spills. The dam has never spilled during the last ten years.



Xeropotamos Downstream Aquifer - Location Map and Water Level (m amsl) Contour Map September 2001

This aquifer, like Germasogeia, is used as a natural water treatment plant. Surface water from Asprokremmos dam is being released in specially constructed shallow ponds for aquifer recharge since 1986. After natural purification (SAT - Soil Aquifer Treatment) the “treated” groundwater is being extracted for the domestic water supply of Pafos town and the surrounding villages. The maximum groundwater flow through the aquifer and consequently the maximum permissible extraction is estimated to be 10,000 m^3/day.

GEOLOGY

The impervious base of the aquifer consists of the Miocene (Pakhna formation) marls, chalks and chalky marls.

The river alluvial aquifer consists of gravels, sands, silts and some clay. The prevailing lithological feature of the aquifer is the presence of a semi-permeable to impermeable pyramidal lens which consists of silty material mixed with some clay from Mamonia formation. The top of the lens is situated 500 meters downstream of the dam and the end of the lens is at the seashore. It covers the whole downstream surface area of the aquifer and at the seashore is about 35 meters thick. The presence of this silty lens does not allow recharge of the aquifer along the whole length of the riverbed. Recharge ponds were constructed within the 500m long river section which runs from the dam to the top of the pyramidal lens. The total thickness of the aquifer at its deepest point i.e. at the seashore is about 45 m. The aquifer thickness at the dam site is 30m. Another interesting feature is that the deepest part of the aquifer, which forms a buried channel, is located east of the present river channel, a very distinctive characteristic met in all rivers of southern Cyprus.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, Monthly, 24 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, occasional, 5 -6 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes (Public boreholes), every month, by water meters. Private boreholes, last survey in 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

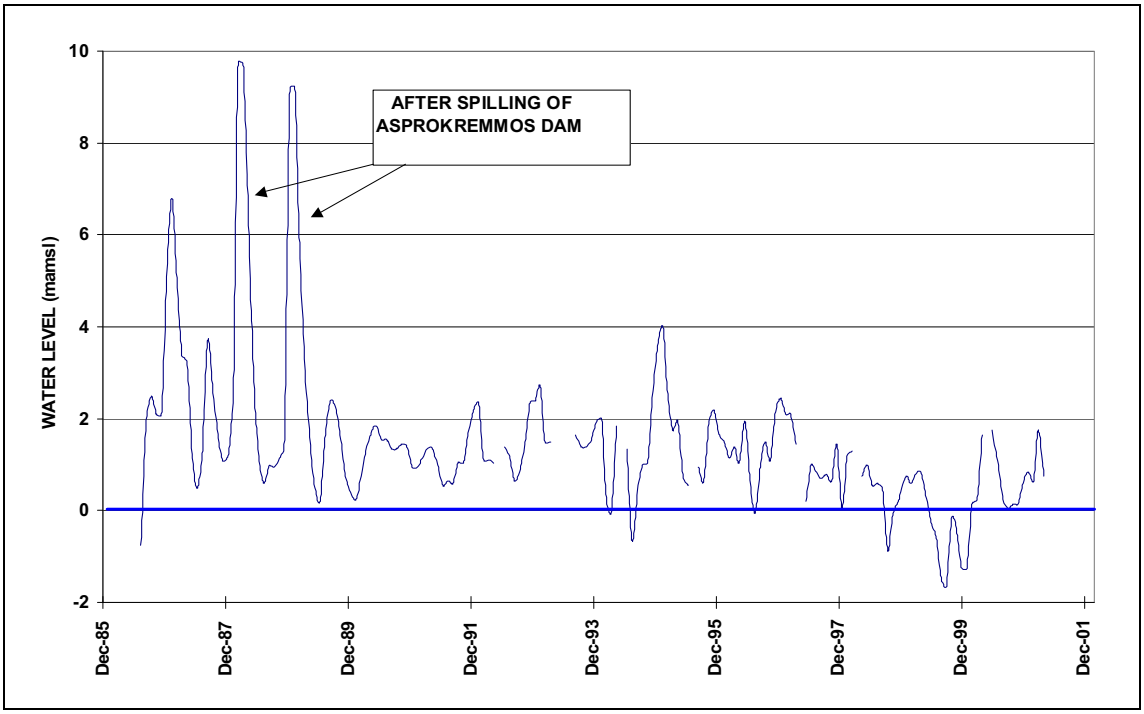
AREA OF THE AQUIFER: 2.5 Km², WIDTH: 800m (150-800m), LENGTH: 3 km, OUTCROP AREA: 2.5 Km².
THICKNESS: 30m at the dam, 45m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 380 mm (Period 1970-2000: 400 mm.
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day, from 20 to 100m/day
Average S = 10 %, from 5 to 15
BOUNDARIES: East and West: semipermeable (inflow – outflow). **South**: Permeable, Sea. **North**: Leaking dam.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The hydrogeological regime and the water balance of the aquifer are "regulated" by releasing predefined quantities of dam water into recharge ponds for artificial recharge to meet the demand of the domestic water supply. The main targets of the aquifer's "regulation" are: a) to cover the domestic water supply demand with groundwater of acceptable quality, b) to protect the aquifer from sea intrusion, and c) to minimize the groundwater losses to the sea.

Today 8 boreholes operate for domestic water supply. Average extraction for domestic water supply in the last ten years was 1.4 mcm/year, varying from 1 mcm in1991 to 2.3 in 1999. The average artificial recharge for the same period is 1.1 mcm/year varying from 0.85 mcm in 1991 to 2.3 in 2000. It is roughly estimated that local farmers are extracting an additional amount of 0.2 to 0.3 mcm/year for irrigation.

Even though the entire aquifer area is cultivated and both the new and the old Pafos – Lemesos highways cross it no measures have been taken to protect it from contamination.



Hydrograph of borehole Kouklia 610 (Elev. 11.44 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Very Good.
Aquifer's area: 2.5 km². Average rainfall = 380mm.

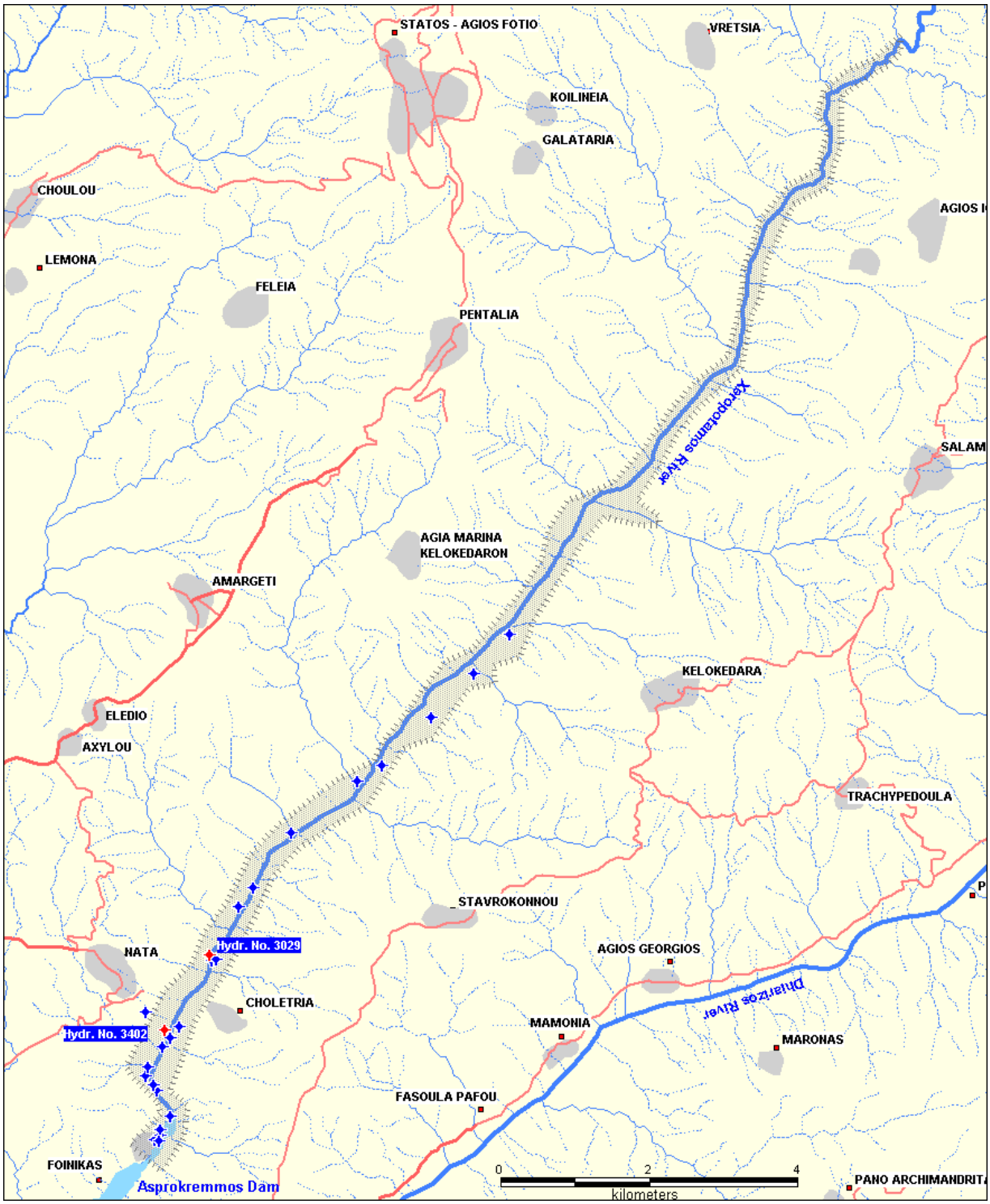
Replenishment (mcm/year)							
	Rainfall	Dam Leakage	Sea intrusion	Return from Irrigation	Artificial Recharge	G/water inflow	Total
Average	0.2	0.4	0.1	0.1	1.1	0.1	2.0

Outflow (mcm/year)				
	Abstraction	Sea Outflow	G/water outflow	Total
Average	1.6	0.3	0.1	2.0

Balance: **0** mcm/year.
Recommended groundwater extraction under natural conditions i.e. with no artificial recharge of the aquifer: **0.5** mcm/year

XEROPOTAMOS UPSTREAM AQUIFER

INTRODUCTION



Xeropotamos Upstream Aquifer - Location Map

Xeropotamos is another typical river alluvial aquifer in Cyprus developed along the Xeropotamos river valley, in the Pafos District. The so-called Xeropotamos Upstream aquifer is the upstream section of this aquifer. It extends for 20km from the tail of the

Asprokremmos Reservoir upstream to the end of the alluvial deposits. This aquifer has not been studied properly.

Most of the exploitation boreholes of the aquifer are concentrated in its downstream section, near the tail of the dam reservoir. These boreholes are used for the domestic water supply of Pafos Town and the Chamila Choria (Low Villages). Boreholes situated in the upstream section of the aquifer are used for irrigation with few of them being used for the domestic water supply of the villages along the valley.

GEOLOGY

The impervious base of the aquifer which extends upstream of the reservoir tail and going upstream, consists mainly of Palaeogene (Lefkara formation) marls, chalks and chalky marls, of Triassic and Cretaceous (Mamonia formation) siltstones, mudstones, clays, sandstones, serpentines, lavas etc. and of upper Cretaceous (Kathikas and Moni formation) clays and bentonitic clays. At the aquifer's upstream end it consists of igneous rocks, lavas and diabase.

The river alluvial aquifer consists of gravels, sands, silts and some clay. Its transmissibility depends on the clay content and especially on the presence of clay lenses originating from Mamonia or other clayey formations. The most extensive lenses which originated from landslides appear in areas adjacent to these clayey formations.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, Monthly, 20 boreholes.
WATER QUALITY OBSERV. NETWORK: No. Only occasionally.
ARE ALL BOREHOLES PLOTTED? : No. Last survey 1995.
EXTRACTION SURVEY: Yes (Public boreholes), every month, by water meters. Last survey of private boreholes: 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

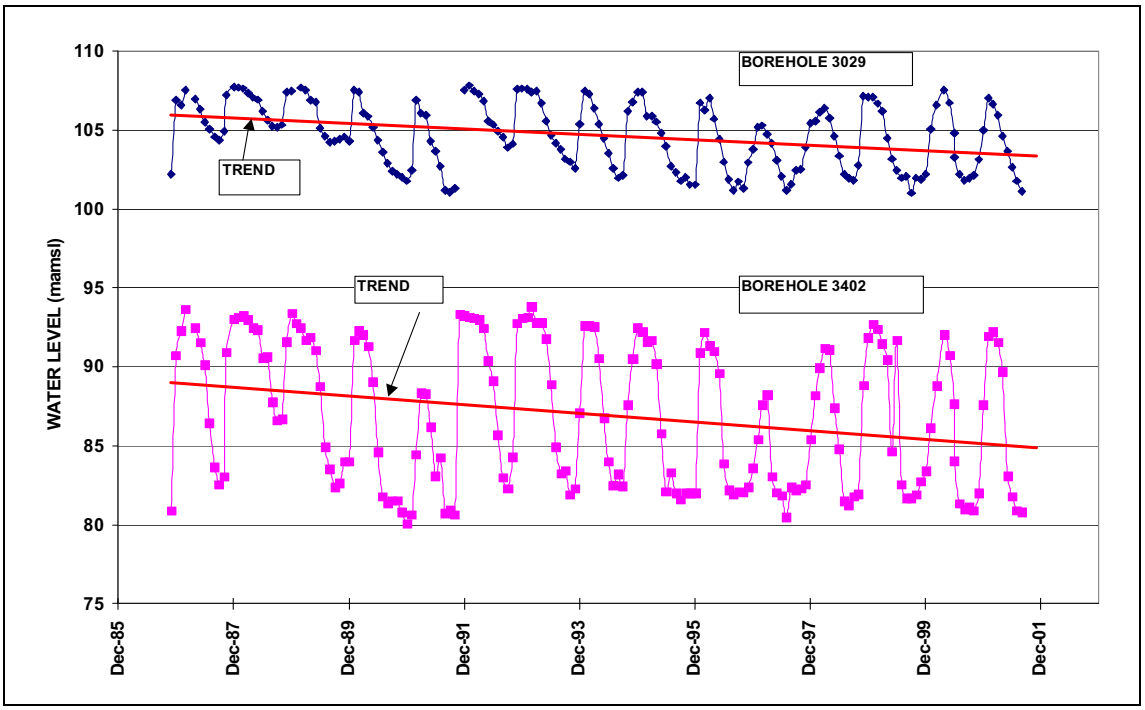
AREA OF THE AQUIFER: 4 Km², WIDTH: 200m (50-500m), LENGTH: 20 km, OUTCROP AREA: 4 Km**².**
THICKNESS: 30m at the reservoir tail, few meters at the upstream end.
AVERAGE RAINFALL: Period 1990-2000: 540 mm (450 to 680mm), [Period 1970-2000: 580 mm (500 to 700 mm)].
HYDROGEOLOGICAL PARAMETERS: Average K = 70 m/day, from 50 to 150m/day
Average S = 13 %, ranging from 7 to 17%
BOUNDARIES: East, West and North: impermeable. **South**: Permeable, Dam reservoir.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The total capacity of the aquifer at maximum water level is estimated to be of the order of 7 mcm. The average extraction of the last ten years is estimated to be 3.7 mcm/year, 2.8 for water supply of Pafos Town and Low Villages and 0.9 for private irrigation. In 2000 this extraction was 4.6 mcm from which 3.7 mcm have been extracted for domestic water supply. Some fourteen boreholes extract water for domestic purposes and another sixteen for irrigation.

Extraction is mainly concentrated in a well field situated in the area of the reservoir tail and the water is used for domestic supply. The yields of the boreholes and the capacity of this part of the aquifer depend on groundwater inflows from two opposite directions. One

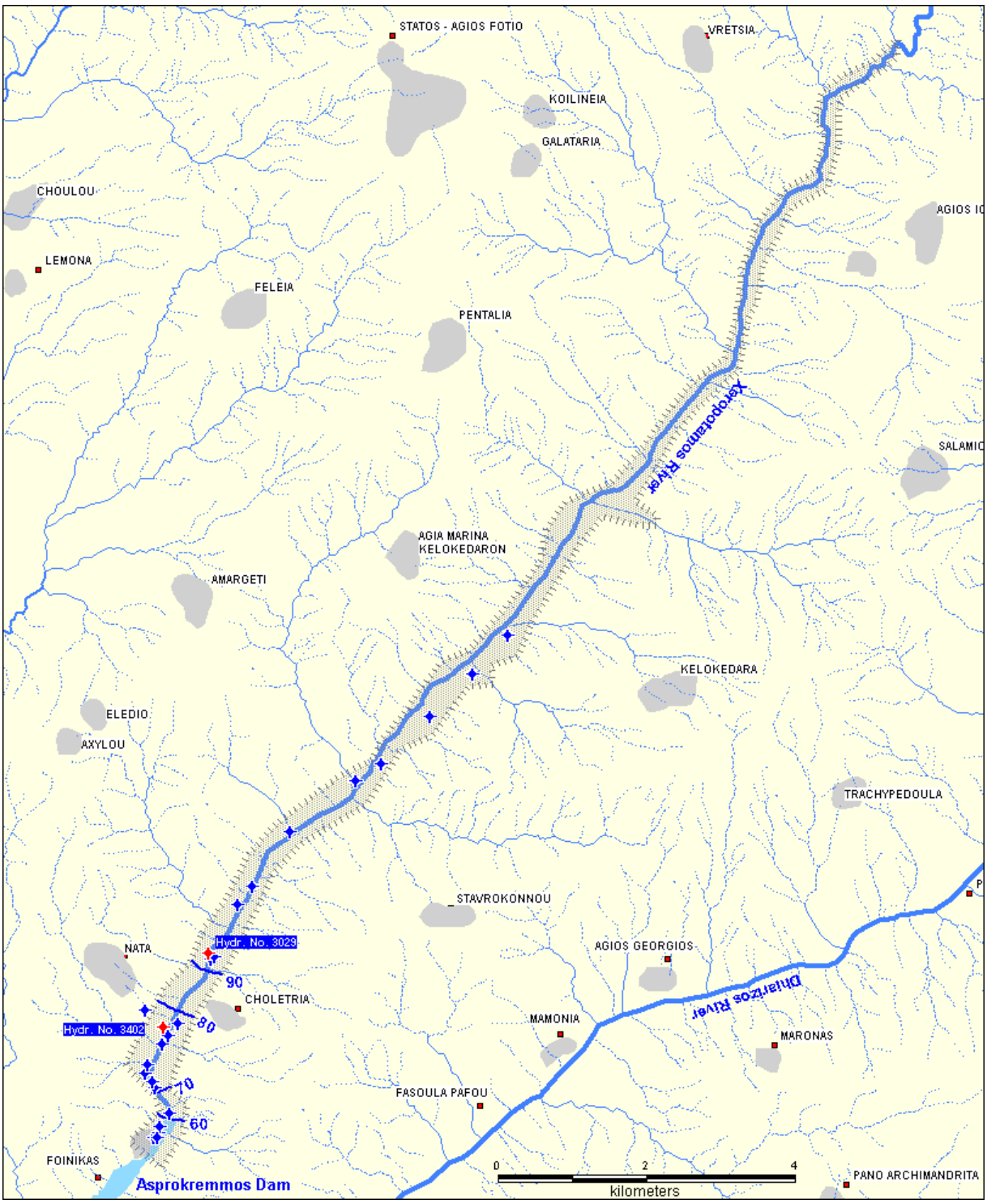
originates in the upstream alluvial deposits and is calculated to be 5000 m^3/day maximum. The second inflow originates in the reservoir area. During dry years, when water level in the reservoir is low and the groundwater inflow from both directions is reduced the yield of the well reduces to critical levels. In the last ten years, during such dry periods, this part of the aquifer has been artificially recharged three times, in 1991, 1998 and 2000. Recharge was effected by pumping dam water and transporting it through a specially constructed pipeline.



Hydrograph of boreholes Nata 3402 (Elev. 95.69 m amsl) and Choletria 3029 (Elev. 108.68)

HISTORIC GROUNDWATER BALANCE

Not available



Xeropotamos Upstream Aquifer - Water Level (m amsl) Contour Map September 2001

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Fair. Aquifer's area: 4 km². Average rainfall: 540mm.

Replenishment (mcm/year)					
	Rainfall	River recharge	Return from Irrigation	Artificial Recharge	Total
Average	0.4	3.4	0.1	0.1	4.0

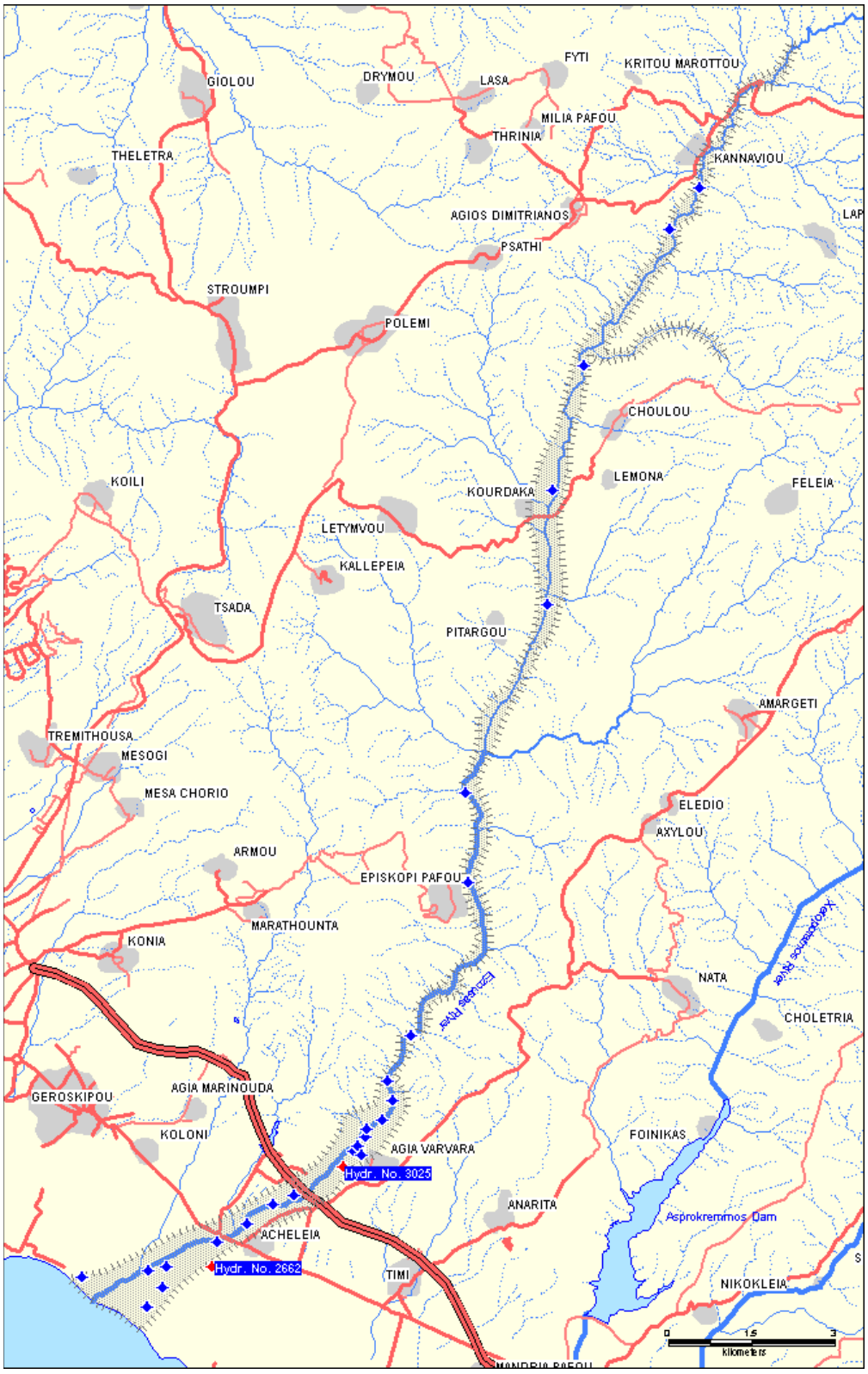
Outflow (mcm/year)			
	Abstraction	Groundwater outflow	Total
Average	3.7	0.3	4.0

Balance: **0** mcm/year

Recommended average extraction under existing conditions: **3.5** mcm/year.

EZOUSAS RIVERBED AQUIFER

INTRODUCTION



Ezousas Riverbed Aquifer - Location Map

Ezousas is a river alluvial aquifer, developed along the Ezousas river valley, in Pafos District. An 18 mcm capacity dam, the Kannaviou dam is being constructed on this river approximately 26 km upstream of the coast. The dam will cover part of the local irrigation demand and some quantities of water will be diverted by pipeline to Asprokremmos Water Treatment Plant for domestic use in Pafos town and several villages. The Ezousas aquifer extends from the coast to the Kannaviou dam site.

A second dam planned to be constructed eight kilometers upstream of the coast near Episkopi village is presently under study. The eight kilometers section of the aquifer stretching downstream of the proposed dam, is being studied as a potential natural reservoir for storage and reuse of the tertiary treated sewage of Pafos town. Treated water will recharge the aquifer through specially constructed shallow spreading grounds. This water, after natural purification, will be pumped again from the aquifer for irrigation in the Pafos Project area.

This aquifer is hydraulically connected to the Letymvou – Polemi gypsum aquifer, 16 km upstream of the coast. The gypsum aquifer discharges in the Ezousas alluvial aquifer through underground leakages and springs e.g. the Ammati spring. This connection and the interchange regime are not well known. The groundwater in the gypsum aquifer is normally saturated in sulfate ion (appr. 1500 mg/lit). The connection between the two aquifers adversely affects the quality of both surface water and groundwater further downstream. The average sulfate concentration in both surface and groundwater is approx. 450 mg/lit. High boron concentration has also been discovered in this aquifer.

GEOLOGY

The impervious base of the lower part of the aquifer consists of Palaeogene (Lefkara formation) and Miocene (Pachna formation) marls, chalks and chalky marls. The allochthonous Triassic and Cretaceous Mamonia formation that consists of a mixture of sedimentary and igneous rocks, clays, sandstones, mudstones, pillow lavas, serpentinite etc. form the middle part of the impervious base. Finally the upper Cretaceous (Kathikas and Moni formation) clays and bentonitic clays in the upper part and the igneous rocks, Lavas and Diabase in the upstream end of the valley constitute the impervious base.

The river alluvial aquifer consists of gravels, sands, silts and some clay. Its transmissibility depends on the clay content and especially on the presence of clay lenses originating from Mamonia and other clayey formations. The most extensive of these lenses originated from landslides and appear in areas adjacent to their parent clayey formations. Because of the presence of these clayey materials the middle section of the aquifer which stretches from the proposed Episkopi damsite to the Pitargou village is shallow (10 to 12m thick), narrow and of low permeability.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, 29 boreholes.
WATER QUALITY OBSERV. NETWORK: No, occasional sample collection for sea intrusion monitoring and control.
ARE ALL BOREHOLES PLOTTED? : No. Last survey in 1995.
EXTRACTION SURVEY: Last survey in 1995.

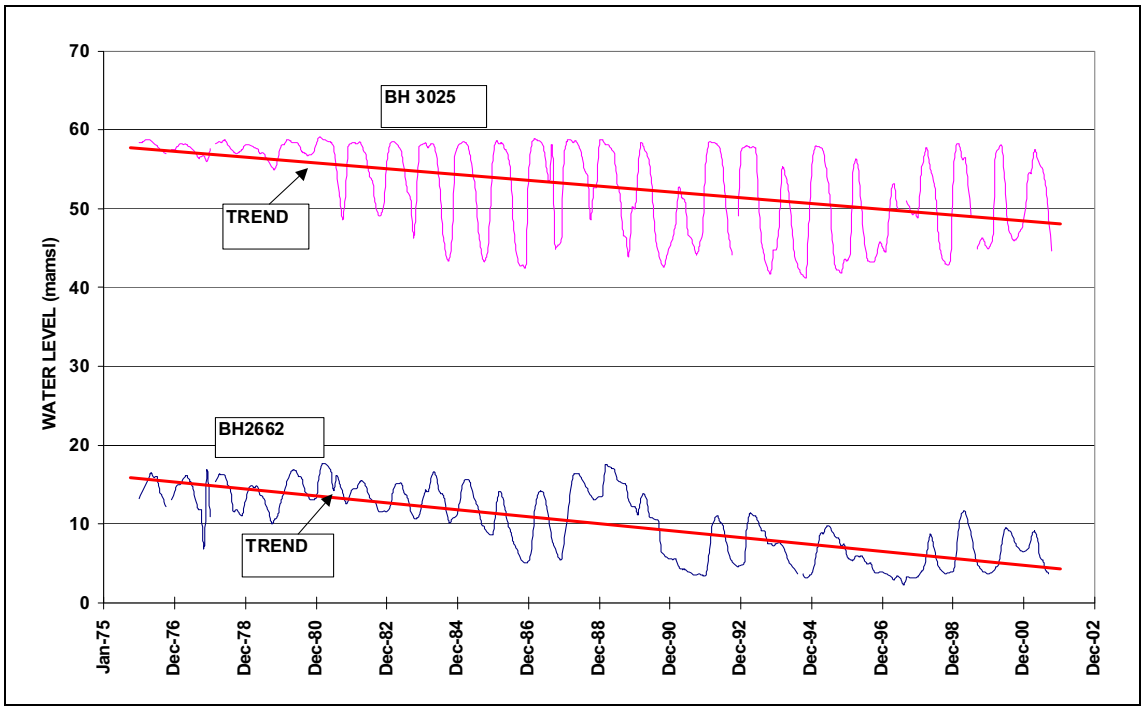
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 6 Km², WIDTH: 250m (50-600m), LENGTH: 26km, OUTCROP AREA: 6 Km².
THICKNESS: 5m near Kannaviou increasing to 45m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 480 mm, (Period 1970-2000: 500 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day, from 10 to 100 m/day
Average S = 9%, from 3 to15%
BOUNDARIES: North, East and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The main source of recharge of the aquifer are river flows. During normal hydrometeorological years the aquifer is fully replenished.

Around 60 boreholes are operating today and they are used mainly for irrigation purposes. Yields of these boreholes range from 10 to 100 m³/hour. Average extraction from the aquifer during the last ten years was about 3 mcm/year, varying from 2.1 to 3.4 mcm.



Hydrograph of boreholes Achelia 2662 (Elev. 28.60 m amsl)
and Agia Varvara 3025 (Elev. 60.04 m amsl)

The construction of the Kannaviou and Episkopi dams in conjunction with the implementation of the scheme to artificially recharge the aquifer with treated water will radically change the aquifer's water balance.

HISTORIC GROUNDWATER BALANCE

Average water balance for the period 1985 – 1990 (5.5 years), (Howard Humphrey's and Partners Ltd/J.I. Theophilou, Paphos Water Supply and Ezousas-Dhiarizos Works, Feasibility Study/Interim Report, April 1992).

Replenishment (mcm/year)		
	From Riverbed + Rainfall+ Groundwater Inflow	Total
Average	7.4	7.4

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	2.2	5.2	7.4

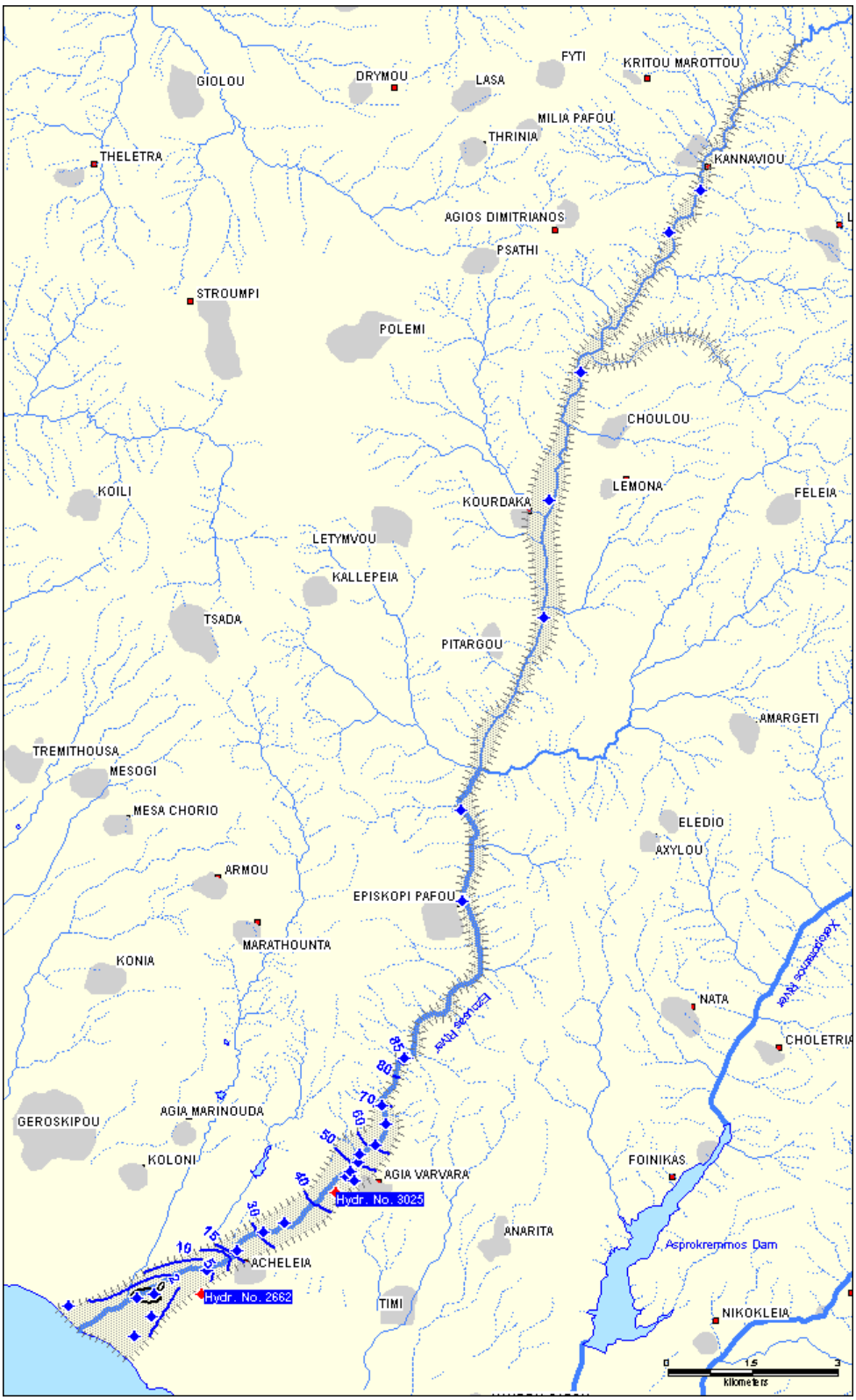
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 6 km².
Average rainfall: 480mm.

Replenishment (mcm/year)					
	Rainfall	Riverbed	Sea intrusion	Return Irrig. + Domestics	Total
Average	0.4	4.2	0.1	0.1	4.8

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	3	1.8	4.8

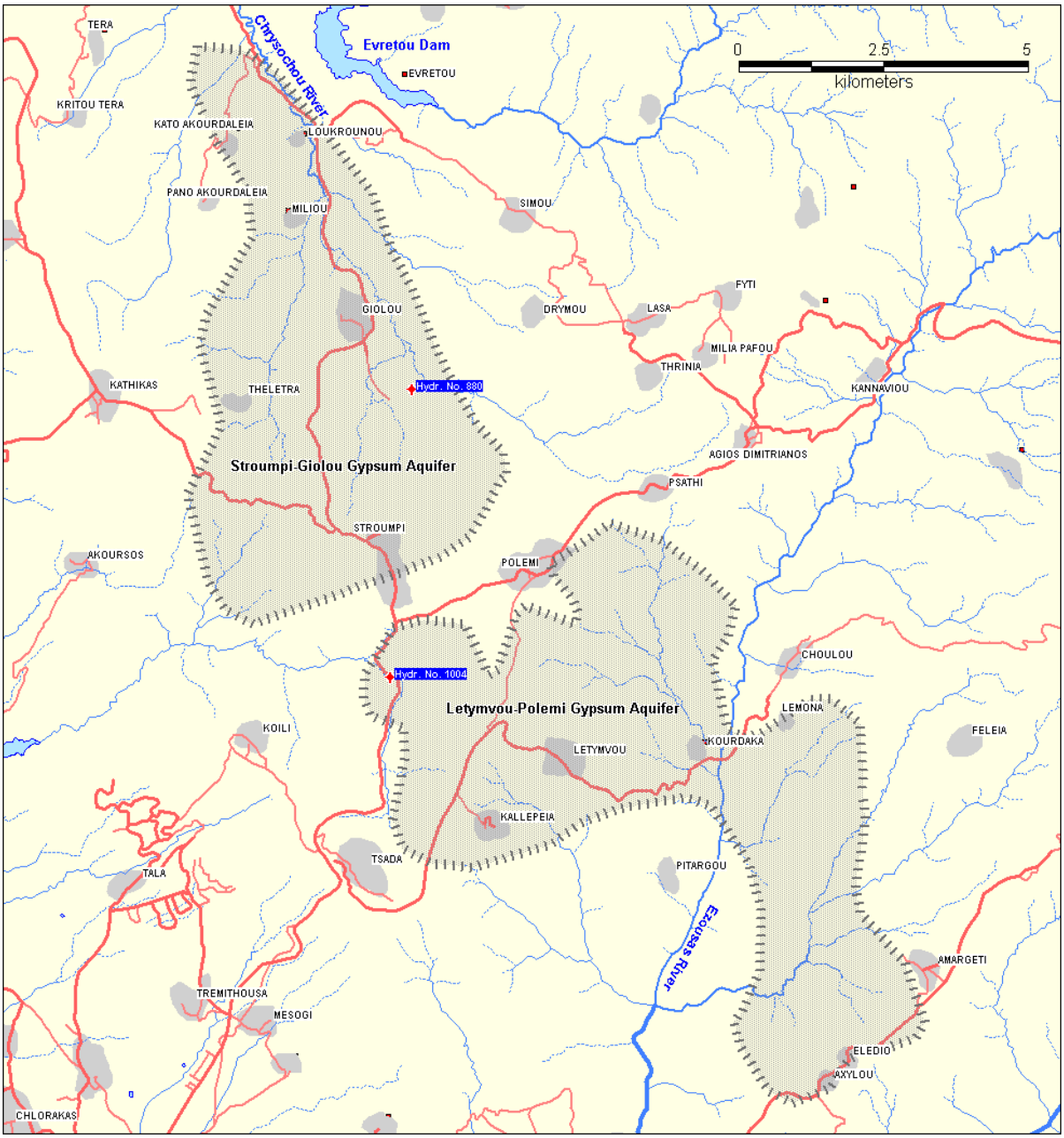
Balance: **0** mcm/year.
Recommended extraction (For the period until the construction of Kannaviou dam): **3** mcm/year.



Ezousas Riverbed Aquifer - Water Level (m amsl) Contour Map September 2001

LETYMVOU- POLEMI AND STROUMPI-GIOLOU GYPSUM AQUIFERS

INTRODUCTION



Letymbou-Polemi and Stroumpi-Giolou Gypsum Aquifers - Location Map

These aquifers consist of two major members, the Letymvou- Lemona – Polemi member at southeast and the Stroumpi – Giolou at northwest. The relationship, continuity, hydraulic connection and water interchange between them are not clearly defined. For this reason these aquifers are treated as one. The aquifer is situated few kilometers northeast of Pafos town in Pafos District. It is the biggest gypsum aquifer in Cyprus in terms of storativity and extension. Only the Stroumpi – Giolou part of the aquifer has been studied properly.

This karstic aquifer is mainly phreatic. The only confined part of the aquifer is its northwestern part. The first artesian boreholes in the confined part were drilled at the beginning of the sixties in the Chrysochou valley, north of Giolou village. Water from some

sulfate springs and boreholes in the Miliou village are used in Spas (Agioi Anargyroi) established in the area.

Gypsum i.e. calcium sulfate ($CaSO_4$) is a mineral highly soluble in water. Groundwater in this aquifer is supposed to be saturated in sulfate ions (SO_4^{--}) the concentration of which ranges between 1400 and 1500 mg/l.

At its southeastern part this aquifer is hydraulically connected to the Ezousas aquifer. The gypsum aquifer discharges in the alluvial aquifer through underground leakages and karstic springs e.g. the Ammati spring. This connection, the interchange regime and the quantities involved are not well known. Groundwater in the gypsum aquifer is normally saturated in sulfate ion thus this connection adversely affects the quality of river water and groundwater in Ezousas aquifer. Similar phenomena of groundwater discharges from this gypsum aquifer and the consequent water quality deterioration also appear in Chrysochou river valley, downstream of Loukrounou village.

GEOLOGY

The impervious base of the aquifer consists mainly of Middle Miocene marls and chalky marls of the Pachna formation.

The gypsum belongs to the Kalavasos formation, of Upper Miocene age. It appears in layers or lenses intercalated with marls, chalky marls and sandstones. The karstification is well developed especially in deeper sections of the aquifer.

The northwestern part i.e. the confined part of the aquifer is partly covered by Pliocene (Nicosia formation) marls, sandy marls and sandstones.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, monthly, 15 boreholes.
WATER QUALITY OBSERV. NETWORK: No, occasional samples only
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

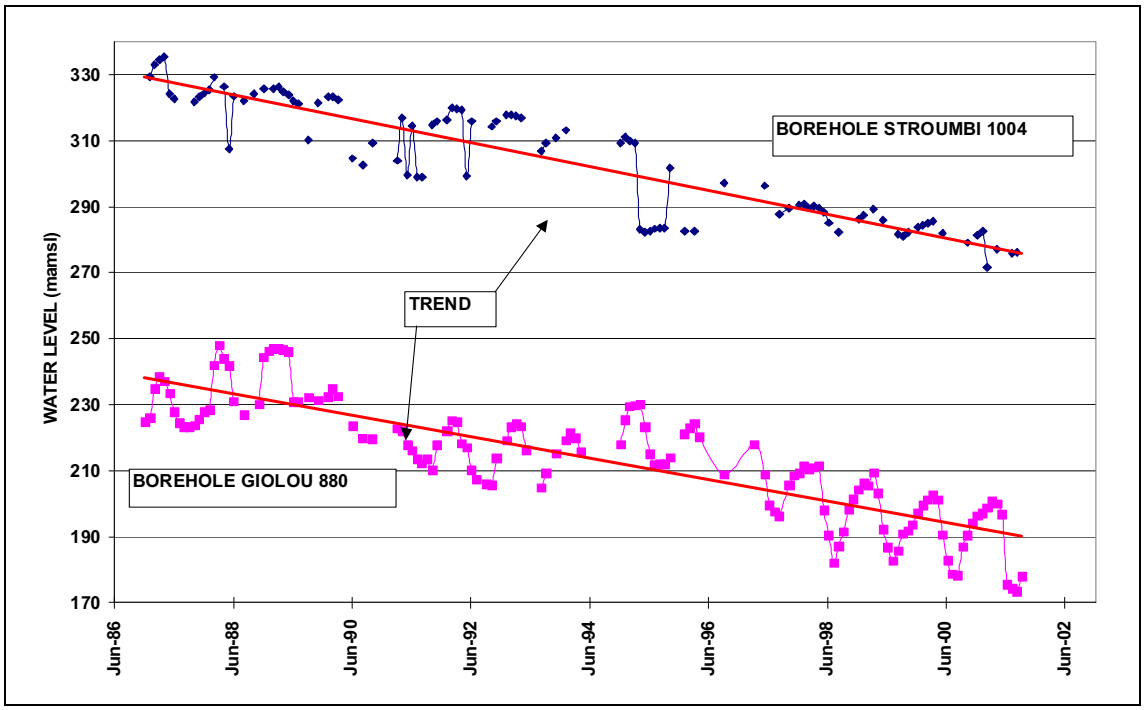
AREA OF THE AQUIFER: 55 Km², WIDTH: 5 km, LENGTH: 11 km, OUTCROP: 48 Km².
THICKNESS: Up to 150 m.
AVERAGE RAINFALL: Period 1990-2000: 550 mm (Period 1970-2000: 600 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 70 m/day (estimated)
Average S = 1% (estimated)
BOUNDARIES: North, South, East and West: impermeable.
CONFINED/UNCONFINED: Unconfined, only the northeastern part is confined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic, karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

The parameters and data available for the estimation of the aquifer's water balance are unreliable. For this reason it is impossible to give any reliable estimates. Extraction and spring outflows are not known. Extraction from the aquifers in year 2000 was indirectly estimated from water demand in the area as given in the report "Assessment of Water Demand of Cyprus "by Loukas Savides, Kyriakos Alexandrou and Gerald Dorflinger, prepared in the framework of the project "Reassessment of the Island's Water Resources and Demand" undertaken in cooperation with FAO.

Many boreholes operate in the aquifer for irrigation purposes. Yields of these boreholes vary from 2 to 50 m³/hour. According to the above-mentioned report total irrigation demand in the villages of the area, is estimated to be around 1.3 mcm/year. Springs and surface water diversions satisfy part of the irrigation demand. The extraction is very roughly estimated to be of the order of 0.8 to 1 mcm/year.

A depleting trend prevails in the area in the last decade because of overpumping. The main source of aquifers recharge is rainfall. It is estimated that total recharge from rainfall is of the order of 2.5 mcm/year.



Hydrograph of boreholes Stroumbi 1004 (Appr. elev. 350 m amsl) and Giolou 880 (Appr. elev. 300 m amsl).

HISTORIC GROUNDWATER BALANCE

Water balance period: 1979 - 81. (WDD-UNDP-FAO, “PRESENT RESOURCES AND THEIR DEVELOPMENT”, KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia Cyprus 1981). Average rainfall: 600mm. In the study only the Stroumbi – Giolou part of the aquifer was included.

Replenishment (mcm/year)		
	Rainfall and River recharge	Total
Average	1.6	1.6

Outflow (mcm/year)			
	Abstraction (irrigation)	Springs and Artesian outflow	Total
Average	0.6	1.0	1.6

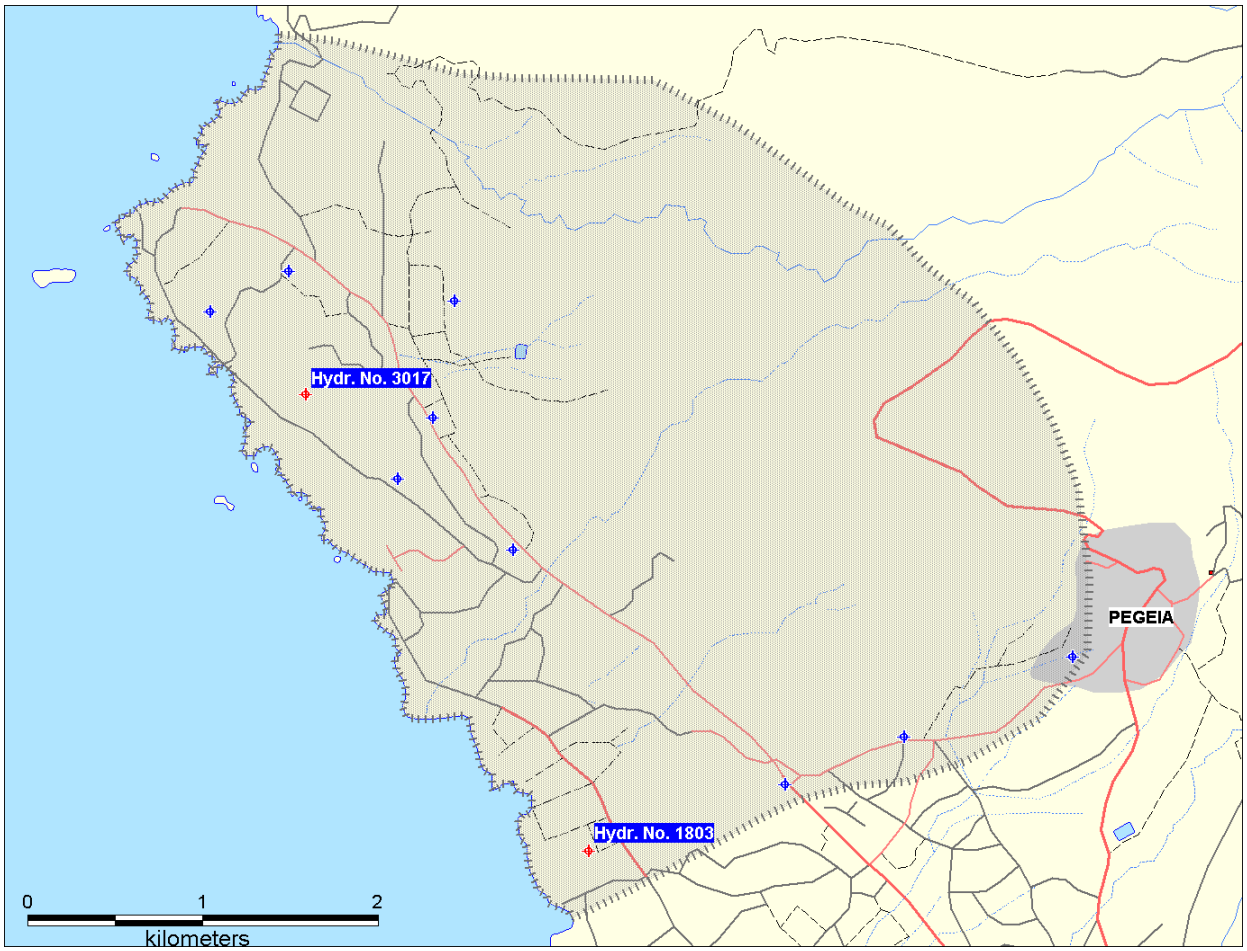
GROUNDWATER BALANCE TODAY

The complex hydrological and hydrogeological conditions of the aquifer together with the absence of reliable data do not allow estimation of the aquifer’s water balance. However, total extraction and the rate of the aquifers’ depletion allowed a rough estimate of permissible extraction, which of course must be lower than today’s level.

Recommended extraction under the hydrometeorological conditions of the last decade: **0.6 to 0.7** mcm/year.

PEGEIA LIMESTONE AQUIFER

INTRODUCTION



Pegeia Limestone Aquifer - Location Map

Pegeia is one of the few limestone aquifers in the free part of Cyprus. It is situated in the area of Pegeia village west of Pafos town. It is a semiconfined coastal aquifer developed in a karstified reef limestone. A hydraulic connection and water interchange with the sea appears at the southwestern boundary of the aquifer. The aquifer is outcropping in its middle part, and its western part is confined between impermeable marls. Its thickness on average is roughly estimated to be 60 m. It varies from a few meters up to 150 -160 m.

Pegeia is a traditional banana producing area. Banana production demands great quantities of water. Citrus is another common crop in the area.

Most of the aquifer's area is included in Pafos Irrigation Project area.

GEOLOGY

The impervious base of the aquifer consists mainly of Palaeogene (Lefkara formation) marls, chalks and chalky marls.

The karstified reef limestone belongs to a member of Lower Miocene age (Pachna formation) known as Terra limestone. Some pouches of the same reef limestone appear 3

to 4 km northwest of the aquifer, but there is no evidence about any connection between these and the Pegeia aquifer.

Middle Pachna formation chalks, sandstones, sandy marls and marls cover the northeastern part of the aquifer. It is assumed that part of aquifer's recharge is coming from this formation.

The ceiling of the confined part of the aquifer along the coastal zone, consists of Plio/Pleistocene marls and sandy marls of the Athalassa formation. It is assumed that there is a connection and water interchange between the calcarenites of this formation and the reef limestone aquifer.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 3 months, 15 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, monthly, 5 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes. Last one in 2000.

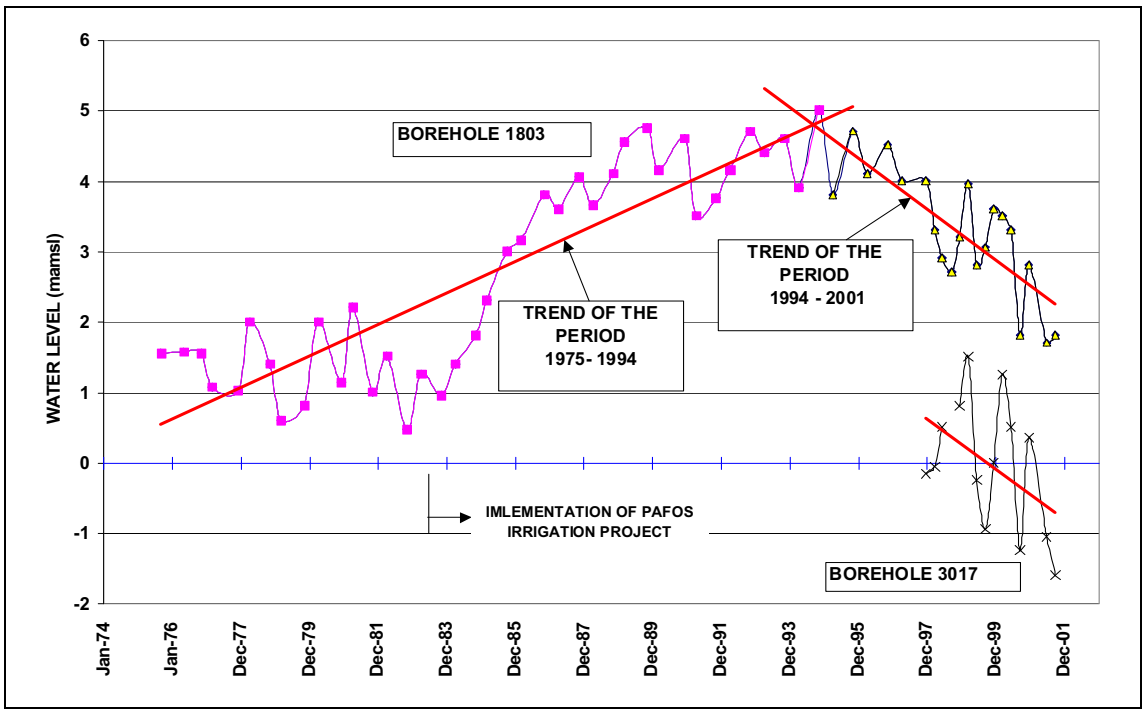
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 20 Km², Width: 5 km, Length: 4 km, Accuracy of Definition: Fair, Outcrop Area: 8 Km².
AVERAGE RAINFALL: Period 1990-2000: 420 mm, (Period 1970-2000: 440 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day, from 10 150 (assumed).
Average S = 1 – 2 % (assumed).
BOUNDARIES: East, West and North: Impermeable. **South:** Permeable, sea.
CONFINED/UNCONFINED: Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

In the last 5 to 6 years i.e. since the time that the amount of water supplied from the Pafos Irrigation Project was reduced the aquifer is under intensive overpumping. Total extraction in 1990 was 0.3 mcm. Extraction increased to 0.8 mcm in 1995 and to 1.3 mcm in 2000. The rate of sea intrusion is very high in the coastal zone of the aquifer.

Borehole yields vary between 5 to 100 m^3/hour. The water is used mainly for irrigation. The rainfall is the main source of aquifer's recharge. Total recharge is estimated to be around 0.8 mcm/year.



Hydrograph of boreholes Pegeia 1803 and 3017 (Elev. 14.61 and 43.31 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

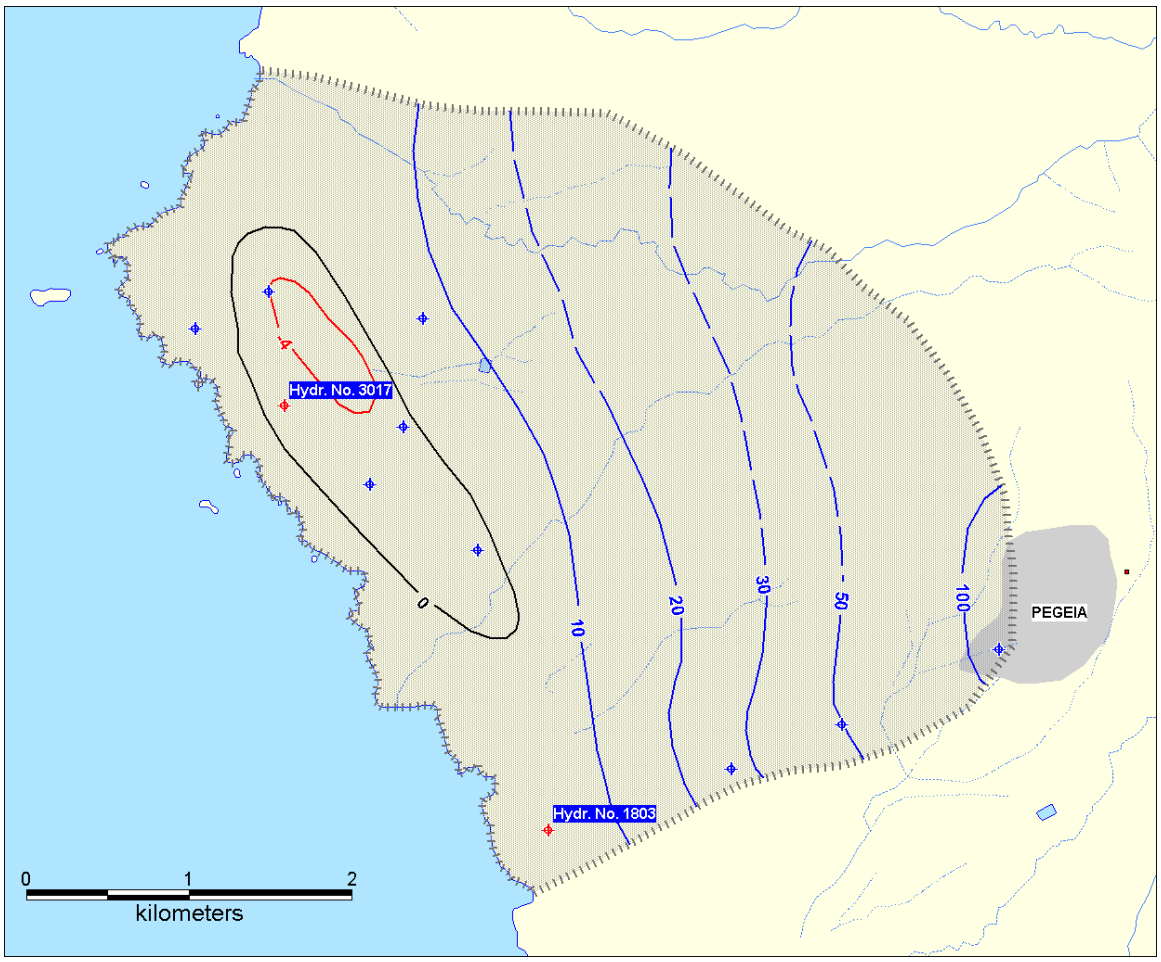
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of definition: Fair. Aquifer's outcrop: 8 km².
Average rainfall = 420mm.

Replenishment (mcm/year)					
	Rainfall	Sea intrusion	Groundwater inflow	Return from irrigation	Total
Average	0.4	0.4	0.3	0.1	1.2

Outflow (mcm/year)			
	Abstraction	Sea outflow	Total
Average	0.8	0.5	1.3

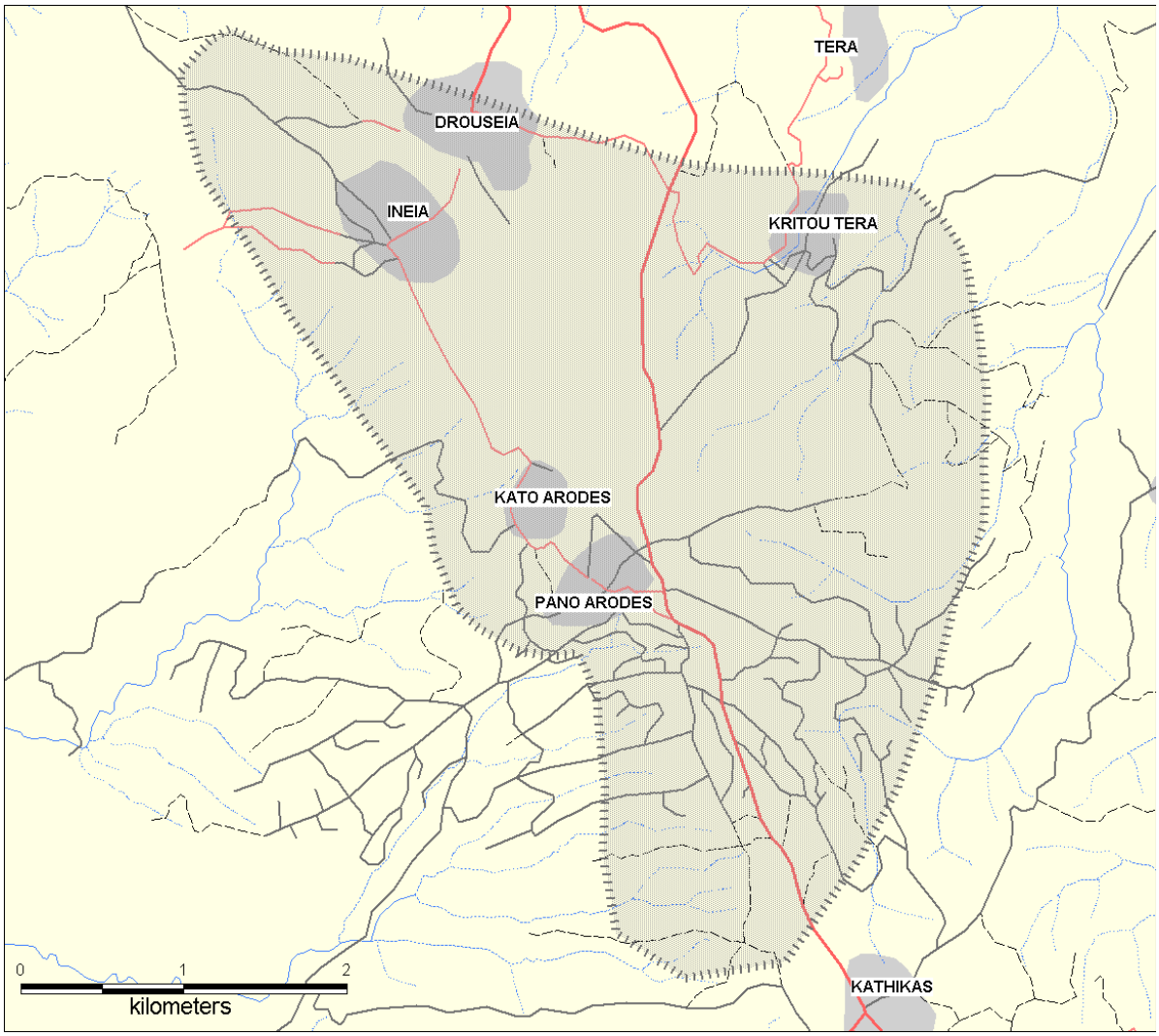
Balance: **-0.1** mcm/year
Recommended extraction until recovery of the aquifer: **0.3** to **0.4** mcm/year. This should be extracted mainly during spring.
Recommended average extraction after recovery of the aquifer: **0.6** to **0.7** mcm/year.



Pegeia Limestone Aquifer - Water Level (m amsl) Contour Map September **2001**

ARODES – KRITOU TERA LIMESTONE AQUIFER

INTRODUCTION



Arodes-Kritou Tera Limestone Aquifer - Location Map

Arodes – Kritou Tera is a karstic limestone aquifer. It appears in the triangle of Kathikas – Arodes - Inia – Tera – Kritou Tera villages in the Chrysochou region. Karstification is only slightly developed. The aquifer is outcropping in its western part. Its eastern part is covered by Middle Miocene (Pachna formation) chalks and marls. It is believed that at its eastern boundary the aquifer is in contact with the sediments of the Chrysochou graben along a north-south fault line.

It is also believed that the aquifer is hydraulically connected with the Androlikou limestone aquifer through a limestone “corridor” at its northeastern boundary and that through the same corridor the aquifer discharges to the sea. The aquifer boundaries, hydraulic connections and groundwater interchange with the surrounding aquifers and generally its hydrogeological regime are not very well defined.

The main source of recharge is rainfall. The aquifer used to be partly discharged through springs such as Kritou Tera and Akourdaleia springs. The Kritou springs have dried up

three decades ago after a series of dry years and water extraction from several boreholes drilled in the area.

GEOLOGY

The impervious base of the aquifer consists of clays of the Mamonia Formation and marls of the Lefkara formation.

The karstified reef limestone belongs to a member of Lower Miocene age (Pachna formation) known as Terra limestone.

Middle Miocene (Pachna formation) chalks, sandy marls and marls cover the eastern part of the aquifer. The chalks are poor in water but some water bearing horizons that are connected to the limestone aquifer are present.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK: No.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 12 Km², Triangle, Base: 6,5 km, Height: 4 km, Outcrop: 8 Km².
AVERAGE RAINFALL: Period 1990-2000: 500 mm, (Period 1970-2000: 520 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day (estimated).
Average S = 1 % (estimated).
BOUNDARIES: East: semipermeable, **West and South:** Impermeable.
North: Permeable to semipermeable.
CONFINED/UNCONFINED: Unconfined to Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

There is neither water level nor quality observation networks for the monitoring of the aquifer. Extraction from the aquifer is not accurately known. It is known that extraction for domestic water supply to the villages in the area is of the order of 0.12 mcm/year. Extraction for irrigation is estimated to be around 0.2 to 0.3 mcm/year. Estimation of extraction from the aquifers for irrigation in year 2000 was based on water demand data prepared by Loukas Savvides, Kyriakos Alexandrou and Gerald Doerflinger. The study was carried out to assess Water Demand in Cyprus, in the framework of the project "Reassessment of the Island's Water Resources and Demand" undertaken in cooperation with FAO.

The aquifer has been exhibiting a depleting trend during the last decade. This is a result of a reduction in recharge and a probable increase in extraction. Water in the aquifer is generally hard.

HISTORIC GROUNDWATER BALANCE

Period: 1979 - 81. (WDD, UNDP, FAO, 1981: “PRESENT RESOURCES AND THEIR DEVELOPMENT”, KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia).

Replenishment (mcm/year)	
	Total
Average	2.0

Outflow (mcm/year)			
	Springs	Groundwater outflow	Total
Average	1.0	1.0	2.0

GROUNDWATER BALANCE TODAY

Period 2000. Accuracy of definition: Poor. Aquifer’s outcrop: 8 km².
Average rainfall: 500mm.

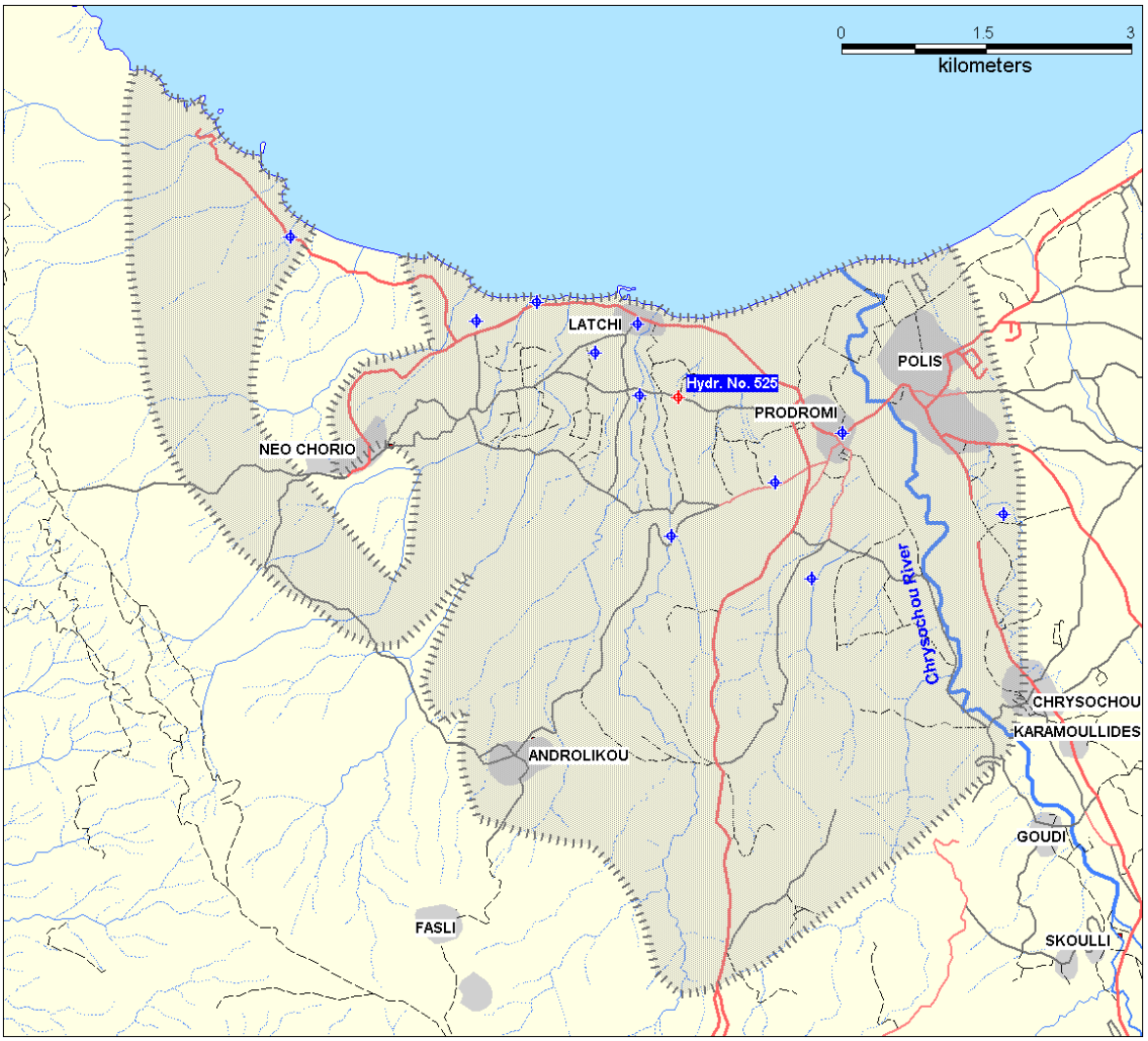
Replenishment (mcm/year)			
	Rainfall and river	Groundwater inflow	Total
Average	0.6	0.2	0.8

Outflow (mcm/year)			
	Abstraction	Groundwater outflow, springs	Total
Average	0.4	0.5	0.9

Balance: **-0.1** mcm/year.
Recommended extraction: **0.3** to **0.4** mcm/year.

ANDROLIKOU LIMESTONE AQUIFER

INTRODUCTION



Androlikou Limestone Aquifer - Location Map

Androlikou is one of the most important karstic limestone aquifers in the government controlled part of the Island. It extends over the area of Androlikou – Prodromi – Loutra tis Afroditis villages in Chrysochou region. It is a semiconfined coastal aquifer developed in a karstified reef limestone. A hydraulic connection and water interchange with the sea appears at the northern boundary of the aquifer. The aquifer is outcropping in its middle part. Impermeable marls confine its northern and eastern parts. At its eastern boundary the aquifer is in contact with the sediments of the Chrysochou graben, along a north-south fault line. The average thickness of limestone is roughly estimated to be 50 to 60 m. It varies from a few meters to 100 m.

It is believed that the aquifer is hydraulically connected with the Arodes-Kritou Terra limestone aquifer through a limestone “corridor” at its southeastern boundary. The aquifer boundaries, hydraulic connections and groundwater interchange with the surrounding aquifers are not very well defined.

The main source of recharge to the aquifer is rainfall. The aquifer discharges partly through springs (Loutra tis Afroditis).

The northern part of the aquifer is included in the Chrysochou Irrigation Project area.

GEOLOGY

The impervious base of the aquifer consists mainly of clays of the Mamonia Formation.

The karstified reef limestone belongs to a member of Lower Miocene age (Pachna formation) known as Terra limestone.

The western part of the aquifer in the area of Loutra tis Afroditis is covered by Middle Miocene (Pachna formation) chalks, sandy marls and marls.

The ceiling of the confined part of the aquifer along both the coastal zone and the eastern boundary consists of Plio/Pleistocene marls and sandy marls of the Nicosia and Terrace deposits formations.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 11 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 8 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes. Last one in 2000.

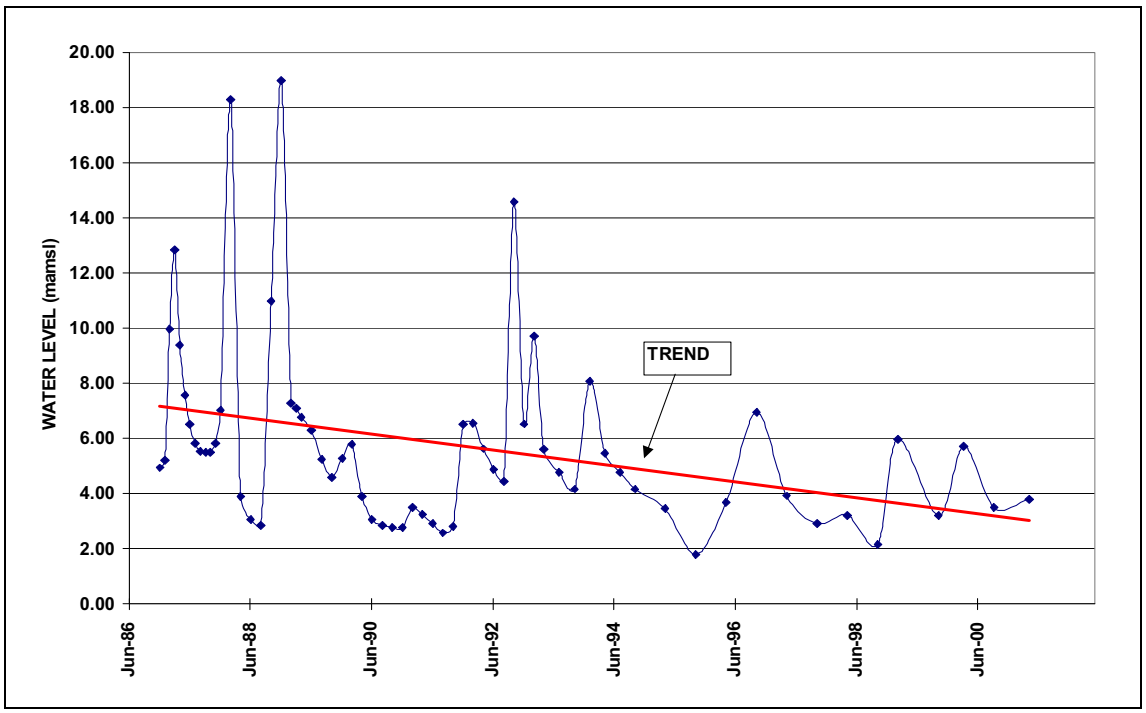
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 36 Km², Width: 6 km, Length: 6 km, Outcrop Area: 20 Km².
AVERAGE RAINFALL: Period 1990-2000: 420 mm, (Period 1970-2000: 450 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day.
Average S = 1 – 2 % (assumed).
BOUNDARIES: East: semipermeable, **West and South:** Impermeable.
North: Permeable, sea.
CONFINED/UNCONFINED: Semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Karstic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

In the last 5 to 6 years the aquifer is under intensive overpumping, especially in the area of Neo Chorio. During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. The average extraction in the last ten years was 0.6 mcm. Extraction increased from 0.5 mcm in 1995 to 0.73 mcm in 2000. Overpumping in the last few years resulted to sea intrusion in the coastal zones of the aquifer.

Average borehole yields are around 10 to 15 m^3/hour. Aquifer water is generally hard and it is used mainly for irrigation. Total recharge is estimated to be around 2.1 mcm/year.



Hydrograph of borehole Prodromi 525 (Elev. 39.60 m amsl)

HISTORIC GROUNDWATER BALANCE

Period: 1979 - 81. (WDD, UNDP, FAO, 1981: "PRESENT RESOURCES AND THEIR DEVELOPMENT", KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia). The recharge was estimated to be 2 mcm/year and the extraction 0.2 mcm/year.

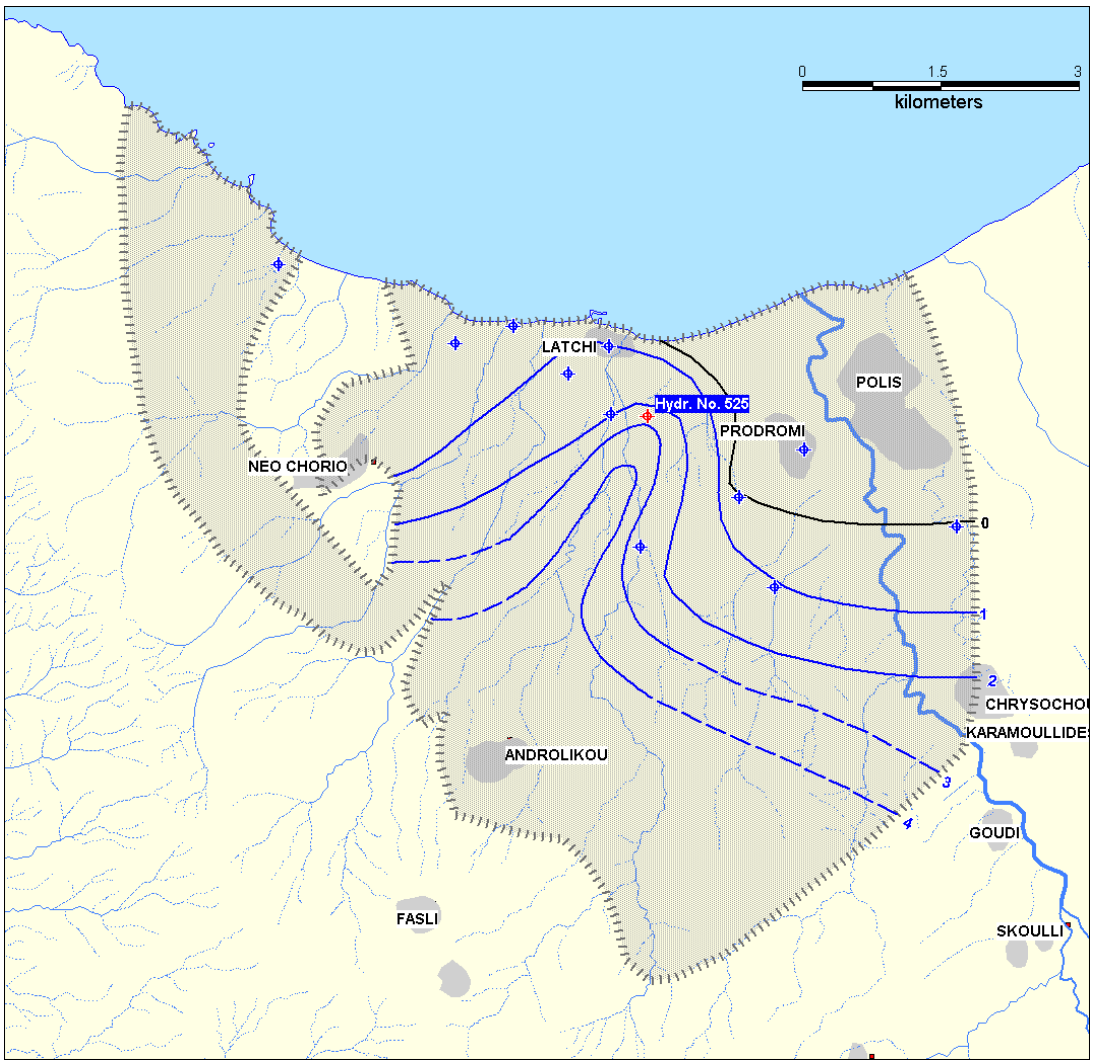
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of definition: Fair. Aquifer's outcrop: 20 km².
Average rainfall = 420mm.

Replenishment (mcm/year)					
	Rainfall and river	Sea intrusion	Groundwater inflow	Return from irrigation	Total
Average	1.5	0.2	0.5	0.1	2.3

Outflow (mcm/year)				
	Abstraction	Groundwater outflow, springs	Sea outflow	Total
Average	0.6	0.4	1.4	2.4

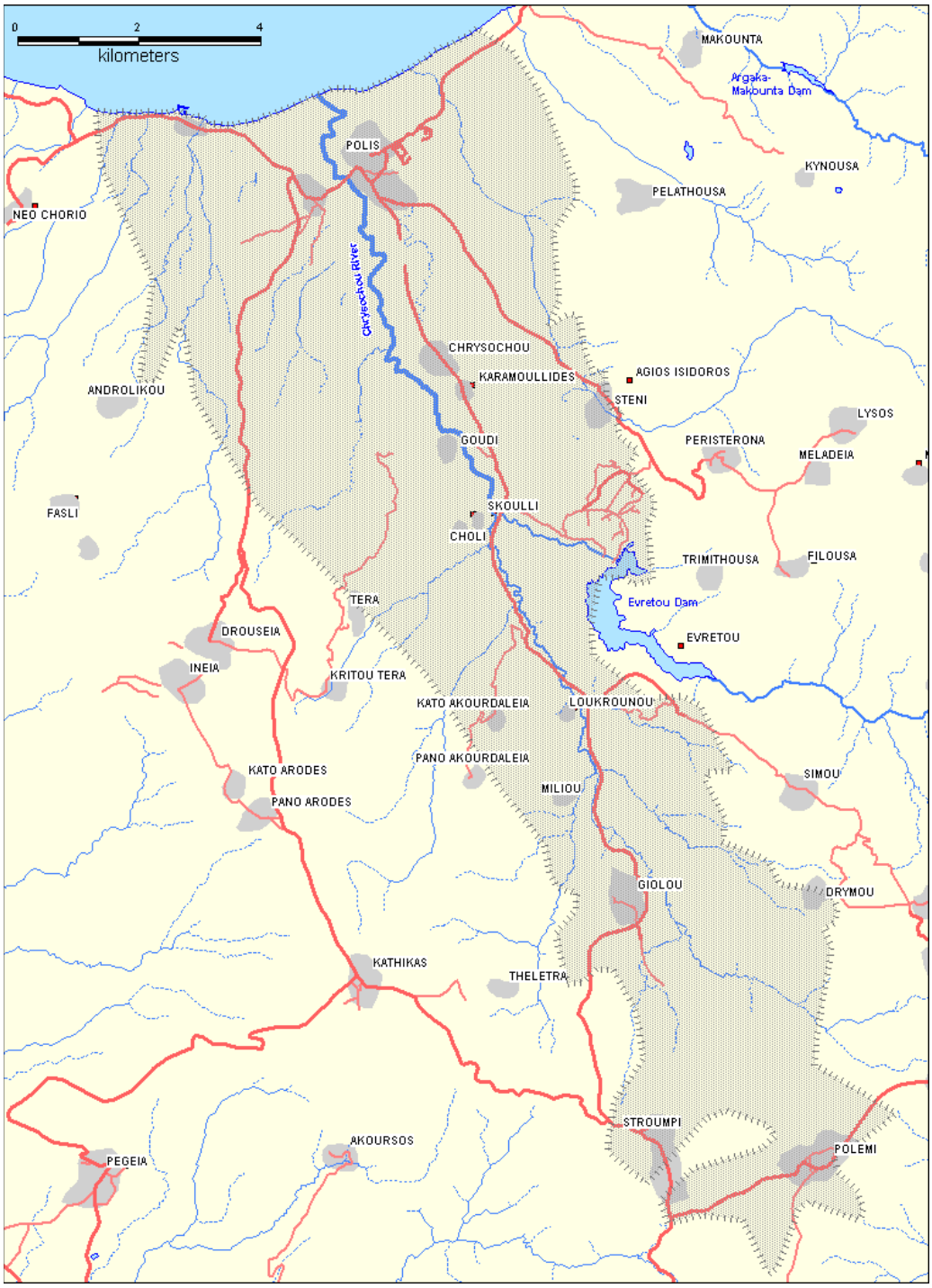
Balance: **-0.1** mcm/year
Recommended extraction until recovery of the aquifer: **0.3** to **0.4** mcm/year. This should be extracted mainly during spring.
Recommended average extraction after recovery of the aquifer: **0.5** mcm/year.



Androlikou Limestone Aquifer – Water Level (m amsl) Contour Map May 2001

CHRYSOCHOU PLIOCENE AQUIFER

INTRODUCTION



Chrysochou Pliocene Aquifer - Location Map

Chrysochou Pliocene is an aquifer on the northern coast of Cyprus. It is developed along the Chrysochou river valley. It extends from the area of Giolou village to the sea. The largest part of irrigation demand in the area is covered by the Chrysochou Irrigation Project.

The borehole yields in the aquifer are very low and the aquifer is practically unexploited. For this reason no observation network was established in the aquifer. Possible

exploitation of the aquifer may be worth investigating especially in the downstream areas near the sea where it is believed that there may be a potential for exploitation. The aquifer has not been properly studied and the information appearing in this report is based mainly on the author's experience.

The aquifer is in direct contact with the Chrysochou riverbed aquifer and the Androlikou limestone aquifer. There is a hydraulic connection and water interchange between these aquifers. The predominant direction of flow is from this Pliocene aquifer to the other two aquifers.

The aquifer is developed in silty sands, silty gravels and silty sandstones of the Nicosia Formation. It is approximately 18 km long and 4 km wide. Its average thickness is estimated to be around 10 to 15 m.

TENTATIVE WATER BALANCE

Accuracy of estimations: Poor. Aquifer's area: 70 km².
Average rainfall: 450 mm.

Replenishment (mcm/year)					
	Rainfall	Sea intrusion	Return from irrigation	Groundwater inflow	Total
Average	2.0	0.0	0.3	0.0	2.3

Outflow (mcm/year)				
	Abstraction	Groundwater Outflow	Sea Outflow	Total
Average	0.0	0.6	1.7	2.3

Balance: 0 mcm/year.
Recommended extraction (Tentative): **1.0** mcm/year.

CHRYSOCHOU RIVERBED AQUIFER

INTRODUCTION

Chrysochou is an alluvial aquifer on the northern coast of Cyprus. It is the most important and the most dynamic aquifer in Chrysochou area. It is developed along the Chrysochou river. The Evretou dam constructed in 1986 on the Stavros tis Psokas tributary, 2 km upstream of its junction with the Chrysochou river, reduces the recharge to the aquifer. This 25 mcm capacity dam is the main reservoir of the Chrysochou Irrigation Project. Most of the area of the aquifer and part of irrigation demand in the area is covered by this Project.

The main sources of recharge are river flows, underground losses of the dam, groundwater inflow from other aquifers and rainfall. The Evretou dam has never spilled. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

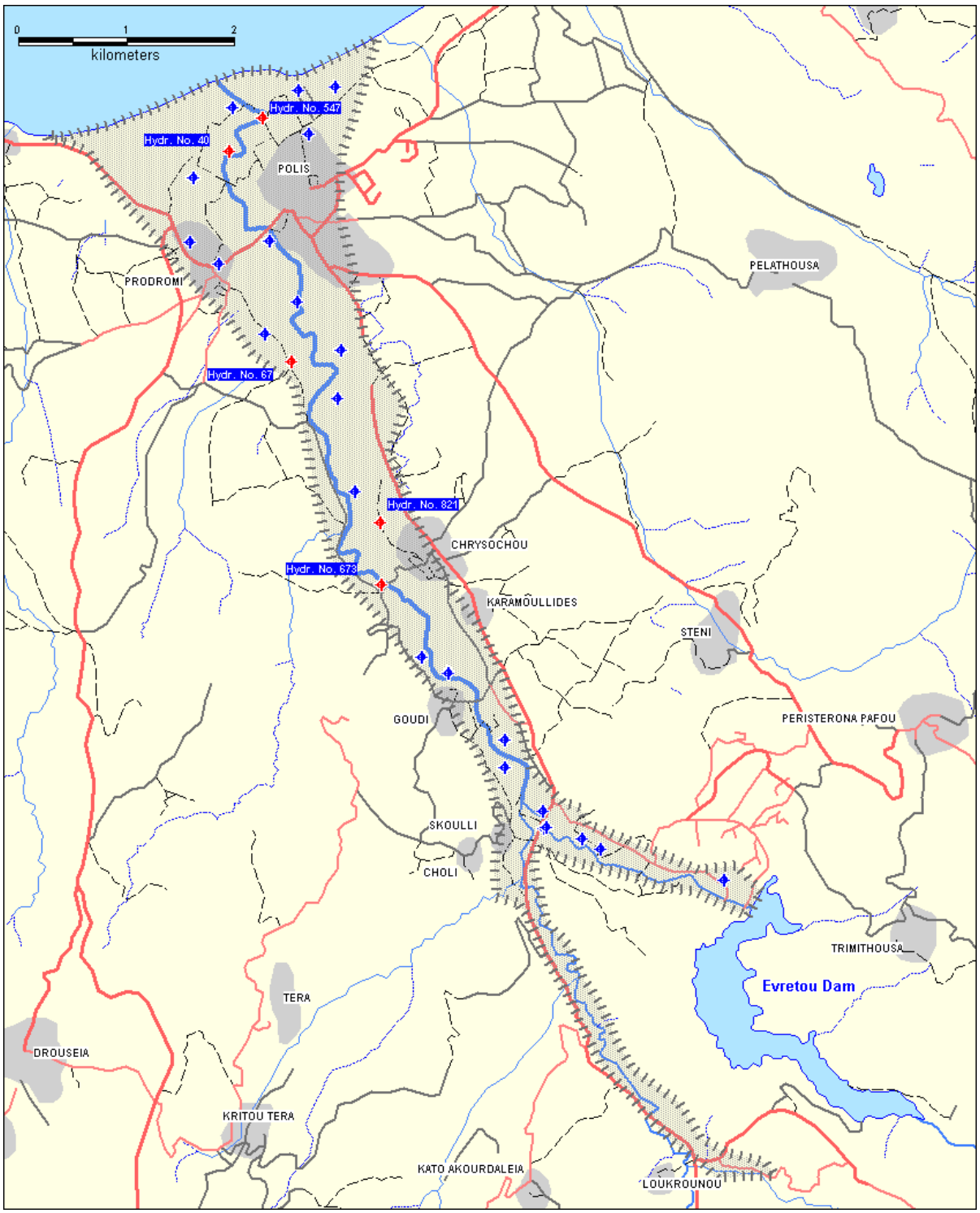
At its southeastern part, in the area of the villages of Miliou and Loukrounou, this aquifer is hydraulically connected to the Letimvou - Giolou gypsum aquifer. The gypsum aquifer discharges in the alluvial aquifer through underground leakages and karstic springs. This connection, the interchange regime and the quantities involved are not well known. Groundwater in the gypsum aquifer is normally saturated in sulfate ion thus this connection adversely affects the quality of river water and groundwater in Chrysochou aquifer downstream of these villages. Groundwater can be used only for irrigation purposes. Groundwater in the aquifer developed in Stavros tis Psokas riverbed and downstream of the Evretou dam is of an acceptable quality and it is used for domestic water supply.

The aquifer is in direct contact along its length with the Chrysochou Pliocene aquifer. There is a hydraulic connection and water interchange between these two aquifers.

GEOLOGY

The impervious base of the aquifer consists of Pliocene (Nicosia formation) marls. The aquifer consists of alluvial deposits, gravels, sands and silts. In downstream sections and especially in the delta area low permeability silty and clayey lenses as well as silty zones are common. The aquifer in these zones is often semiconfined or confined.

The thickness of the aquifer near Evretou dam on the Stavros tis Psokas tributary is of the order of 30 m. In the delta area the aquifer thickness increases to 50m. The thickness of the alluvial deposits upstream of Skoulli village on the second main tributary of the Chrysochou river is not more than 10 m. It practically disappears in the area of Giolou village.



Chrysochou Riverbed Aquifer - Location Map

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 30 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 13 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

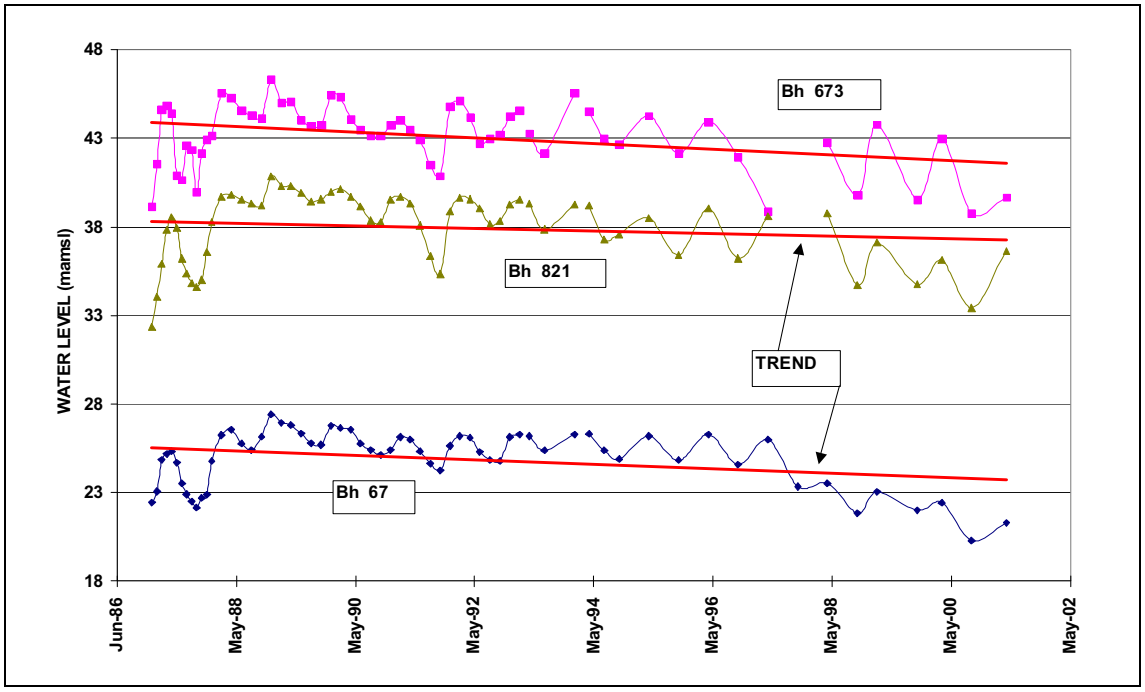
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 6.0 Km², WIDTH: 500 m, LENGTH: 12 Km, OUTCROP: 6.0 Km².
AVERAGE RAINFALL: Period 1990-2000: 450 mm (Period 1970-2000: 470 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 40 m/day.
Average S = 10%.
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined to semiconfined in delta area.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

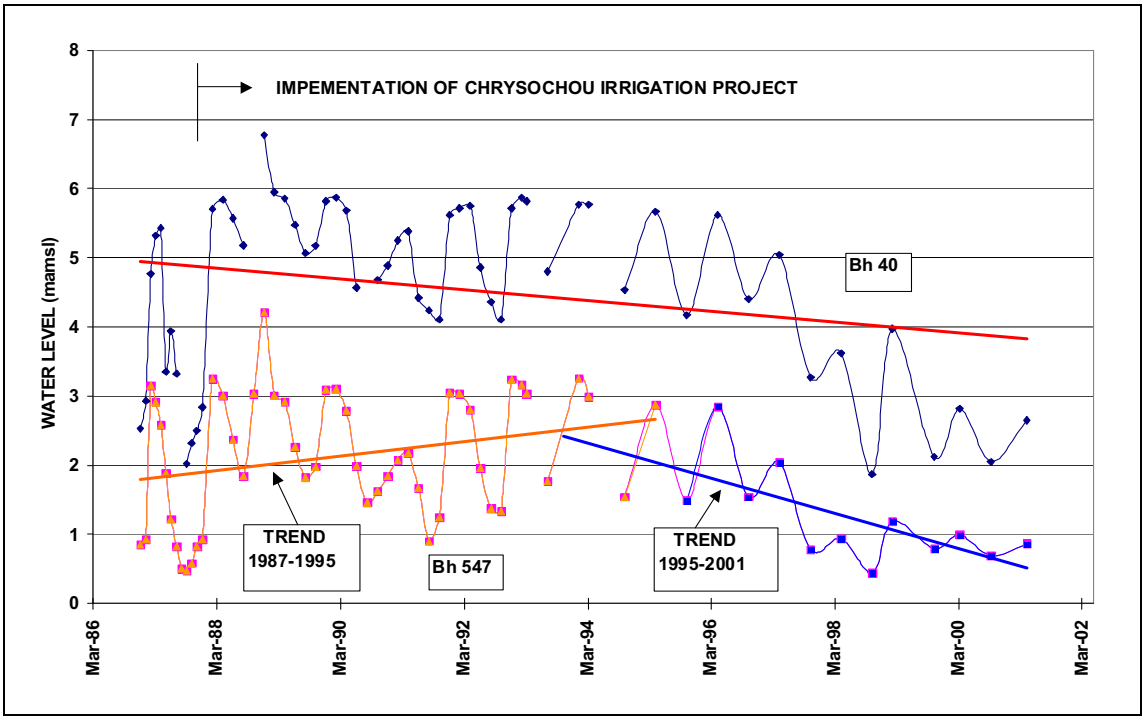
HYDROGEOLOGICAL CONDITIONS TODAY

Around 70 boreholes operate in the aquifer for local irrigation and domestic water supply. Borehole yields vary from 10 to 50 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be 1.3 mcm/year. Total extraction increased from around 0.8 mcm/year in years earlier than 1994 to around 1.8 mcm/year in 1998. Extraction in 2000 was 1.7 mcm. Average natural recharge for the same period is estimated to be around 2.8 mcm/year.

The aquifer is overpumped. During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge in conjunction with an increase in extraction. This trend has intensified during the last five to six years. Nevertheless no serious sea intrusion problems have been reported in the delta area.



Hydrograph of boreholes Prodromi 672, Chrysochou 637 and 821
(Elev. 31.69, 52.07 and 50.27 m amsl)



Hydrograph of boreholes Chrysochou 40 and 547 (Elev. 10.7 and 5.39 m amsl).

HISTORIC GROUNDWATER BALANCE

Period: 1979 - 81. (WDD, UNDP, FAO, 1981: "PRESENT RESOURCES AND THEIR DEVELOPMENT", KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia). Average rainfall: 500mm.

Replenishment (mcm/year)					
	Rainfall	Sea intrusion	Riverbed recharge	Groundwater inflow	Total
Average	0.3	0.0	1.1	0.6	1.9

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.6	1.4	2.0

Balance: - **0.1** mcm/year.

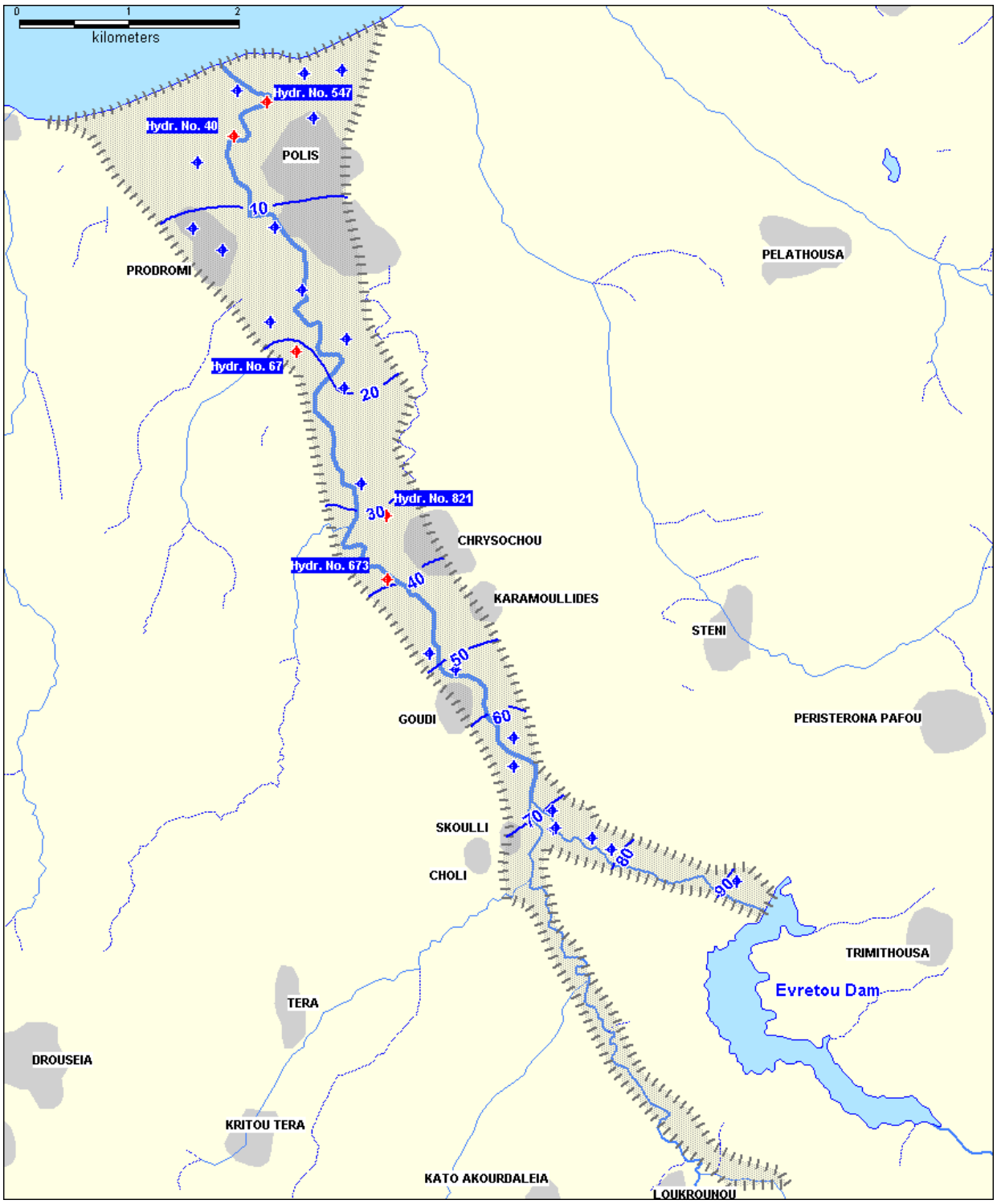
GROUNDWATER BALANCE TODAY

Period 1991 – 2000: Accuracy of estimations: Good. Aquifer's area: 6.0 km².
Average rainfall: 450 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.4	0.0	0.9	0.3	1.2	2.8

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	1.3	1.7	3.0

Balance: **- 0.2** mcm/year.
Recommended sustainable extraction: **1.1** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.

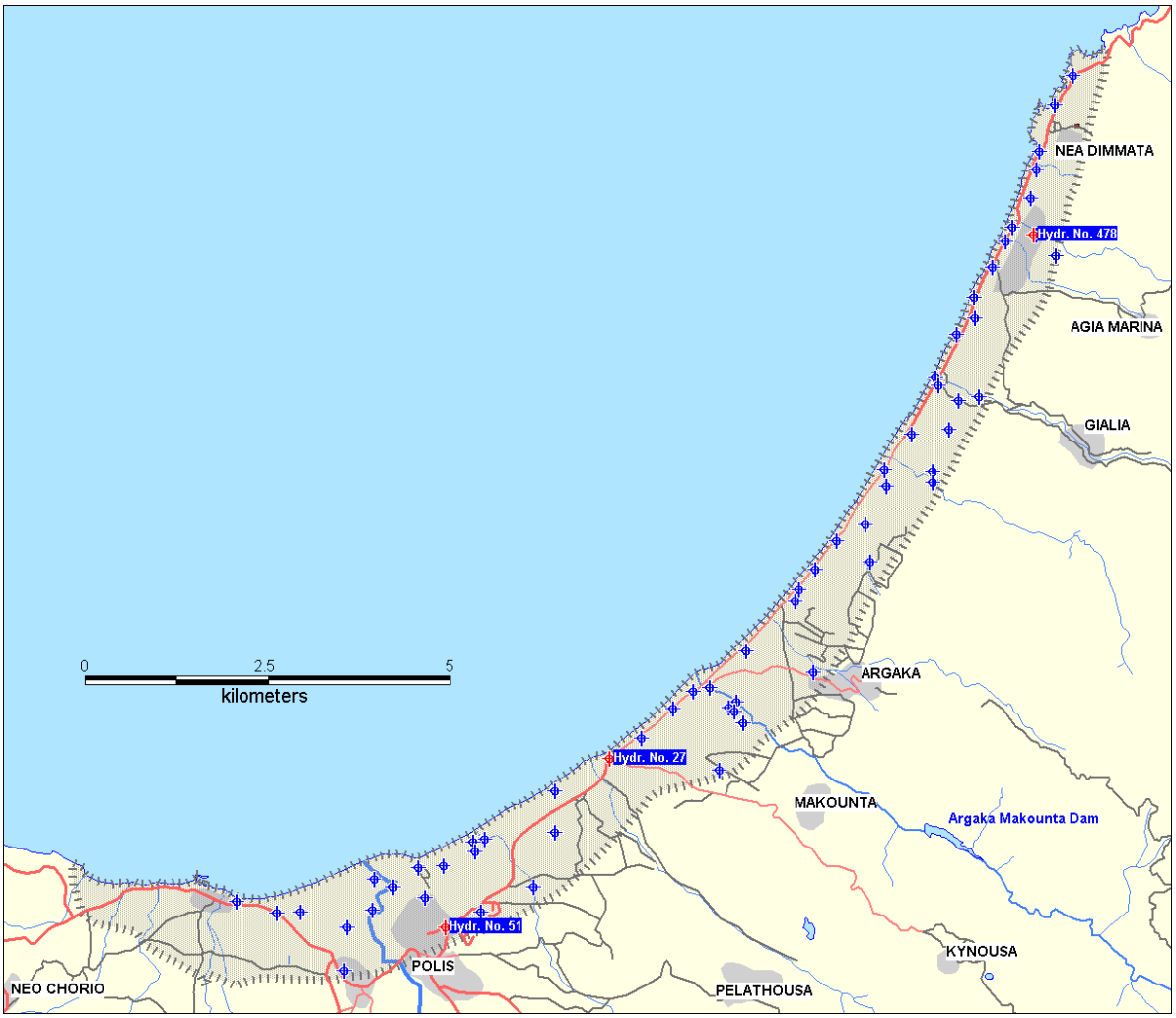


Chrysochou Riverbed Aquifer - Water Level (m amsl) Contour Map May 2001

CHRYSOCHOU - GIALIA COASTAL PLAIN AQUIFER

INTRODUCTION

The Chrysochou-Gialia Coastal Plain aquifer is developed along an 18 km long coastal strip, stretching from the Polis Chrysochou area at the west to Nea Dimmata village at the east. Its average width is about 1.5 km. It is developed in sea terrace deposits laid along the Chrysochou bay. The area of this aquifer is completely covered by the Chrysochou Irrigation Project.



Chrysochou-Gialia Coastal Plain Aquifer - Location Map

The aquifer is crossed by the alluvial deltas of Chrysochou, Mirmigofou, Limni, Makounta, Xeropotamos, Gialia and Xeros rivers. There are underground hydraulic connections and groundwater interchanges between these riverbed aquifers developed along these rivers and the coastal plain aquifer. Descriptions of these riverbed aquifers are given in separate chapters.

The southeastern boundary of the aquifer is in contact with theTroodos igneous rocks. Lavas appear at the southwestern section of this boundary and diabase at the northeastern section. Groundwater in igneous rocks in the area and especially in lavas is rich in Boron. Boron concentration is very high along the Limni and Argaka fault zones. Concentrations as high as 6 and 7 mg/lit are often encountered in these zones. Boron

concentrations higher than o.3 to 0.5 mg/lit are not tolerated by citrus and other sensitive plants. Concentrations higher than 4 mg/lit are poisonous to most plants. The aquifers developed in these igneous rocks and fault zones are hydraulically connected to and recharge the coastal plain aquifer. This state of affairs resulted in a general Boron contamination of the water in the coastal plain aquifer. Boron levels in this aquifer vary from 0.2 to 0.7 mg/lit. Boron contamination is more pronounced in the areas of Limni and at the north of Argaka village where it reaches levels as high as 3 mg/lit. Both areas are connected to the Limni and Argaka fault zones. Other local anomalies in the area such as high sulfate concentrations and high water temperatures are associated with several other faults.

GEOLOGY

The impervious base of the aquifer at the southwestern part of the aquifer consists mainly of Pliocene (Nicosia formation) marls and chalky marls. The northwestern part of the aquifer base consists of igneous rocks, lavas and diabase.

The aquifer is mainly developed in the Pleistocene Fanglomerate and Terrace Deposits formations. It consists of gravels, sands, silts and sandstones intercalated by marly sections.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 35 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 20 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 27 Km², WIDTH: 1.5 km, LENGTH: 18 km, OUTCROP: 26 Km².
AVERAGE RAINFALL: Period 1990-2000: 400 mm, (Period 1970-2000: 430 mm).
AVERAGE THICKNESS: 10 m, from few to 40m.
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day (estimated).
Average S = 6 % (estimated).
BOUNDARIES: South, southeast: Semipermeable to Impermeable.
North, Northwest: Permeable, Sea.
CONFINED/UNCONFINED: unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): High, phreatic aquifer.

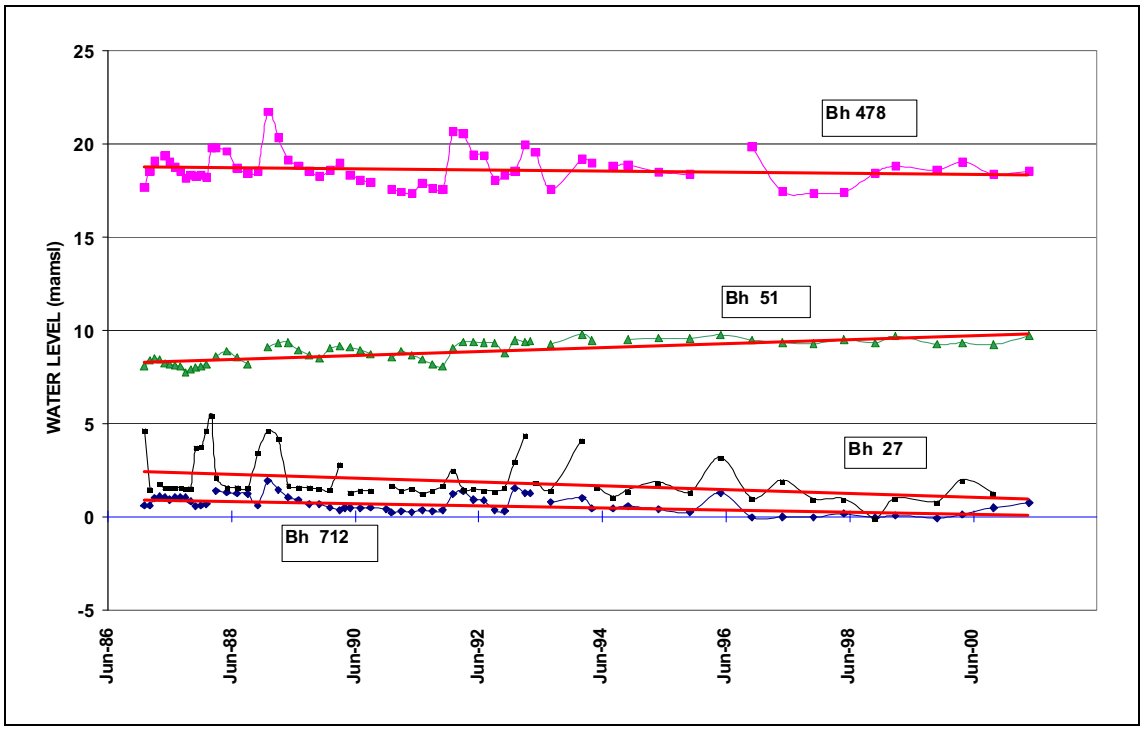
HYDROGEOLOGICAL CONDITIONS TODAY

The impervious base of the aquifer in the coastal zone is below sea level. Many areas of the aquifer, such as Makounta-Limni area, have been sea intruded since the beginning of the eighties because of overpumping of the aquifer.

It is estimated that around 200 boreholes and wells operate in the area today and their yield ranges from 1 to 20 m³/hour. Dry years in the last ten years forced extraction to double from a steady 0.4 mcm up to 1995 to 0.8 mcm in 1998. The extraction in 2000 was 0.77mcm. Average extraction during the last decade was 0.6 mcm/year.

The aquifer in general is overpumped. During the last decade the aquifer exhibits a depleting trend. This is a result of reduced recharge and increase in extraction. Overexploitation resulted in the sea intrusion of many zones e.g. in Argaka, Agia Marina and Gialia areas.

The interannual storage of the aquifer is very small. Aquifer yield during dry years is very low and the potential danger for sea intrusion is very high.



Hydrograph of boreholes Pomos 712, Agia Marina 478, Polis 51 and Argaka 27 (Elev. 5.37, 24.25, 19.17 and 5.76 mamsl).

HISTORIC GROUNDWATER BALANCE

Period: 1979 - 81. (WDD, UNDP, FAO, 1981: "PRESENT RESOURCES AND THEIR DEVELOPMENT", KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia, Cyprus). Average rainfall: 500mm. Annual extraction from this aquifer, including extraction from the riverbed aquifers was estimated to be 1.2 mcm.

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 26 km².
Average rainfall: 400mm.

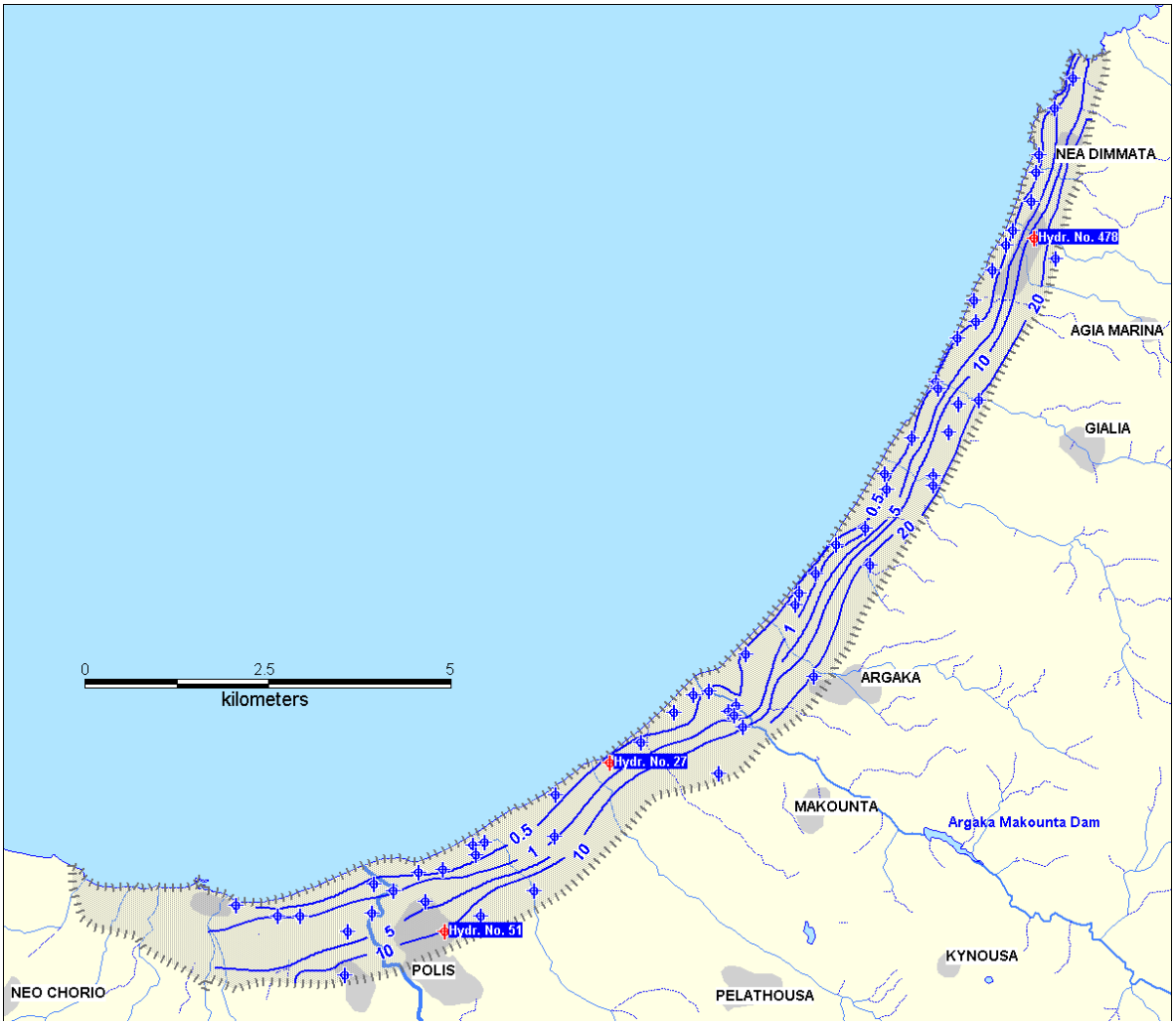
Replenishment (mcm/year)					
	Rainfall	Subsurface Inflow	Sea intrusion	Return from irrigation /dom.	Total
Average	1.4	0.3	0.1	0.3	2.1

Outflow (mcm/year)				
	Abstraction for irrigation	Subsurface outflow	Sea Outflow	Total
Average	0.6	0.1	1.5	2.2

Balance: **-0.1** mcm/year

An increase in extraction in early spring and a decrease in extraction in summer is recommended. Increase of pumpage in spring by several hundreds of thousands of cubic meters will reduce groundwater outflow to the sea with no adverse effects on the aquifer.

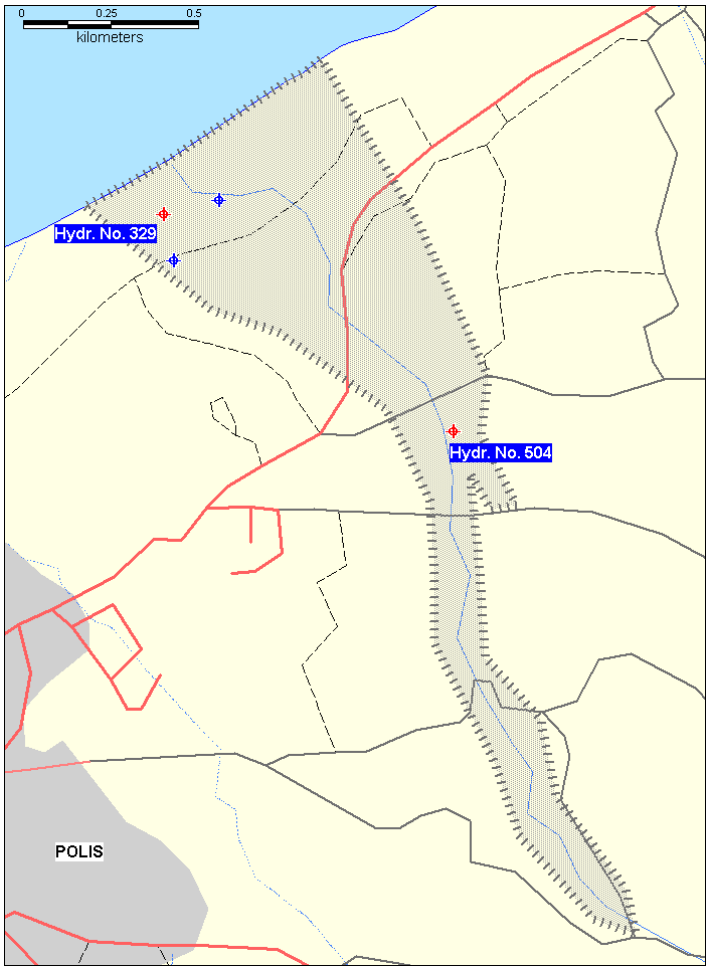
Recommended total extraction: **0.4** mcm/year



Chrysochou-Gialia Coastal Plain Aquifer – Water Level (m amsl) contour map May 2001

MIRMIGOFOU RIVERBED AQUIFER

INTRODUCTION



Mirmigofou Aquifer - Location Map

Mirmigofou is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Mirmigof river. It is of local importance. Its most water productive part is its downstream, coastal section. Part of irrigation demand in the area is covered by the Chrysochou Irrigation Project.

The delta area of the aquifer crosses the Chrysochou - Gialia coastal plain aquifer. It is assumed that there is a hydraulic connection between them but at this stage of the study the water interchange cannot be quantified.

The main sources of recharge are river flows and rainfall. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

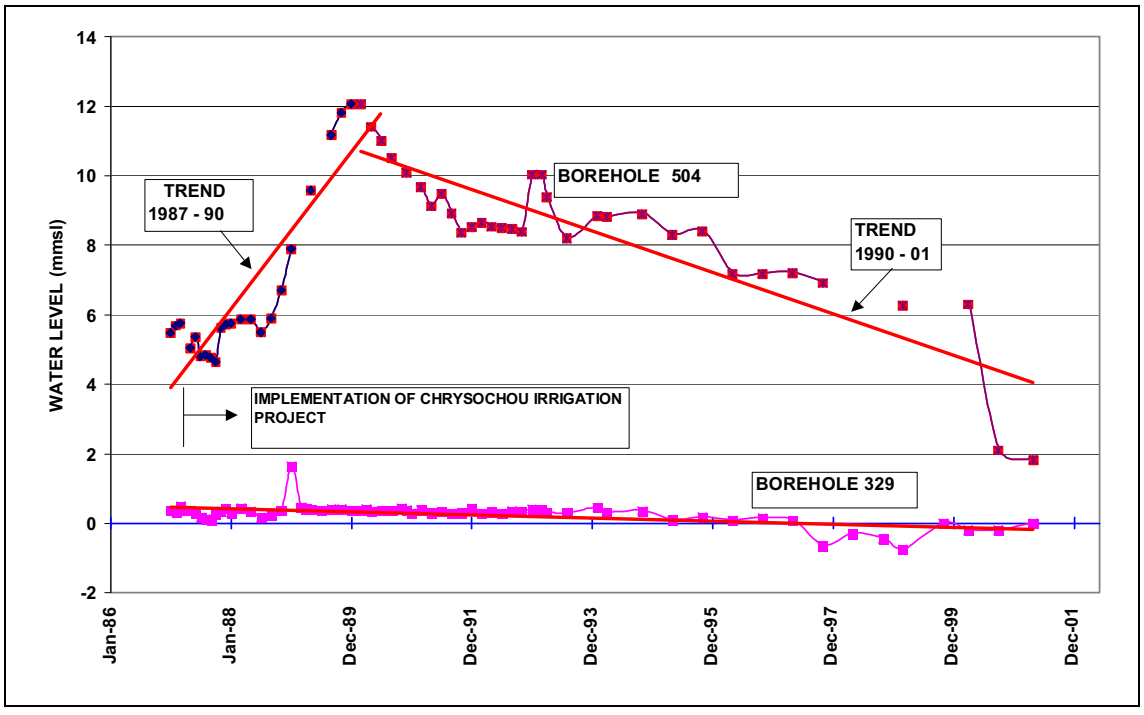
The impervious base of the aquifer is made up of Pleistocene marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 6 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 2 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0. 5 Km², AVERAGE WIDTH: 200 m, LENGTH: 2.5 Km, OUTCROP: 0.5 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 40 m/day (estimated).
Average S = 8% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of boreholes Polis 329 and 504 (Elev. 4.47 and 18.33m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Around eight boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 10 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 0.04 mcm/year. Total extraction increased from around 0.03 mcm/year before 1995 to around 0.05 mcm/year in 1998. Average natural recharge for the same period is estimated to be around 0.16 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. No problems with sea intrusion in the delta area have been reported.

HISTORIC GROUNDWATER BALANCE

Not available.

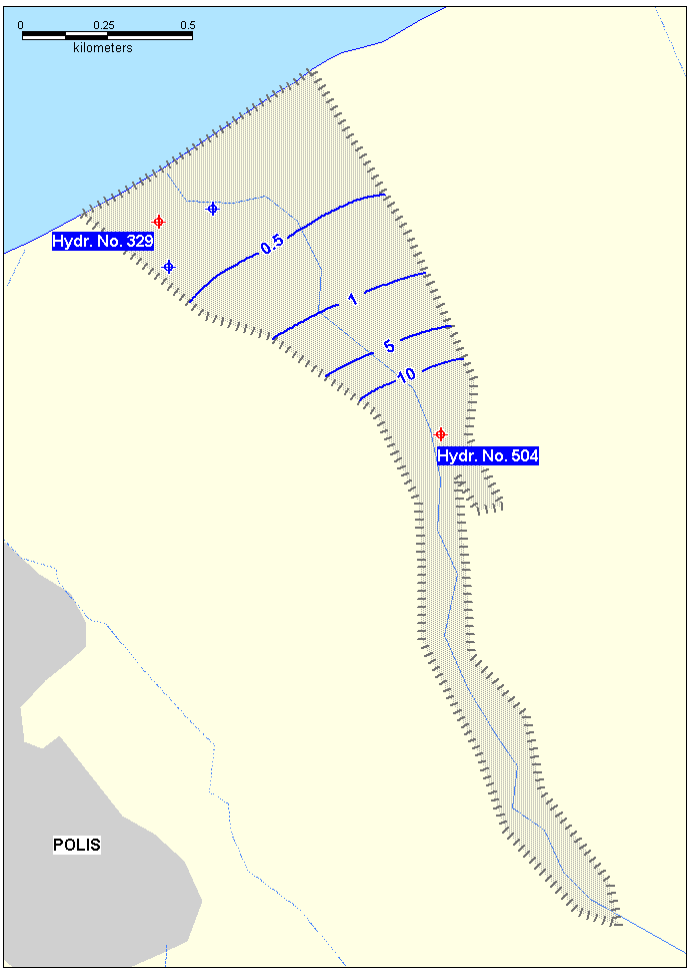
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 0.5 km². Average rainfall: 400 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.03	0.00	0.10	0.02	0.01	0.16

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.04	0.14	0.18

Balance: **- 0.02** mcm/year.
Recommended sustainable extraction: **0.03** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer

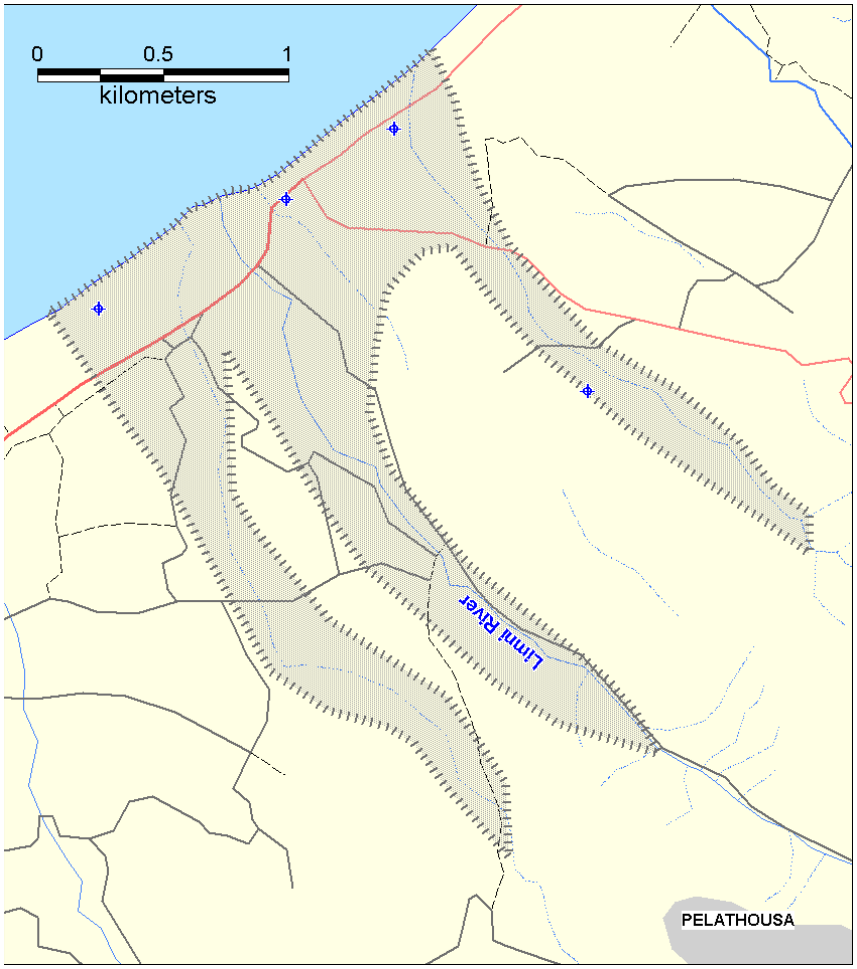


Mirmigofou Aquifer – Water Level (m amsl) Contour Map May 2001

LIMNI RIVERBED AQUIFER

INTRODUCTION

Limni riverbed aquifer is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Limni river. There are some small riverbed aquifers developed along the valleys of adjacent rivulets connected to it. Irrigation demand in the area is covered by Chrysochou Irrigation Project.



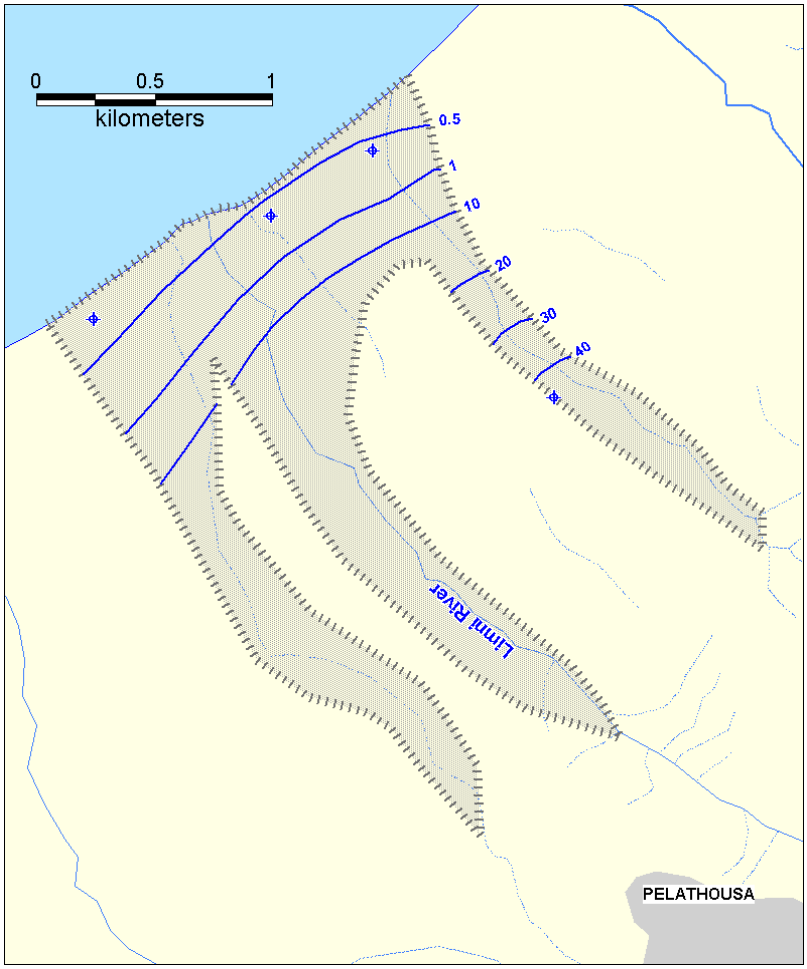
Limni Riverbed Aquifer - Location Map

Limni is a fault-controlled valley. Groundwater in the aquifer developed in the Limni fault zone is highly mineralized. Limni riverbed aquifer is connected to and is partly recharged by this fault zone aquifer. This connection resulted in the contamination of the groundwater in the alluvial aquifer by the highly mineralized water in the fault zone. The concentration of Boron exceeds the 3 mg/lit in places. This concentration is poisonous to most plants and especially to citrus. The presence of this ion and the general high mineralization do not allow any serious exploitation of this aquifer. There is no water abstraction in the area and none is recommended.

GEOLOGY

The impervious base of the upstream section of the aquifer consists of Pillow Lavas. The base of the downstream section of the aquifer consists of Pleistocene marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

The highly mineralized water circulating within the fault zone resulted in the deposition of minerals in the area. Hence the presence of Limni mine



Limni Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 1 borehole.
WATER QUALITY OBSERV. NETWORK: No.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: No extraction in the area.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0. 5 Km², AVERAGE WIDTH: 200 m, LENGTH: 2.5 Km, OUTCROP: 0.5 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30 m/day (estimate).
Average S = 6% (estimated).
BOUNDARIES: East, South and West: Semipermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high.

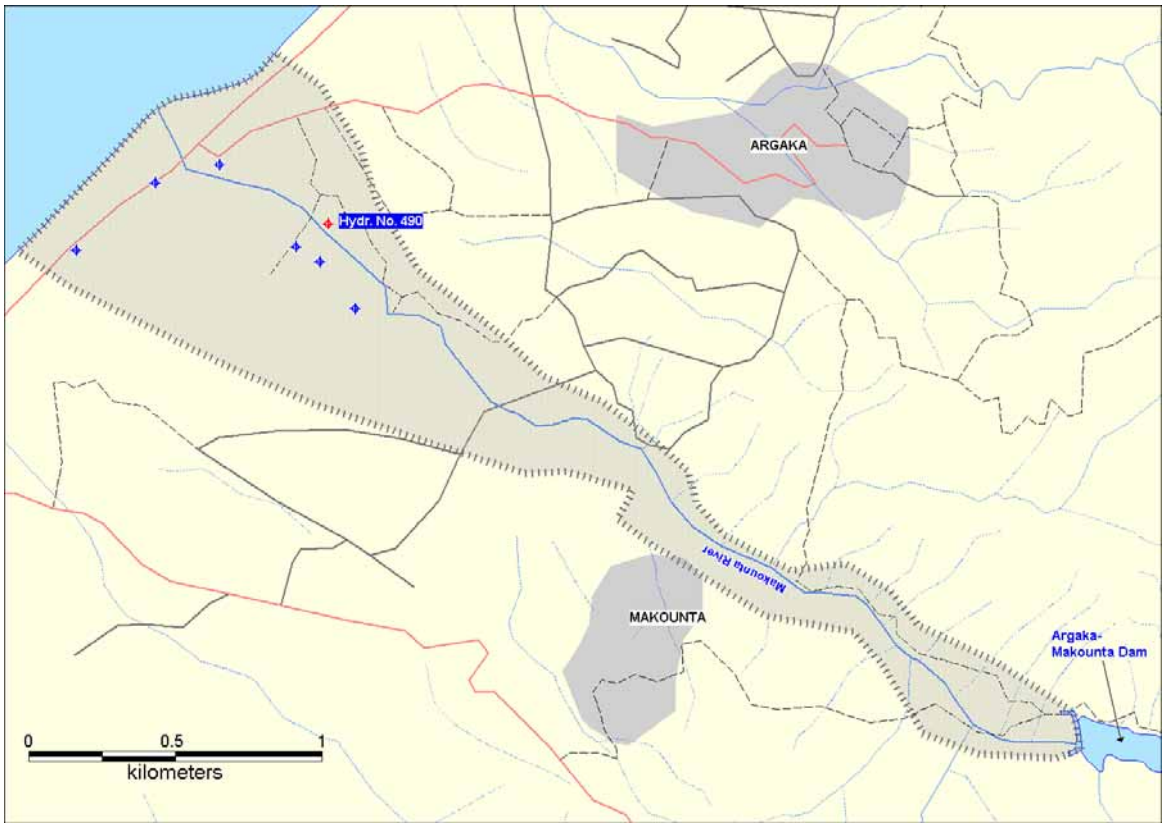
HYDROGEOLOGICAL CONDITIONS TODAY

There is no groundwater of acceptable quality available in the aquifer. For this reason no water balance of the aquifer is presented in this report.

ARGAKA-MAKOUNTA RIVERBED AQUIFER

INTRODUCTION

Argaka-Makounta is an alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Makounta river. It is of local importance and represents a major resource of water in the area. Its most water productive part is its downstream, coastal part. The construction of Argaka dam in 1964 on Makounta river, 4.0 km upstream of the coast resulted in a reduced recharge to the aquifer. This being a small dam of capacity of only 1.1 mcm spills almost every year. The dam is now connected to and forms part of the Chrysochou Irrigation Project. Part of irrigation demand in the area is covered by this Project. The aquifer extends from Argaka dam to the sea.



Argaka-Makounta Riverbed Aquifer - Location Map

The delta area of the aquifer crosses the Chrysochou - Gialia coastal plain aquifer. The hydraulic connection between these two aquifers causes periodical increase in the concentration of Boron in Argaka-Makounta aquifer to levels 0.2 to 0.3 mg/lit.

The main sources of recharge are river flows, spills from the dam and rainfall. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

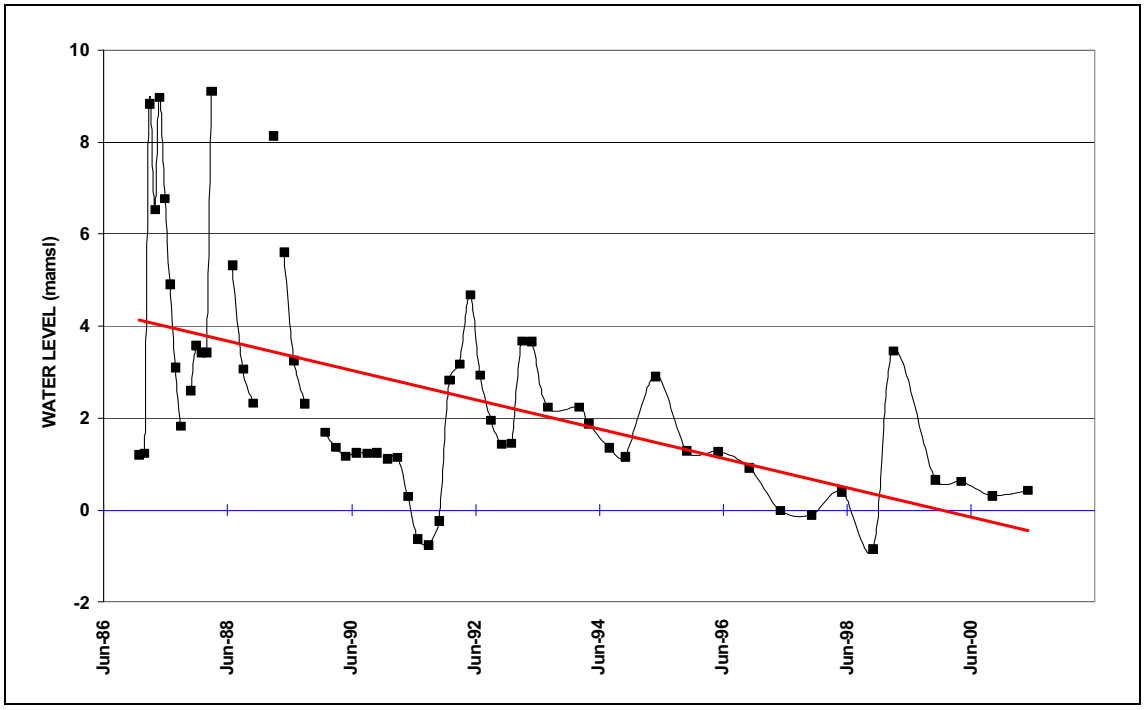
The impervious base of the aquifer at its upstream section consists of Pillow Lavas. At the downstream section of the aquifer the base consists of Pleistocene marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 6 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 4 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 1.2 Km², WIDTH: 300 m, LENGTH: 4 Km, OUTCROP: 1.2 Km².
THICKNESS: Few meters at the southern end, 30 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day (estimated).
Average S = 12% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Argaka 490 (Elev. 13.77 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Around ten boreholes operate in the aquifer for local irrigation. Yields of these boreholes vary from 5 to 20 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 0.2 mcm/year. Total extraction increased from around 0.1 mcm/year in 1995 to about 0.4 mcm/year in 1997 and 1998. The extraction reduced again in 2000 to the level of 0.1 mcm. Average natural recharge for the same period is estimated to be around 0.62 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of reduced recharge and periodical increase of extraction. The aquifer was intensively overpumped in years 1997 and 1998. Overexploitation resulted in the sea intrusion of the coastal zone. This in turn forced farmers and other water users to reduce pumping.

HISTORIC GROUNDWATER BALANCE

Period: 1979 - 1981. (WDD, UNDP, FAO, 1981: “PRESENT RESOURCES AND THEIR DEVELOPMENT”, KHRISOCHOU WATERSHED IRRIGATION PROJECT, Feasibility Report, Annex 2, Nicosia, Cyprus). Average rainfall: 500mm. The annual pumpage from this aquifer and the adjacent parts of the coastal plain was about 0.7 mcm. The safe future extraction estimated to be the same.

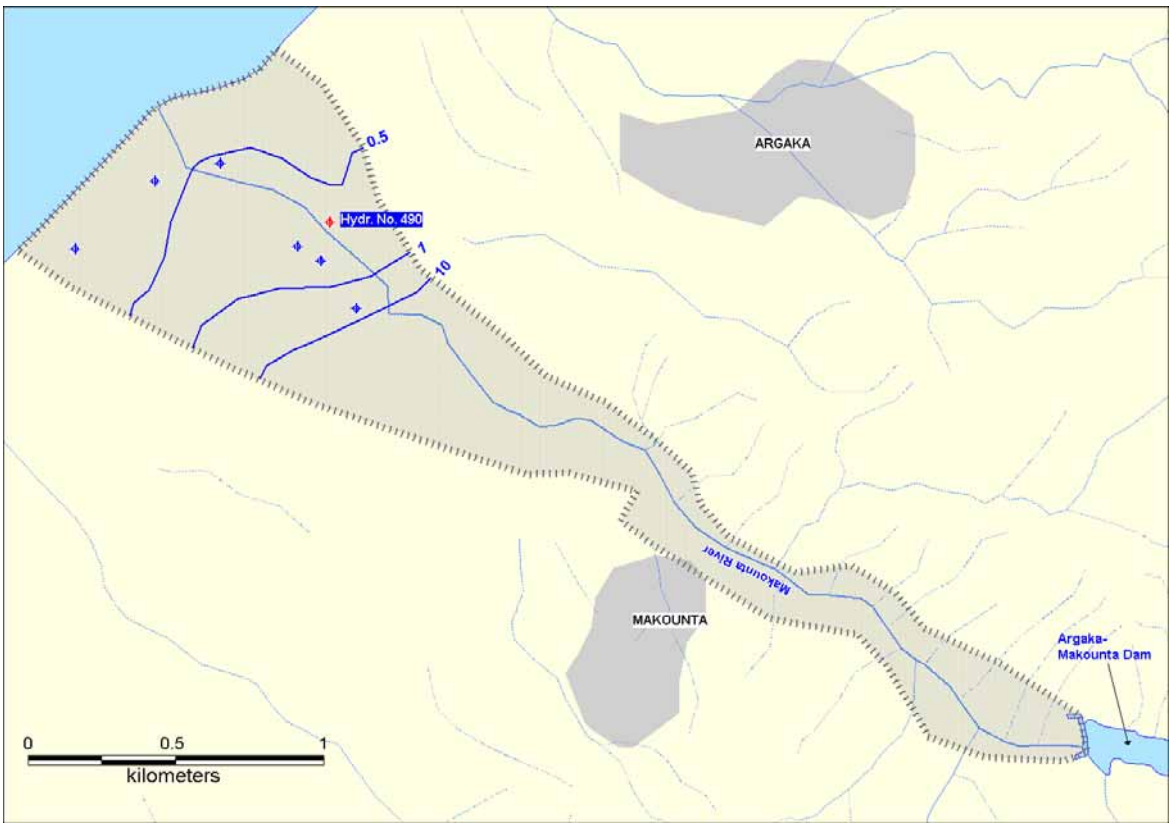
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer’s area: 1.2 km².
Average rainfall: 400 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.07	0.05	0.4	0.05	0.1	0.67

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.2	0.5	0.7

Balance: **- 0.03** mcm/year.
Recommended sustainable extraction: **0.1** mcm/year. An increase in extraction in spring i.e. immediately after the cessation of dam spillages, and a decrease in extraction in summer are recommended. Increasing the pumpage in spring by 0.1 to 0.15 mcm will reduce groundwater outflow to sea with no adverse effects to the aquifer.

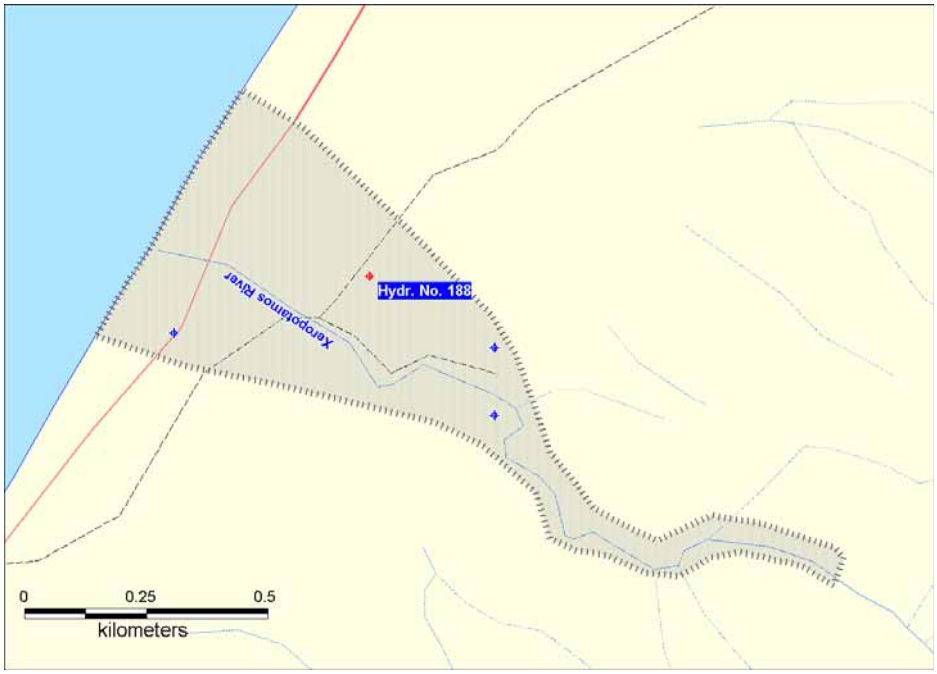


Argaka-Makounta Riverbed Aquifer – Water Level (m amsl)Contour Map May 2001

XEROPOTAMOS (CHRYSOCHOU) RIVERBED AQUIFER

INTRODUCTION

Xeropotamos is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Xeropotamos river. It is of local importance. Its most water productive part is its downstream, coastal section. Part of irrigation demand in the area is covered by the Chrysochou Irrigation Project.



Xeropotamos (Chrysochou) Riverbed Aquifer - Location Map

The delta area of the aquifer crosses the Chrysochou - Gialia coastal plain aquifer. It is assumed that there is a hydraulic connection between them but at this stage of the study the water interchange cannot be quantified.

The main sources of recharge are river flow and rainfall. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

The impervious base of the aquifer at its upstream section consists of Pillow Lavas. At the downstream section of the aquifer the base consists of Pleistocene marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 4 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 3 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

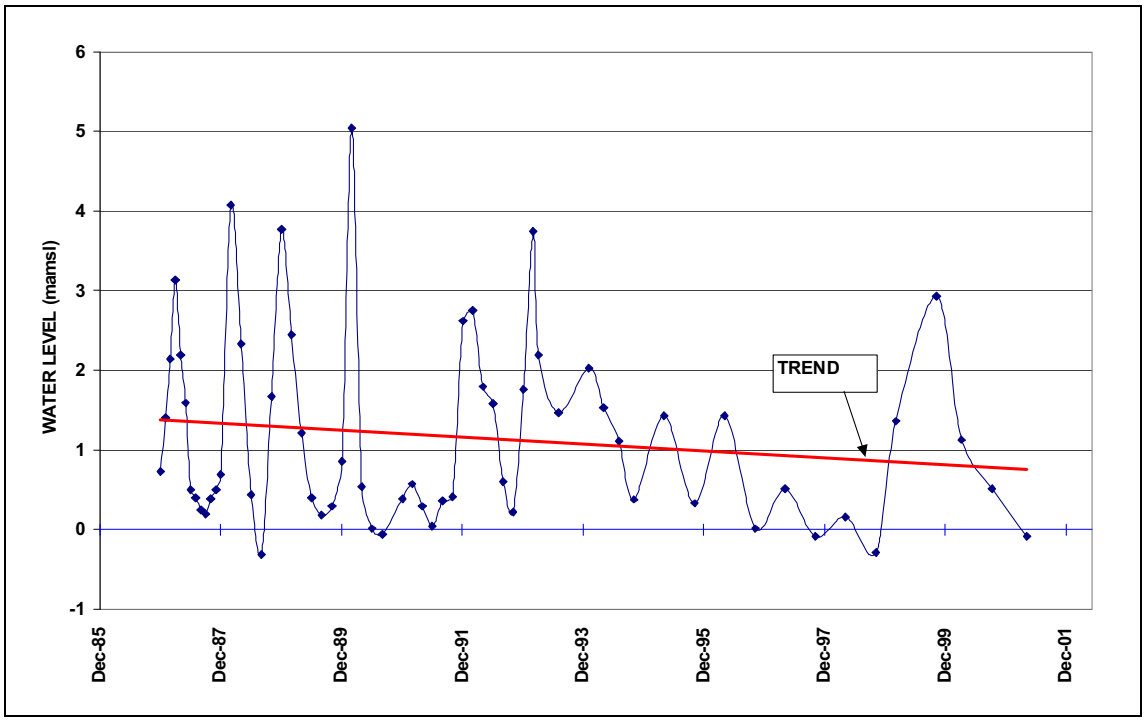
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0. 5 Km², AVERAGE WIDTH: 200 m, LENGTH: 2.5 Km, OUTCROP: 0.5 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day (estimated).
Average S = 10% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Around ten boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 15 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 0.04 mcm/year. Total extraction increased from around 0.03 mcm/year before 1995 to around 0.06 mcm/year in 1998. Average natural recharge for the same period is estimated to be around 0.17 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. Overpumping of the aquifer resulted in the contamination of the coastal zone by seawater propagation.



Hydrograph of borehole Gialia 188 (Elev. 9.01 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

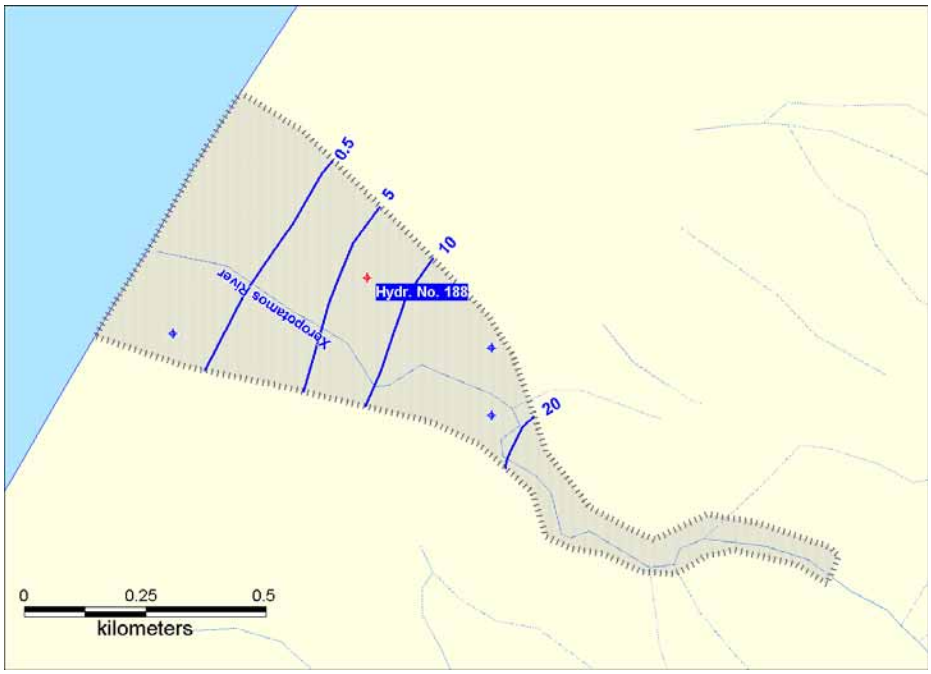
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 0.5 km².
Average rainfall: 400 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	GW inflow	Total
Average	0.03	0.01	0.11	0.02	0.01	0.18

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.04	0.15	0.19

Balance: **- 0.01** mcm/year.
Recommended sustainable extraction: **0.02** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.

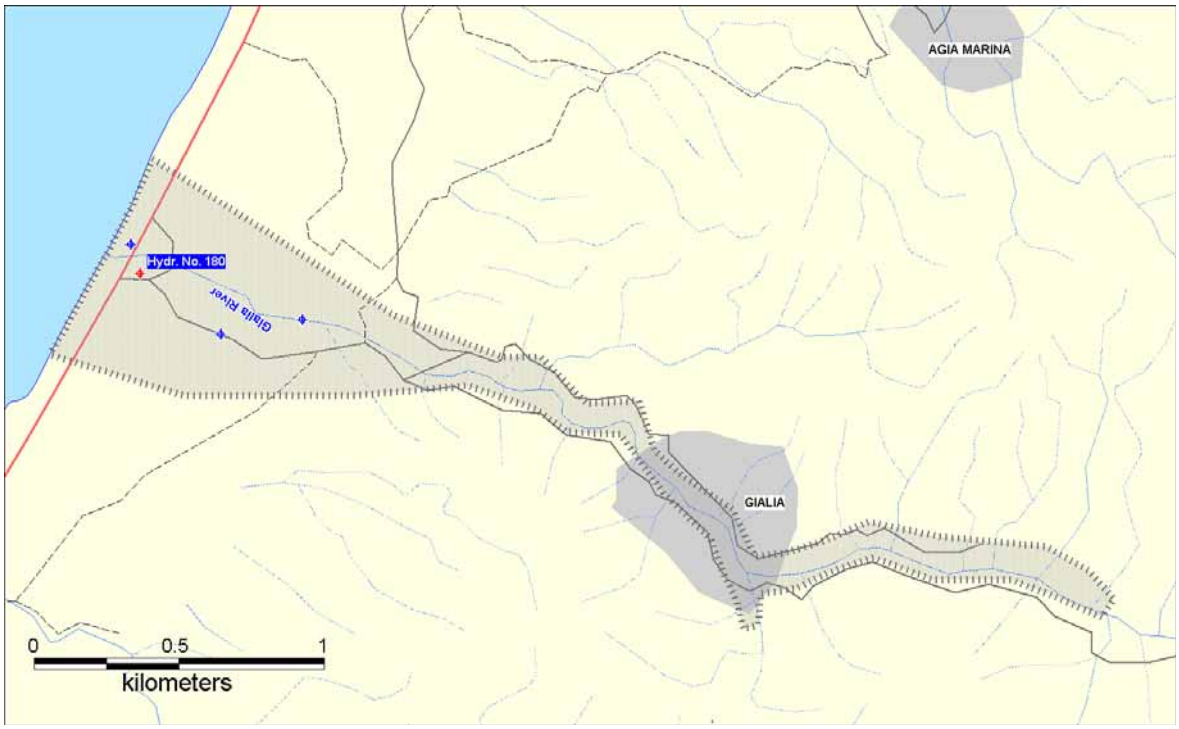


Xeropotamos (Chrysochou) Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

GIALIA RIVERBED AQUIFER

INTRODUCTION

Gialia is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Gialia river. It is of local importance. Its most water productive part is its downstream, coastal section. In the early eighties a water intake was constructed on Gialia river 4.5 km upstream of the coast. This intake is part of the Chrysochou Irrigation Project (C.I.P.). The diversion of water reduces the recharge to the aquifer. Part of irrigation demand in the area is covered by C.I. Project.



Gialia Riverbed Aquifer - Location Map

The delta area of the aquifer crosses the Chrysochou - Gialia coastal plain aquifer. It is assumed that there is a hydraulic connection between them but at this stage of the study the water interchange cannot be quantified.

The main sources of recharge are river flows and rainfall. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

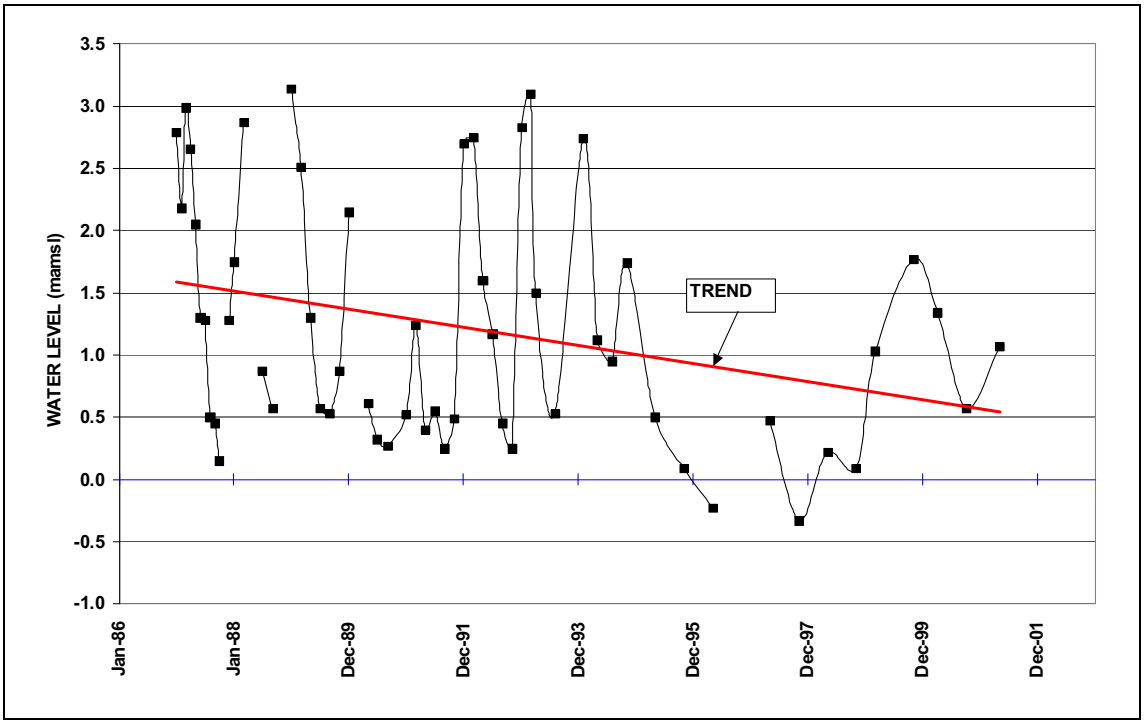
The impervious base of the aquifer at its upstream section consists of Pillow Lavas. At the downstream section of the aquifer the base consists of Pleistocene marls. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 6 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 4 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0.75 Km², AVERAGE WIDTH: 250 m, LENGTH: 2.5 Km, OUTCROP: 0.75 Km².
THICKNESS: Few meters at the southern end, 25 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day (estimated).
Average S = 10% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Gialia 180 (Elev. 6.57 m amsl)

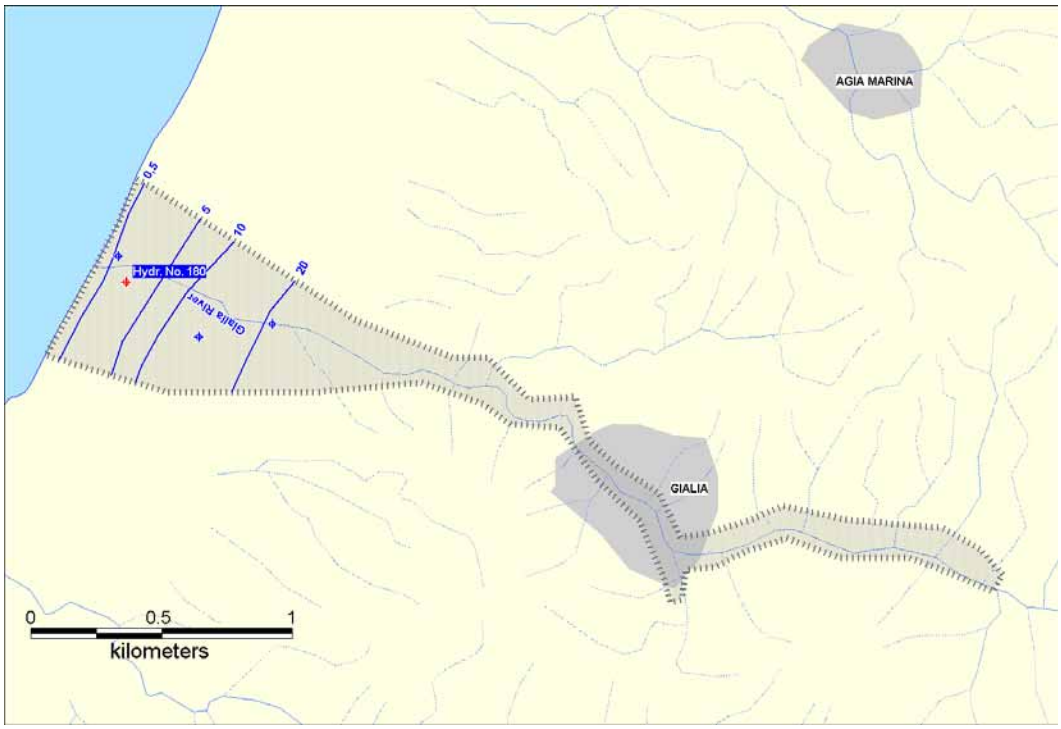
HYDROGEOLOGICAL CONDITIONS TODAY

Around fifteen boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 15 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 0.05 mcm/year. Total extraction increased from around 0.03 mcm/year before 1995 to around 0.07 mcm/year in 1998. Average natural recharge for the same period is estimated to be around 0.23 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. No problems with sea intrusion in the delta area have been reported.

HISTORIC GROUNDWATER BALANCE

Not available.



Gialia Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 0.75 km².
Average rainfall: 400 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.05	0.00	0.15	0.02	0.01	0.23

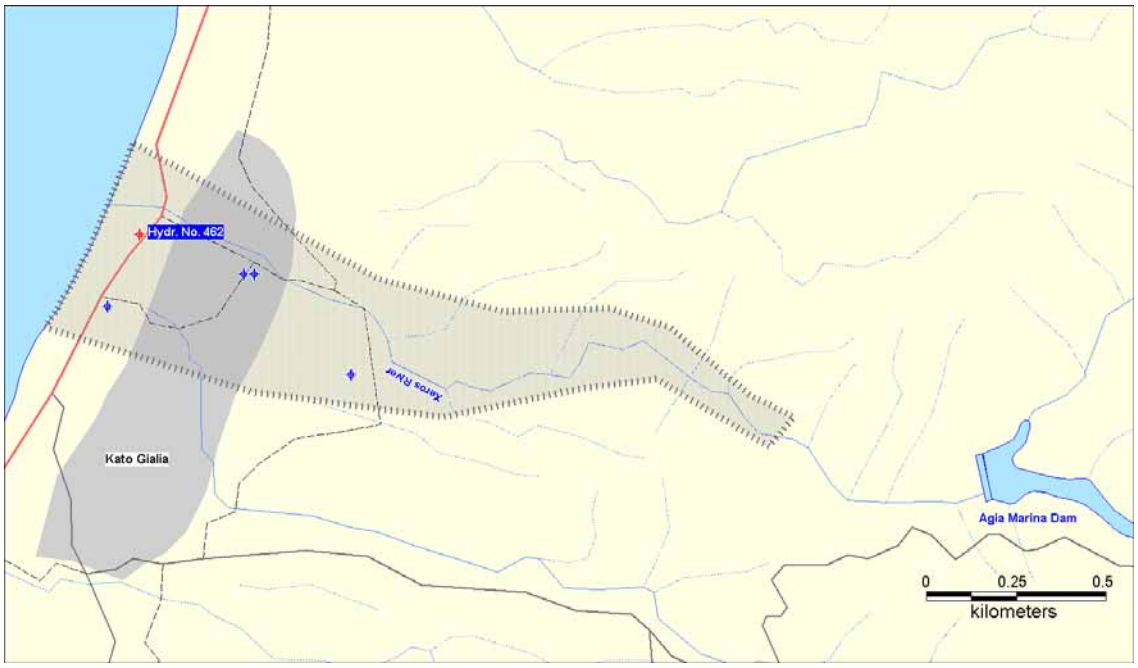
Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.05	0.2	0.25

Balance: **- 0.02** mcm/year.
Recommended sustainable extraction: **0.03** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.

XEROS (CHRYSOCHOU) RIVERBED AQUIFER

INTRODUCTION

Xeros is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Xeros river. It is of local importance and represents a major resource of water in the area. Its most water productive part is its downstream, coastal section. Agia Marina Dam, a small dam, constructed in 1965 on this river, 2.5 km upstream of the coast reduces the recharge of the aquifer. Part of the irrigation demand in the area is covered from this dam which is now connected to and forms part of the Chrysochou Irrigation Project. Agia Marina Dam has a capacity of only 0.3 mcm and rarely spills. The aquifer extends from the dam to the sea.



Xeros (Chrysochou) Riverbed Aquifer - Location Map

The delta area of the aquifer crosses the Chrysochou - Gialia coastal plain aquifer. It is assumed that there is a hydraulic connection between them but at this stage of the study the water interchange cannot be quantified.

The main sources of recharge are the river flow or the spills from the dam and rainfall. Low rainfall and rare spills of the dam during the last ten years have reduced total river flows and consequently the recharge to the aquifer.

GEOLOGY

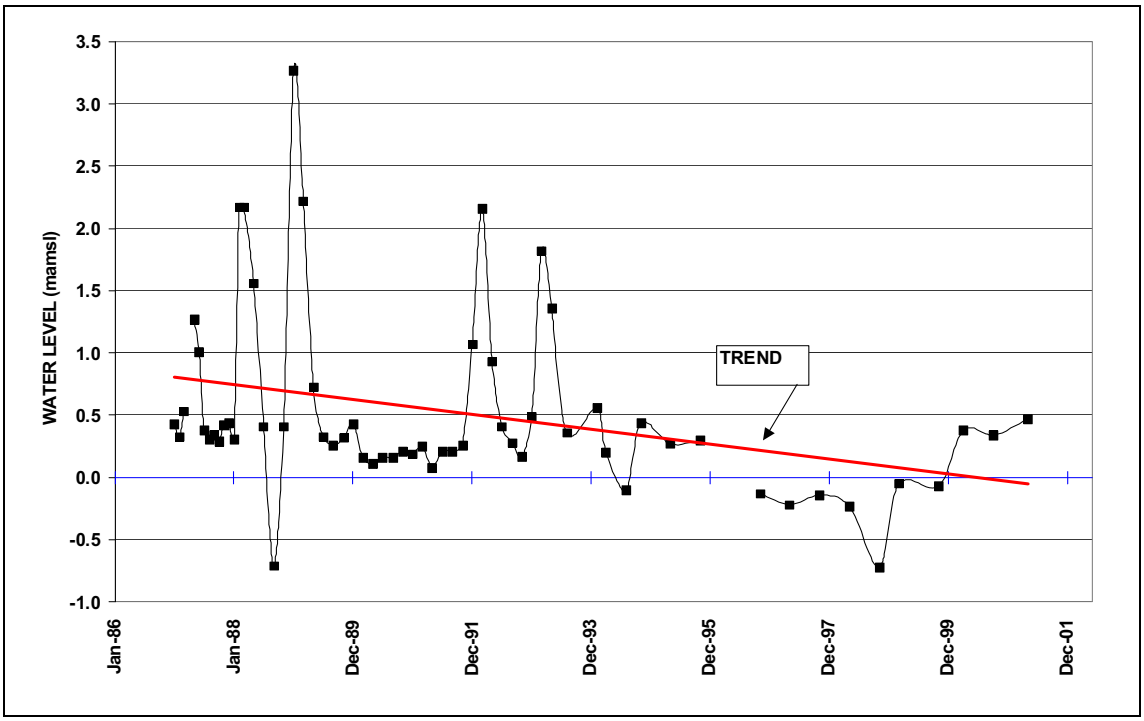
The impervious base of the aquifer consists of Pillow Lavas. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 4 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 3 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0.75 Km², AVERAGE WIDTH: 250 m, LENGTH: 2.5 Km, OUTCROP: 0.75 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 400 mm (Period 1970-2000: 430 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day (estimated).
Average S = 10% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Agia Marina 462 (Elev. 7.13 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Around 10 boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 15 m³/hour. Average extraction from the aquifer during the last ten years is estimated to be roughly 0.07 mcm/year. Total extraction increased from around 0.04 mcm/year before 1994 to about 0.09 mcm/year in 1998. Average natural recharge for the same period is estimated to be around 0.15 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. Overpumping of the aquifer resulted in the contamination of the coastal zone by sea intrusion.

HISTORIC GROUNDWATER BALANCE

Not available.

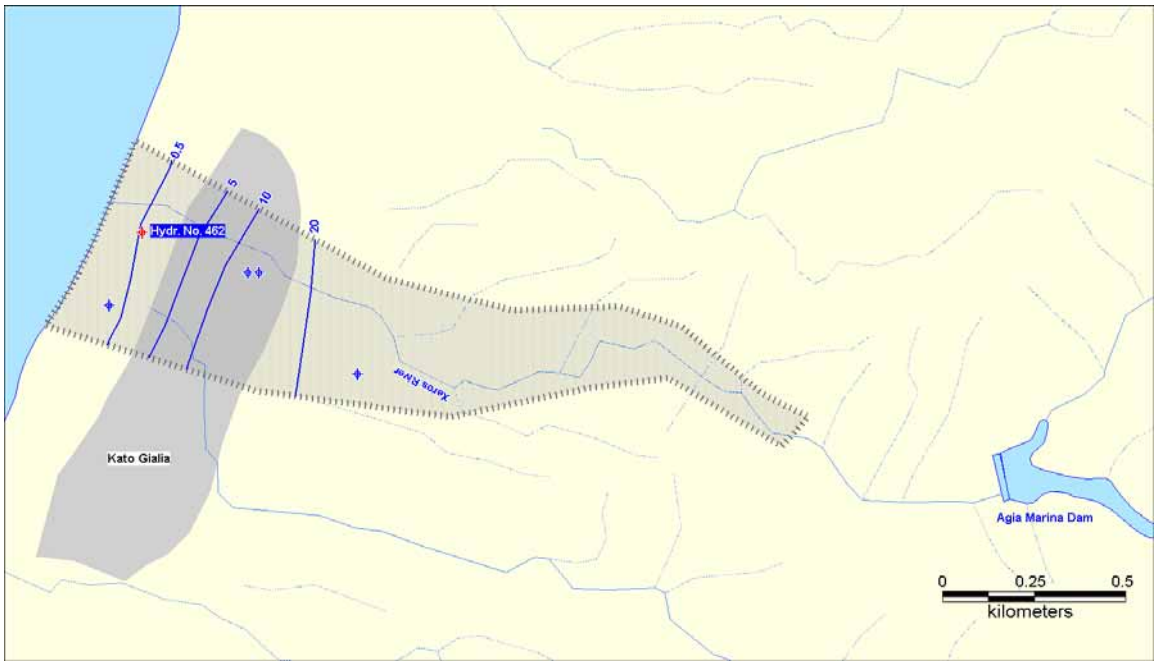
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 0.75 km². Average rainfall: 400 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.05	0.05	0.05	0.02	0.03	0.20

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.07	0.15	0.22

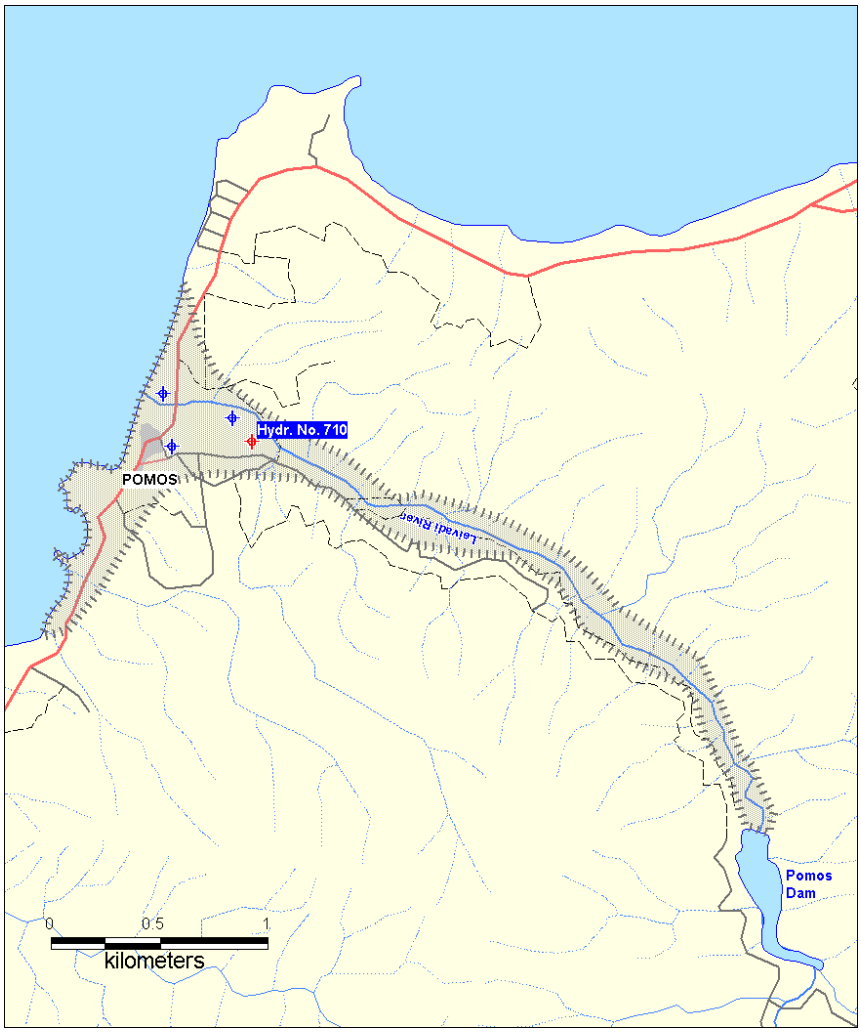
Balance: **- 0.02** mcm/year.
Recommended sustainable extraction: **0.05** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.



Xeros (Chrysochou) Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

POMOS RIVERBED AQUIFER

INTRODUCTION



Pomos Riverbed Aquifer - Location Map

Pomos is a small alluvial aquifer on the northern coast of Cyprus. It belongs to the Pafos District and it is situated in the Chrysochou area. It is developed along the valley of Leivadi river. It is of local importance and represents a major resource of water in the area. Its most water productive part is its downstream, coastal part. A small dam constructed in 1966 on Leivadi river, 3.5 km upstream of the coast reduces the recharge of the aquifer. The dam, known as Pomos Dam, is now connected to and forms part of the Chrysochou Irrigation Project. Part of the irrigation demand in the area is covered by this Project. Pomos, being a small dam, of a capacity of only 0.86 mcm, spills almost every year. The aquifer extends from Pomos dam to the sea.

The main sources of recharge are river flows, spills from the dam and rainfall. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

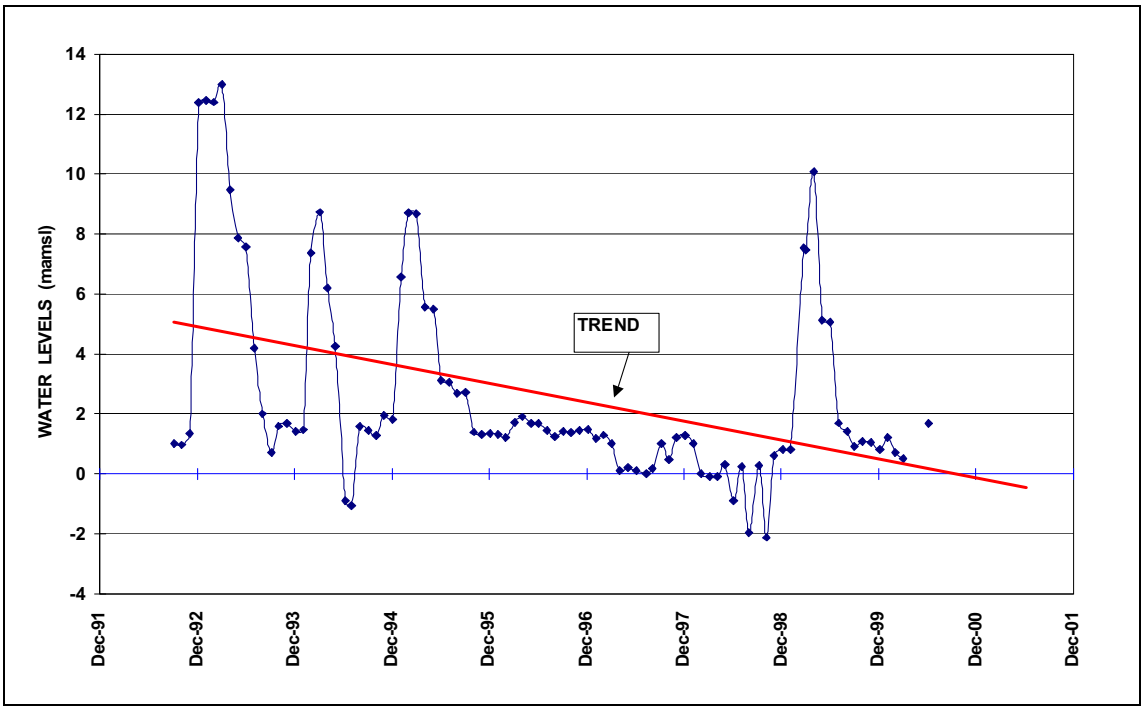
The impervious base of the aquifer consists of Pillow Lavas. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 4 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 2 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 1.0 Km², WIDTH: 250 m, LENGTH: 3.5 Km, OUTCROP: 1.0 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 500 mm (Period 1970-2000: 510 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 50 m/day (estimated).
Average S = 10% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Pomos 710 (Appr. elev.18 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Around 12 boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 20 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 0.08 mcm/year. Total extraction increased from around 0.03 mcm/year before 1996 to around 0.16 mcm/year in 1998. Average natural recharge for the same period is estimated to be around 0.57 mcm/year.

The aquifer is overpumped. During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. No problems with sea intrusion in the delta area have been reported.

HISTORIC GROUNDWATER BALANCE

Not available.

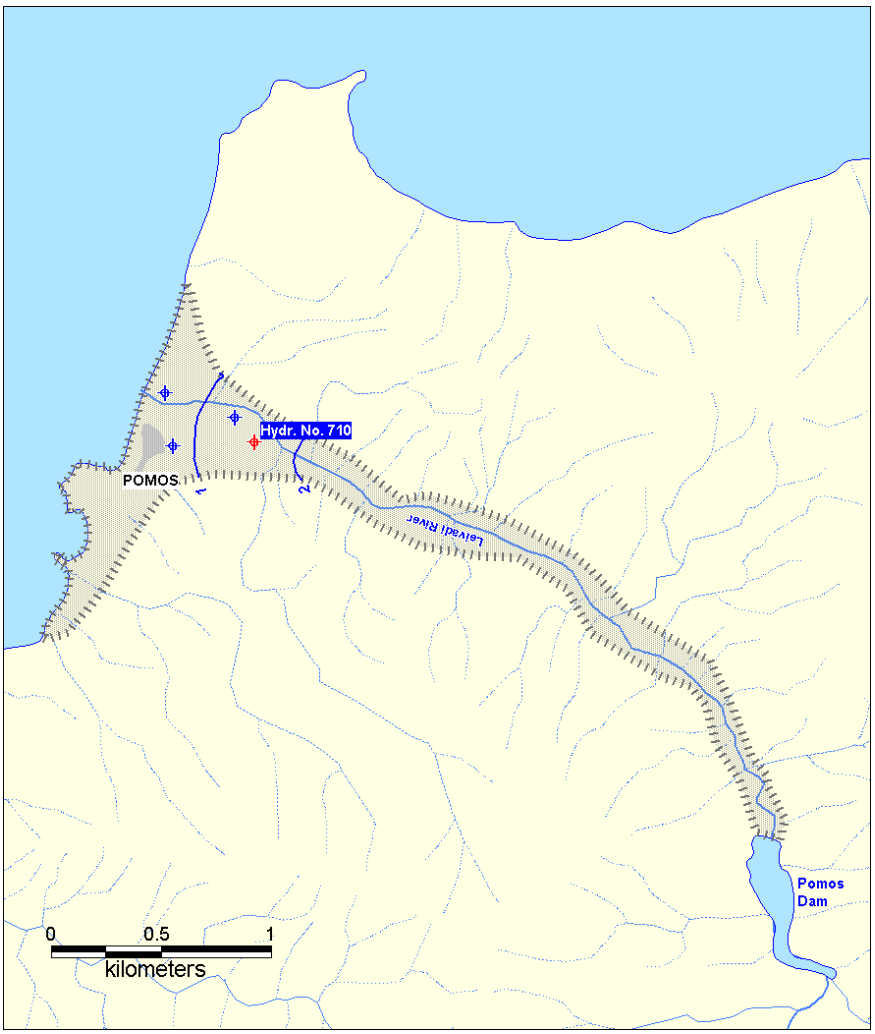
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 1.0 km².
Average rainfall: 500 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	Groundwater inflow	Total
Average	0.07	0.0	0.4	0.05	0.05	0.57

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.1	0.5	0.6

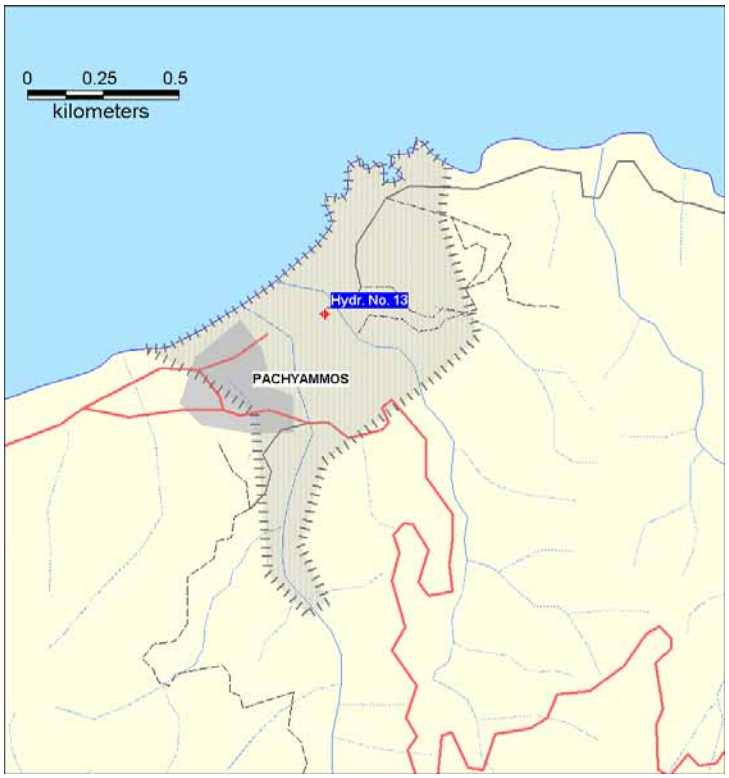
Balance: - **0.03** mcm/year.
Recommended sustainable extraction: **0.1** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.



Pomos Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

PACHYAMMOS RIVERBED AQUIFER

INTRODUCTION



Pachyammos Riverbed Aquifer - Location Map

Pachyammos is a remote area on the northern coast of Cyprus and even though administratively it belongs to Lefkosia District it is a part of the Chrysochou area. The Pachyammos riverbed aquifer is a very small alluvial aquifer monitored by the Pafos Regional Office of the Water Development Department. It is developed in the delta area and along the valley of the Pachyammos rivulet. It has been included in this report because it is of a great local importance and represents a significant resource of water in the area. Part of the local irrigation demand is covered by Pomos Dam on Leivadi river. The downstream, coastal part of the aquifer is the most water productive.

The main sources of recharge are rainfall and river flows. Low rainfall during the last ten years resulted in lower river flows and consequently lower recharge to the aquifer.

GEOLOGY

The impervious base of the aquifer consists of Pillow Lavas. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 1 borehole.
WATER QUALITY OBSERV. NETWORK: Yes, 1 borehole.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

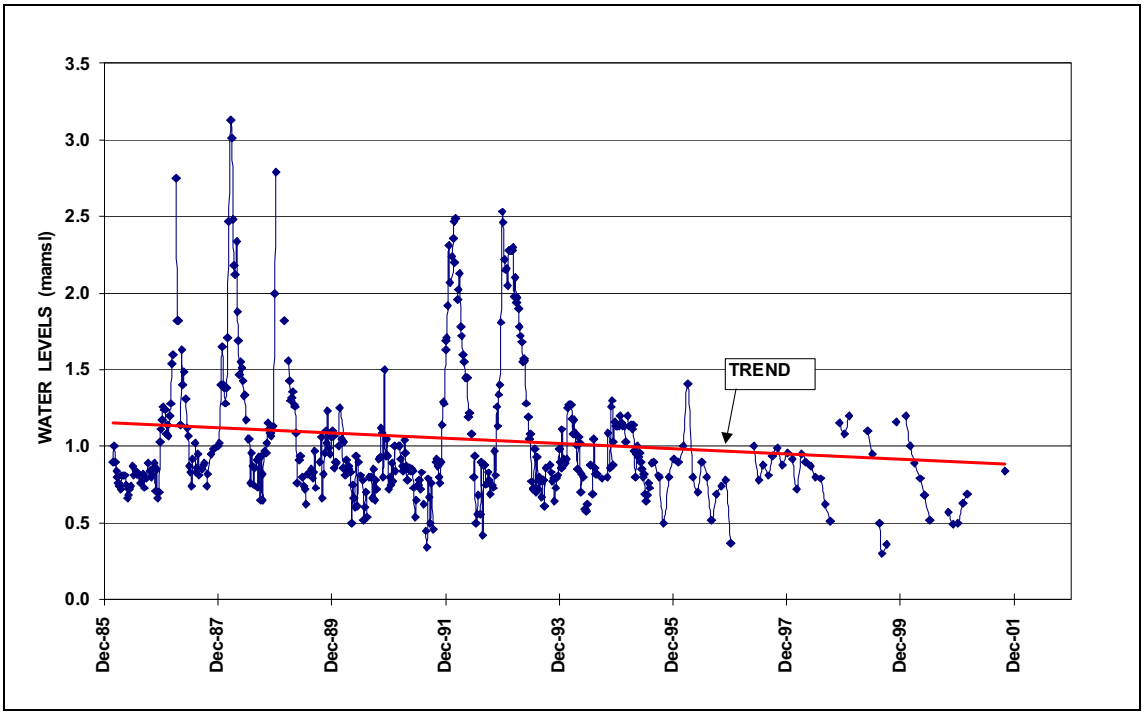
AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 0.5 Km², WIDTH: 0.9 km, LENGTH: 0.5 Km, OUTCROP: 0.5 Km².
THICKNESS: Few meters at northern end, 15 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 500 mm (Period 1970-2000: 510 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 30m/day (estimated).
Average S = 8% (estimated).
BOUNDARIES: East, North and West: impermeable. **South**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.

HYDROGEOLOGICAL CONDITIONS TODAY

Five boreholes operate in the aquifer extracting water for local irrigation and domestic water supply. Borehole yields vary from 5 to 10 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be around 0.03 mcm/year. Average natural recharge for the same period is estimated to be around 0.2 mcm/year.

During the last decade the aquifer has been exhibiting a depleting trend which is a result of a reduction in recharge and an increase in extraction. No problems with sea intrusion in the delta area have been reported.



Hydrograph of borehole Pachyammos 13 (Appr. elev. 15 m amsl)

HISTORIC GROUNDWATER BALANCE

Not available.

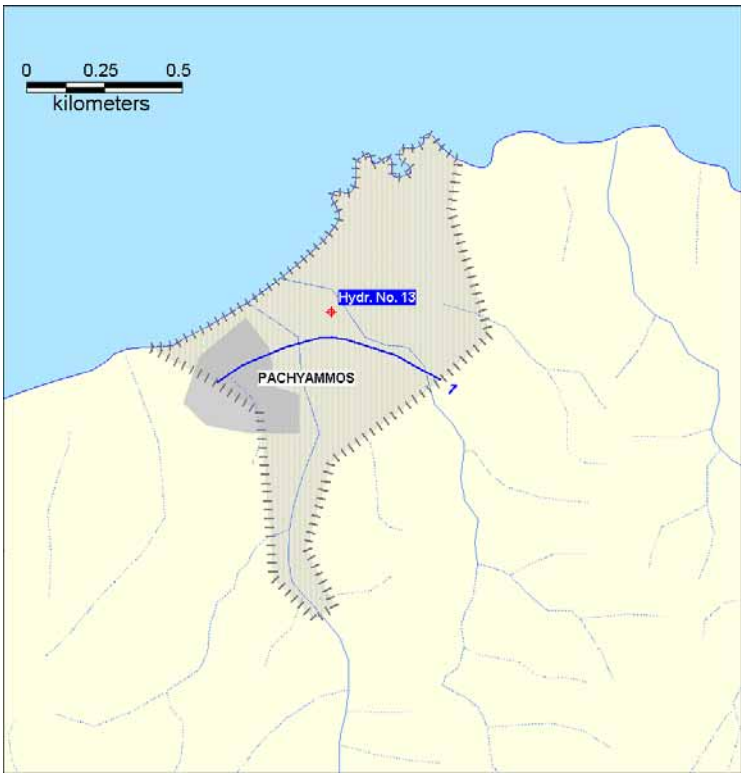
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 0.5 km².
Average rainfall: 500 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	GW inflow	Total
Average	0.03	0.0	0.12	0.00	0.05	0.20

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	0.03	0.18	0.21

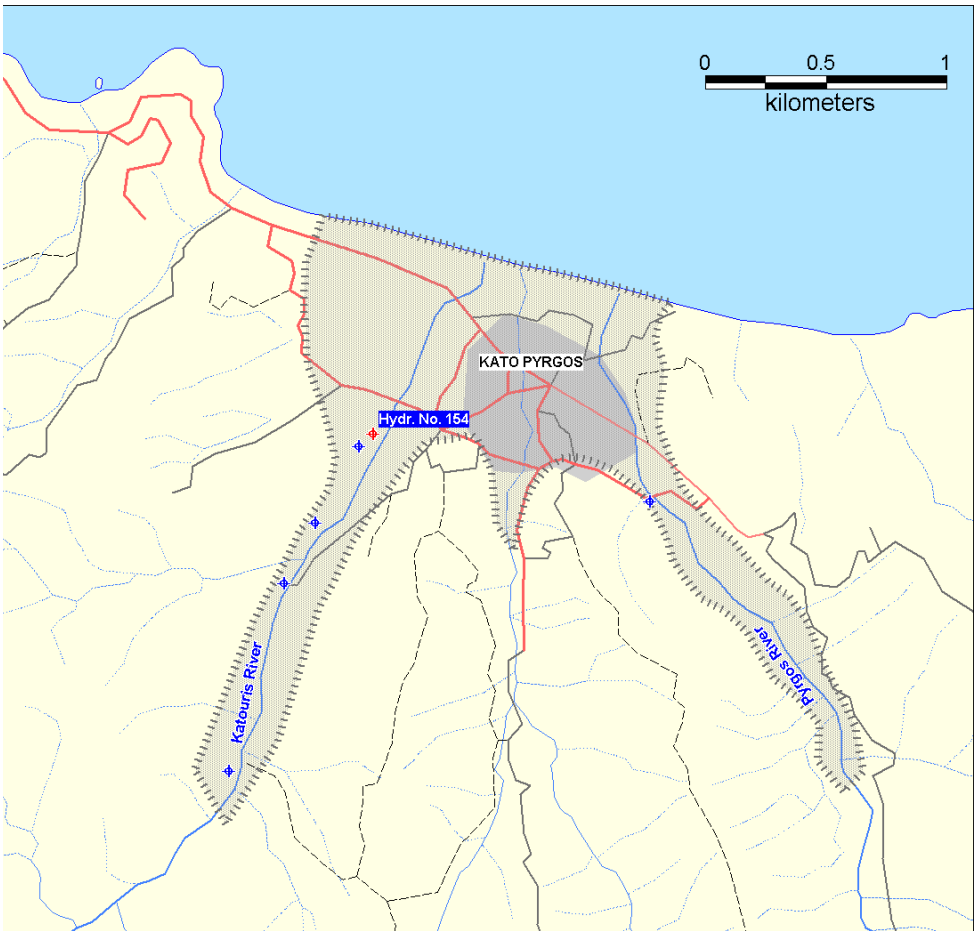
Balance: - **0.01** mcm/year.
Recommended sustainable extraction: **0.03** mcm/year. It is recommended that extraction from the aquifer should increase during spring and decrease during summer.



Pachyammos Riverbed Aquifer – Water Level (m amsl) Contour Map May 2001

PYRGOS ALLUVIAL AQUIFER

INTRODUCTION



Pyrgos Alluvial Aquifer - Location Map

Pyrgos is a remote area on the northern coast of Cyprus. Administratively it belongs to the Lefkosia District but practically is a part of the Chrysochou area. After the Turkish invasion access to the area has become difficult. The Pyrgos is a small alluvial aquifer monitored by the Pafos Regional Office. It is developed in the delta areas and along the valleys of Pyrgos and Katouris rivers. It is of local importance and represents a major resource of water in the area. Its most water productive part is its downstream, coastal part. A small dam constructed in 1957 on Katouris river, 4.5 km upstream of the coast reduces the recharge of the aquifer. Part of the irrigation demand in the area is covered from this dam. This being a small dam of a capacity of only 0.28 mcm spills almost every year.

The main sources of recharge are flows from both rivers and rainfall. Low rainfall during the last ten years has reduced the total river flows and consequently the recharge to the aquifer.

GEOLOGY

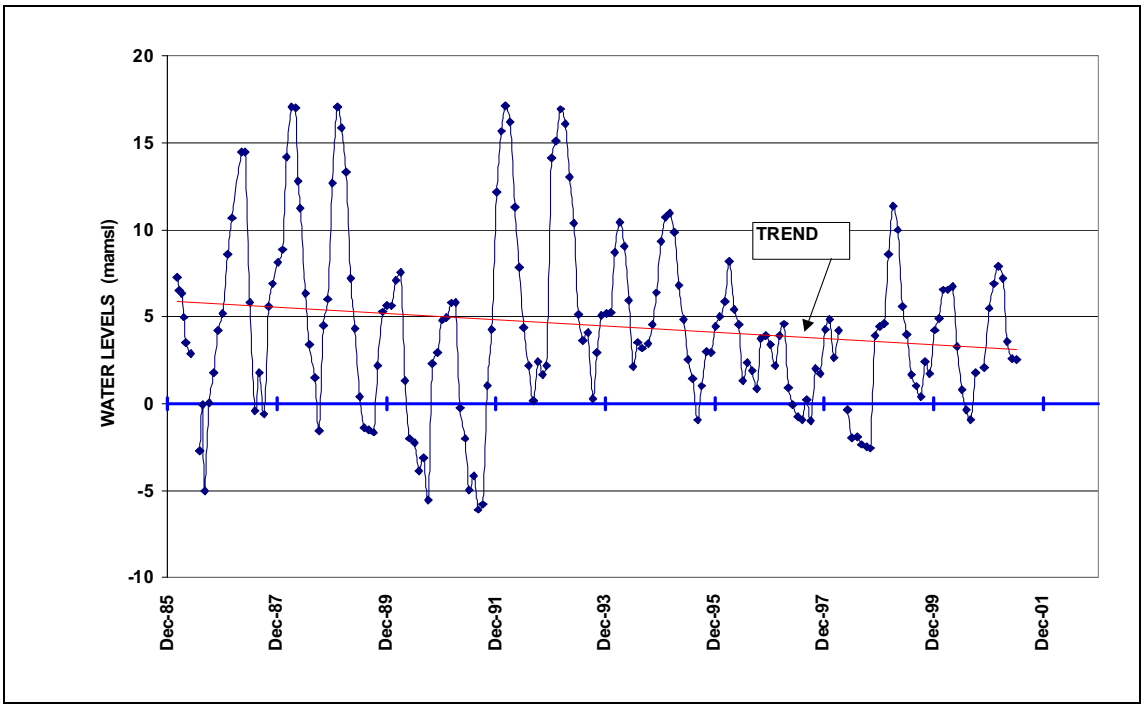
The impervious base of the aquifer consists of Pillow Lavas. The aquifer consists of alluvial deposits, gravels, sands and silts.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : Yes, every 6 months, 6 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, 6 boreholes.
ARE ALL BOREHOLES PLOTTED? : Yes.
EXTRACTION SURVEY: Yes, last survey in 2000.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 2.0 Km², WIDTH: 1.5 km, LENGTH: 1.3 Km, OUTCROP: 2.0 Km².
THICKNESS: Few meters at the southern end, 20 m at the coast.
AVERAGE RAINFALL: Period 1990-2000: 440 mm (1970-2000: 450 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 70 m/day (estimate).
Average S = 12% (estimated).
BOUNDARIES: East, South and West: impermeable. **North**: Permeable, Sea.
CONFINED/UNCONFINED: Unconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high. Phreatic aquifer.



Hydrograph of borehole Pyrgos 154 (Appr. elev. 18 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Around eighty boreholes operate in the aquifer for local irrigation and domestic water supply. Yields of these boreholes vary from 5 to 20 m³/hour. Average extraction from the aquifer during the last ten years was estimated to be roughly 1 mcm/year. Total extraction increased from around 0.6 mcm/year before 1996 to about 1.5 mcm/year after 1997. Average natural recharge for the same period is estimated to be around 1.5 mcm/year.

In the last decade the aquifer exhibits a depleting trend, which is a result of the reduced recharge and the increase of extraction. The aquifer is overpumped and the sudden increase of extraction after 1997 resulted in the contamination of the coastal zone by seawater intrusion.

HISTORIC GROUNDWATER BALANCE

Not available.

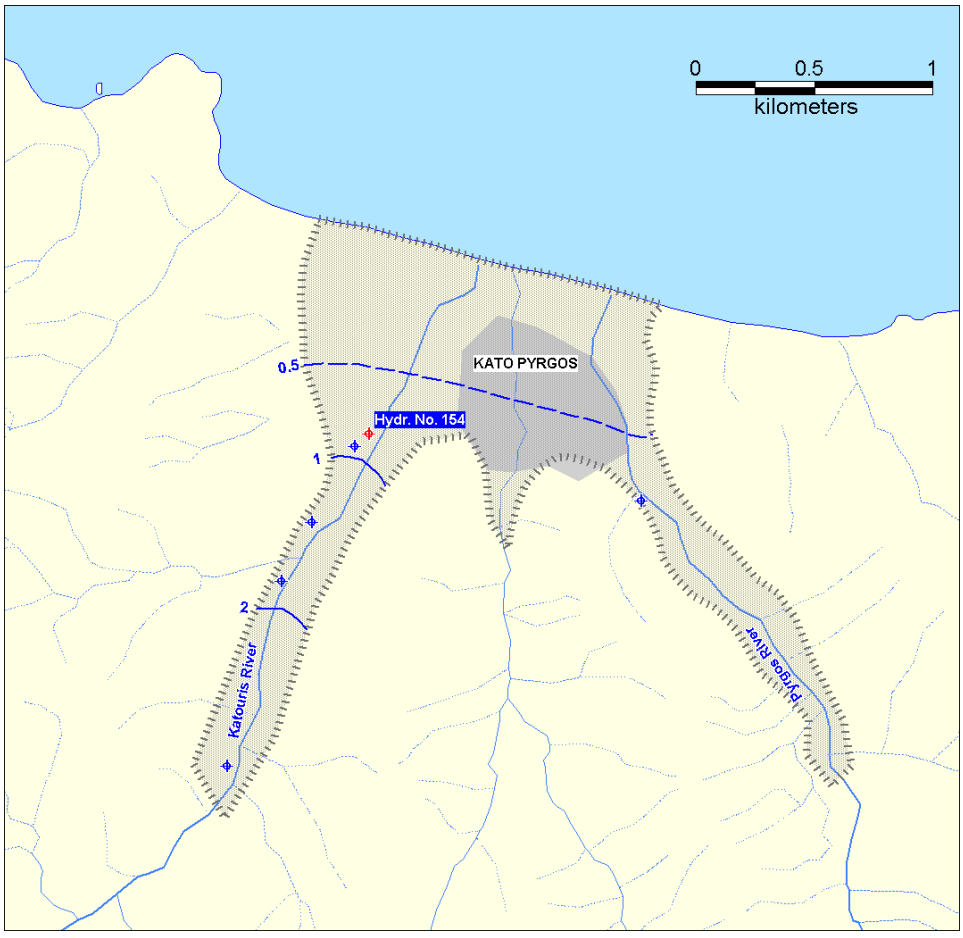
GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 2.0 km².
Average rainfall: 440 mm.

Replenishment (mcm/year)						
	Rainfall	Sea intrusion	Riverbed recharge	Return from irrigation	GW inflow	Total
Average	0.1	0.2	1.2	0.1	0.1	1.7

Outflow (mcm/year)			
	Abstraction	Sea Outflow	Total
Average	1	0.8	1.8

Balance: - **0.1** mcm/year.
Recommended sustainable extraction: **0.6** mcm/year.



Pyrgos Alluvial Aquifer – Water Level (m amsl) Contour Map May 2001

WESTERN MESAORIA AQUIFERS

INTRODUCTION

Western Mesaoria Aquifers - Location Map

Western Mesaoria is a complex aquifer developed in the area of Fyllia – Morfou – Zodeia – Agia Eirini - Pentageia villages. It is the biggest and the most dynamic aquifer in Cyprus. The area is under Turkish occupation since 1974. There is no Government control in the aquifer and the data available have been collected before that date.

The southern and southeastern boundaries of the aquifer coincide with the Turkish occupation line. It is a recharge boundary and the groundwater inflows originate from the Central Mesaoria aquifer and the river aquifers of Akaki, Peristerona, Elaias, Atsas and

Kargiotis. The shoreline is the western boundary and the Kythrea impermeable formation the north/northeastern boundary of the aquifer. In reality this aquifer is the extension of the Central Mesaoria aquifer which is described in a separate chapter.

The main sources of recharge are river flows, rainfall and groundwater inflows.

The aquifer had been overpumped for decades. The water levels in Morfou area in 1974 were as low as 25 meters below sea level. A zone several kilometers wide was sea intruded much earlier than 1974. It is believed that overpumping of the aquifer and sea intrusion are still active. Low rainfall during the last decade has most probably increased water deficits in the area.

GEOLOGY

The impervious base of the aquifer consists mainly of Miocene marls.

The aquifer is a very complex one. It consists of various geological formations and complex interconnected and isolated water-bearing members. The main aquifer members are developed in Athalassa and Nicosia formations sandstones and in recent river alluvial deposits.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No information available.
WATER QUALITY OBSERV. NETWORK: No information available.
ARE ALL BOREHOLES PLOTTED? : No information available.
EXTRACTION SURVEY: No information available.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 300 Km², TRIANGLE: 30X20/2 km. OUTCROP AREA: 300 Km².
AVERAGE RAINFALL: 1990-2000: 280 mm (roughly estimated by extrapolation).
HYDROGEOLOGICAL PARAMETERS: Average K = 8 m/day.
Average S = 6 %.
BOUNDARIES: Southeast: A permeable boundary with Central Mesaoria aquifer along the Turkish occupation line. **West:** Permeable. Sea. **Northeast:** Impermeable
CONFINED/UNCONFINED: Unconfined to semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high.

HYDROGEOLOGICAL CONDITIONS TODAY

There is no reliable information about the hydrogeological conditions in the aquifer today. However, having in mind the droughts of the last decades and the fact that the aquifer is the main source of water in the occupied part of Cyprus it is almost certain that the aquifer is being overpumped. It is expected that low natural recharge and overpumping of the aquifer must have resulted to even lower than 1974 water levels. It is certain that the most productive part of the aquifer is already contaminated by seawater and part of the area is under threat of desertification.

HISTORIC GROUNDWATER BALANCE

The long term water deficit estimated for the period before 1974 is 18 mcm/year. This figure represents the difference between 47 mcm/year of recharge (rainfall, riverbed, diversions and return flow) and 65 mcm/year of extraction. Record deficits of 53 mcm and 45 mcm appeared in hydrological years 1972/73 and 1973/74 respectively (J. S. Jacovides, Ministry of Agriculture and N.R./WDD, "BRIEF REPORT ON THE PRESENT STATE OF THE MORPHOU WATER PROBLEMS (1974), May 1974).

Average water balance: 1960/61 – 1966/67 (7 years). (J. S. Jacovides, " WATER BALANCE AND MATHEMATICAL MODEL OF MORPHOU AQUIFER", CYPRUS WATER PLANNING PROJECT/WDD, Nicosia, April 1969). Area of the aquifer: 270 km^2. Average rainfall: 286 mm

Replenishment (mcm/year)					
	Riverbed Recharge	Return from abstraction and Diverted water	Rainfall	Subsurface inflow	Total
Average	34.2	24.1	4.6	0.4	63.3

Outflow (mcm/year)			
	Abstraction irrig/dom.	Subsurface outflow	Total
Average	66.9	2.9	69.8

Balance: **- 6.5** mcm/year

GROUNDWATER BALANCE TODAY

Not available.

CENTRAL MESAORIA AQUIFERS

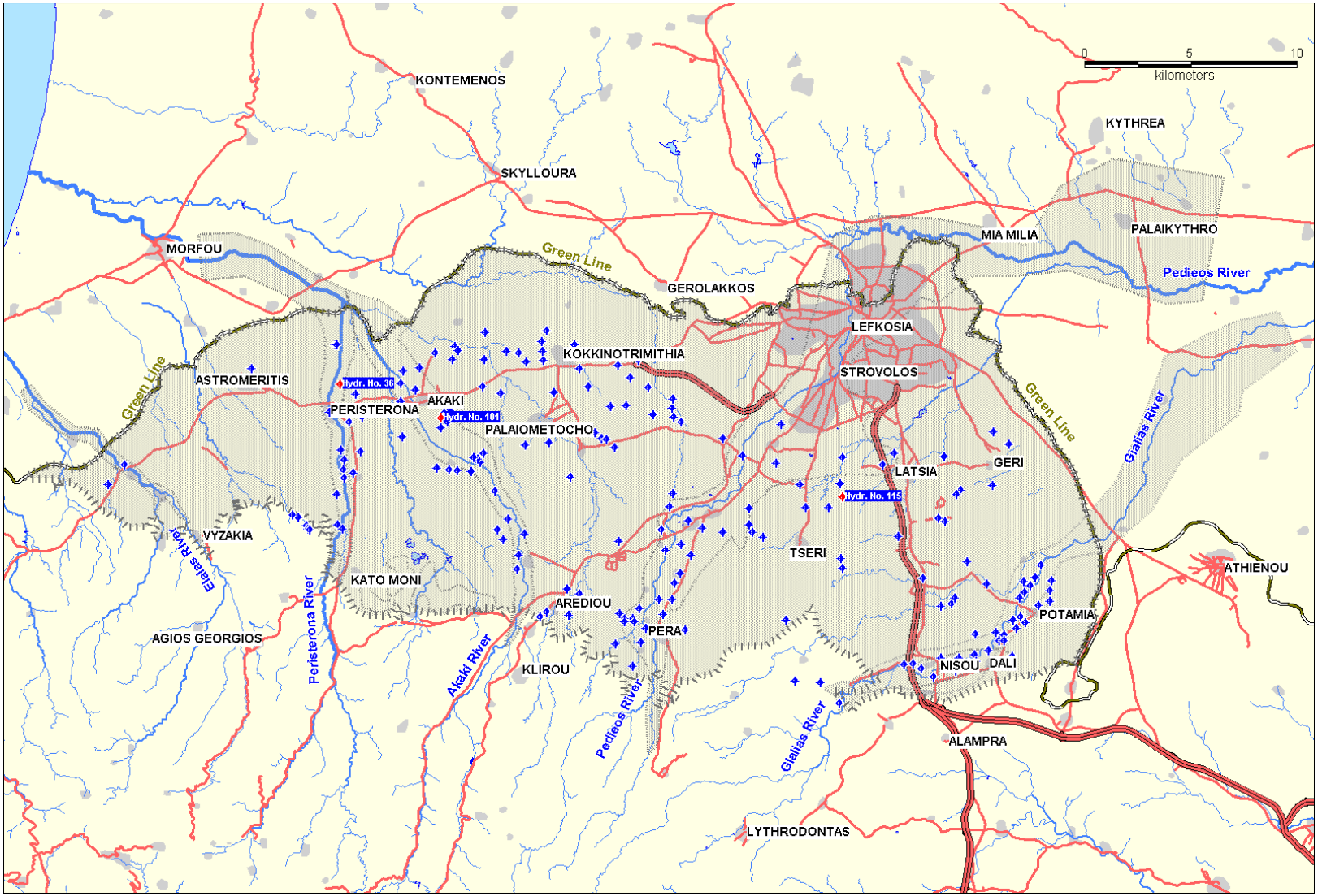
INTRODUCTION

Central Mesaoria is defined as the complex aquifer developed between the villages of Koutrafas/Astromeritis and Lefkosia/Potamia. Its southern boundary is the contact line of the sedimentary rocks with the Troodos igneous rocks, and its north boundary coincides with the Turkish occupation line. The groundwater from this aquifer outflows into the occupied Morfou – Pentageia aquifer through its northwestern permeable boundary. Central Mesaoria aquifer is one of the most important aquifers in Cyprus and represents the main source of water for irrigation and domestic supply for the area. Several Government water projects involving the development of surface water are being under consideration.

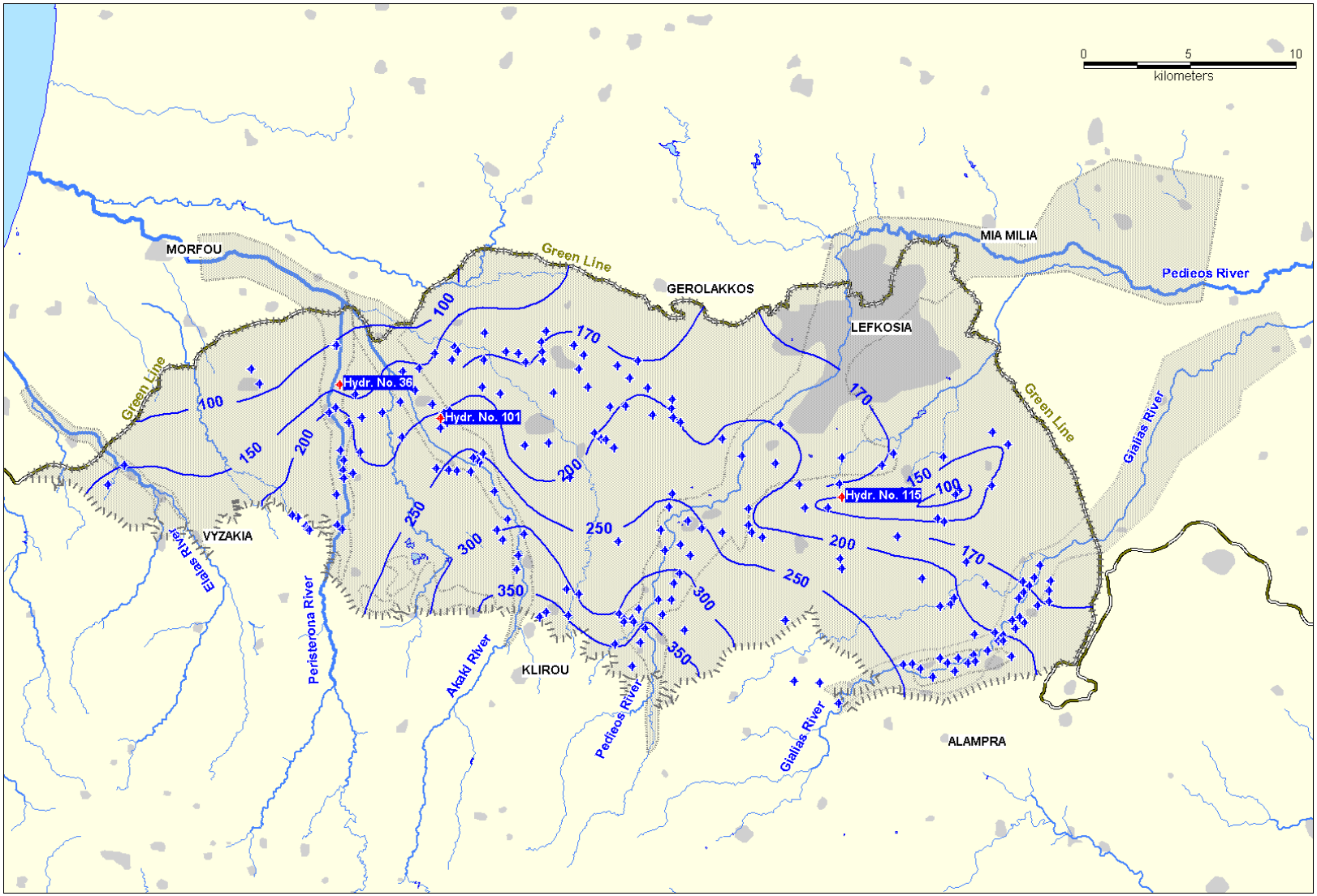
The aquifer is very complex. It consists of various geological formations and interconnected and/or isolated water bearing members. Insufficient knowledge of the system, unsatisfactory historical data and a basically inadequate monitoring system do not allow differentiation of the various “aquifers”. For this reason this complex system is treated as one aquifer in this study. The main aquifer members are developed in the formations of Nicosia, Athalassa and Fanglomerates and river alluvium deposits.

The main sources of recharge are the river flow and rainfall. Five rivers are crossing the aquifer. They recharge the alluvial deposits and through them the aquifer members that are in contact with them. These rivers are the Gialias, Pediaios, Akaki, Peristerona and Elaia. The contribution of the Elaia river to the recharge of the aquifer is limited. The recharge of the deepest, confined members of the aquifer originates in the contact area of the aquifer with the igneous rocks.

The aquifer is being overpumped for decades. Low rainfall in the last decade has exacerbated the water deficits in the area. The general depleting trend of the aquifer is reflected in the deterioration of the groundwater quality.



Central Mesaoria Aquifers - Location Map



Central Mesaoria Aquifers – Water Level (m amsl) Contour Map March 2001

GEOLOGY

The impervious base of the aquifer consists mainly of Miocene marls.

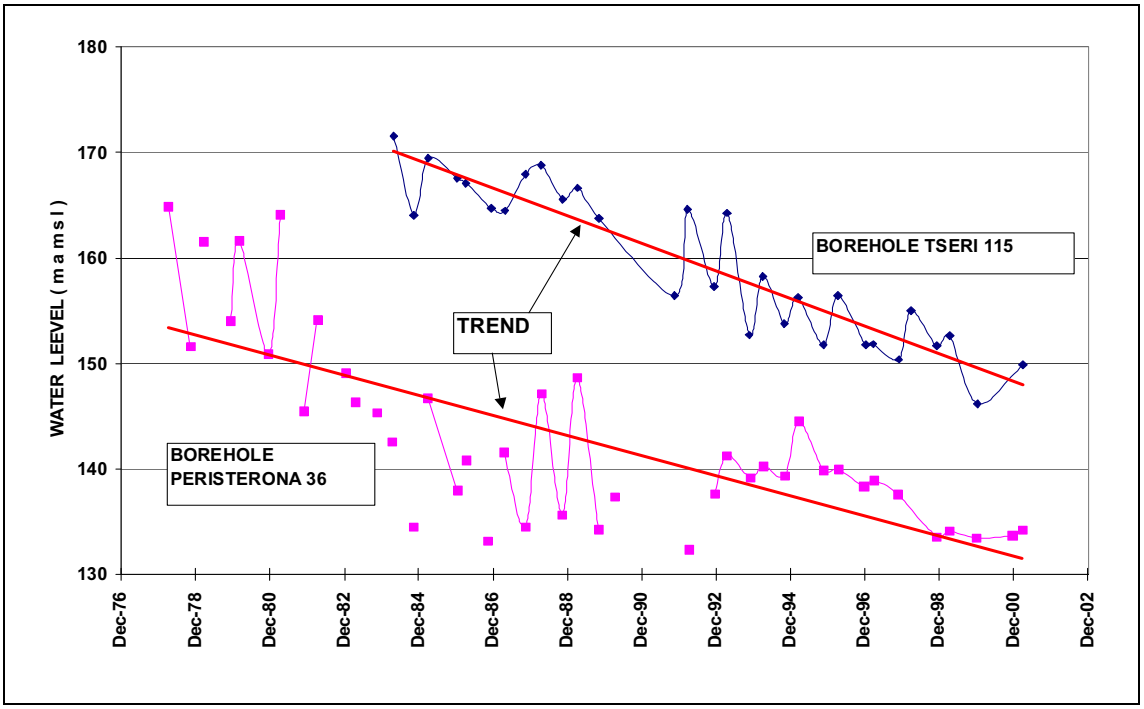
The water bearing members of the aquifer, developed in a succession of aquiclude marly sediments, consist of:
Upper Miocene (Pachna formation) reef limestone, which represents the oldest sediment of the aquifer. It appears along the south boundaries of the aquifer, forming the Kato Moni aquifers.
Upper Miocene (Kalavasos formation) gypsum. On average it is 40 to 50 m thick and usually appears in depths greater than 300 m. In these depths the water is saline. A block of this aquifer forms the Nisou – Dali gypsum aquifer which outcrops in the Gialias riverbed. In this outcropping area several karstic sinkholes have been developed. The aquifer is recharged through these sinkholes.
Upper Miocene to Lower Pliocene sandstone, gravels and conglomerates. They appear sporadically in thin layers and in thicker pockets at depths greater than 200m. Slow aquifer recharge together with slow groundwater movement increase water salinity, with chloride concentration rising above 1000 mg/lit.
Pliocene (Nicosia formation) sandstone and marly sandstone. They are extensive and appear in thick layers up to a depth of 250 meters. These, together with younger members, represent the main Central Mesaoria aquifer. These members are usually isolated from the younger Athalassa formation aquifer's member by a 100 to 150 meters thick layer of marl.
Pleistocene (Athalassa and Fanglomerate formation) sandstones, sands and gravels. These together with the Pliocene members make up the main aquifer. It is up to 150 thick and it outcrops in most of the area of the aquifer.
Alluvium riverbed deposits are the most recent sediments and they are developed along the valleys of the five rivers. Some of them are extensive and are up to 20 meters thick.

GENERAL INFORMATION

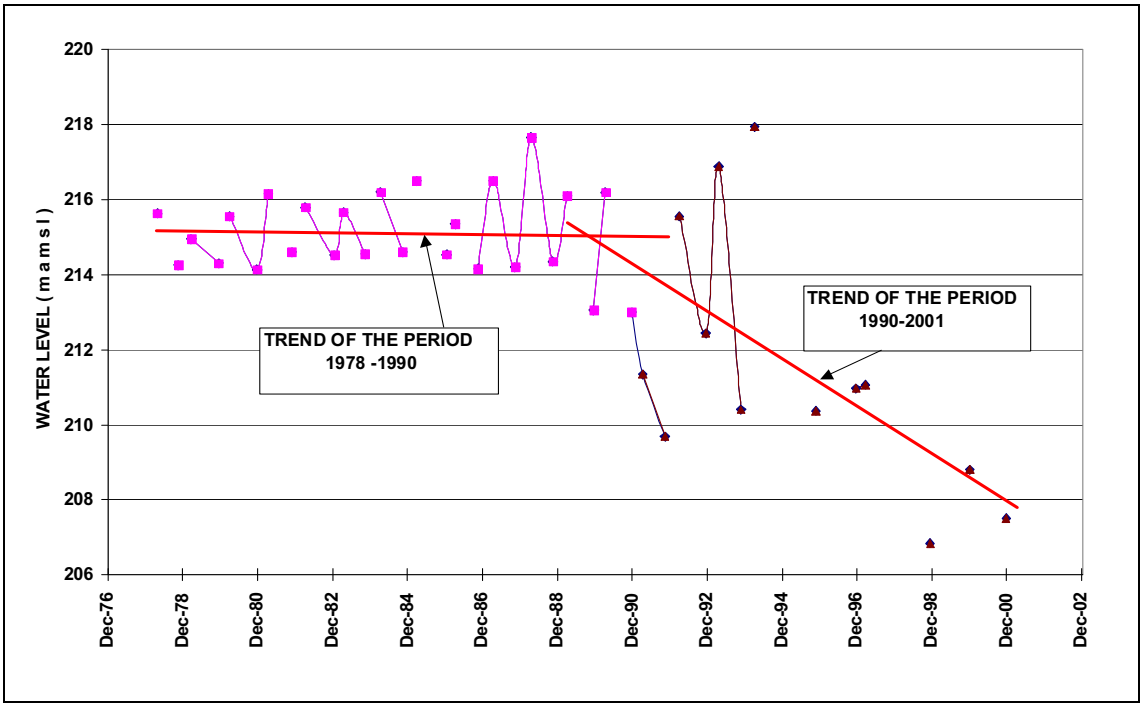
WATER LEVEL OBS. NETWORK : Yes, every six months, 200 boreholes.
WATER QUALITY OBSERV. NETWORK: Yes, every 12 months, 60 boreholes.
ARE ALL BOREHOLES PLOTTED? : No, last update before 1990.
EXTRACTION SURVEY: Yes, last survey in 1995.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 600 Km², WIDTH: 15 km, LENGTH: 40 km. OUTCROP AREA: 600 Km².
AVERAGE RAINFALL: Period 1990-2000: 280 mm, (Period 1970-2000: 330 mm).
HYDROGEOLOGICAL PARAMETERS: Average K = 3 - 4 m/day, from 0.5 to 30.
Average S = 2 -3 %, from 1 to 5.
BOUNDARIES:
East: Semipermeable to impermeable, Turkish occupation line.
West – Northwest: Permeable. Outflow to Morfou aquifer.
South: Semipermeable to impermeable, igneous rocks.
North: Impermeable, Kythrea formation.
CONFINED/UNCONFINED: Upper members unconfined, lower members confined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Medium to high.



Hydrograph of boreholes Tseri 115 and Peristerona 36 (Elev. 228.75 and 119.08 m amsl)



Hydrograph of borehole Akaki 101 (Elev. 226.5 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Because the aquifer has been overpumped for many years a general depleting trend predominates.

It is estimated that today, around 10 000 boreholes operate in the aquifer. The average yearly extraction in the last ten years is estimated to be about 27 to 29 mcm. Individual households use around 7000 boreholes. They extract 200 to 300 m^3/year per borehole. Farmers use the remaining 3000 boreholes for irrigation. Some boreholes are used for

local and Lefkosia domestic water supply. The yield of these boreholes ranges from 2 to 25 m³/hour. In parts of the main aquifer where the water movement is very slow the groundwater is highly mineralized, with chloride concentration in excess of 500 mg/lit.

It was estimated that during the last decade the water level dropped by an average of 0.5 meters per year. This led to a water deficit of about 6 mcm per year. A reduction in water extraction in the affected areas by at least 6 to 7 mcm/year is strongly recommended.

HISTORIC GROUNDWATER BALANCE

Average water balance for the period 1968/69 – 1973/74 (6 years). (S. L. ZOMENI, "HYDROGEOLOGY OF CENTRAL MESAORIA – CYPRUS". A Thesis submitted for the degree of Doctor of Philosophy to the University of London. January 1977, Cyprus).
Aquifer's area: 139 km² (Only the eastern part of the aquifer was included in the study).
Average rainfall: 340mm

Replenishment (mcm/year)				
	Rainfall + Riverbed Recharge	Return from abstraction	Change in storage	Total
Average	7.7	0.8	2.0	10.5

Outflow (mcm/year)			
	Abstraction irrig/dom.	Subsurface outflow	Total
Average	9	1.5	10.5

Balance: **- 2** mcm/year

GROUNDWATER BALANCE TODAY

Period 1991 – 2000. Accuracy of estimations: Good. Aquifer's area: 600 km².
Average rainfall: 280mm.

Replenishment (mcm/year)					
	Rainfall	Riverbed Recharge	Subsurface Inflow	Return from abstraction/ domestic	Total
Average	8	21	2	3	34

Outflow (mcm/year)			
	Abstraction irrig/dom.	Subsurface outflow	Total
Average	29	11	40

Balance**: -6.0** mcm/year
Recommended maximum extraction: **22** mcm/year.

LEFKARA AND PACHNA FORMATION AQUIFERS

INTRODUCTION

The Lefkara and Pachna sedimentary formations are mainly developed in the Lemesos and Larnaka Districts i.e. south and southeast of Troodos Igneous Massif. In the Pafos District these are less frequent and only appear in patches mainly over the Mamonia formation located south and southwest of Troodos. The Pachna formation aquifers studied in this chapter include only the aquifers developed in the Middle Miocene member of this formation.

Conditions for the development of the aquifer are not favorable. The impermeable marly sediments prevail in these formations. Generally, the fault and sheer zones are filled up with impermeable marly materials which block recharge and groundwater movement. The presence of virtually horizontal layers of impermeable marls suppresses infiltration and deep percolation of water. The hard rocks of these formations e.g. chalks, are not intensively disturbed and fracture systems are not well developed. In the fault and sheer zones where these fracture systems are extensively developed the conditions are more favorable. Karstic phenomena have in some cases developed in these fracture systems allowing free groundwater circulation.

The most common aquifers are formed in thin sandy layers of Pachna formation. They are low capacity aquifers and they discharge mainly through short-lived springs or seepages. Some higher yielding aquifers formed in thicker and coarser sandstones layers. Successful, high yielding boreholes are generally rare. The main source of the aquifers' recharge is rainfall.

Chemically the aquifer is generally hard because of the presence of calcium carbonate rocks. In places water of high Boron and Fluorite concentrations appears.

The degree of the aquifers' exploitation is not clearly defined. The number of boreholes drilled is not known exactly and their yearly extraction is not being registered. The extraction is estimated indirectly through the size of the irrigated area and the types of crops irrigated. Extraction has gradually increased in the last decades. In general the aquifers are over-pumped today.

The general hydrological and hydrogeological prevailing conditions are not well known. In this stage of the study it is very difficult to define the various aquifers and their relations, the water interchange conditions, the recharge and discharge conditions, etc. For this reason and looking macroscopically, the whole area is treated as one complex water bearing formation.

GEOLOGY

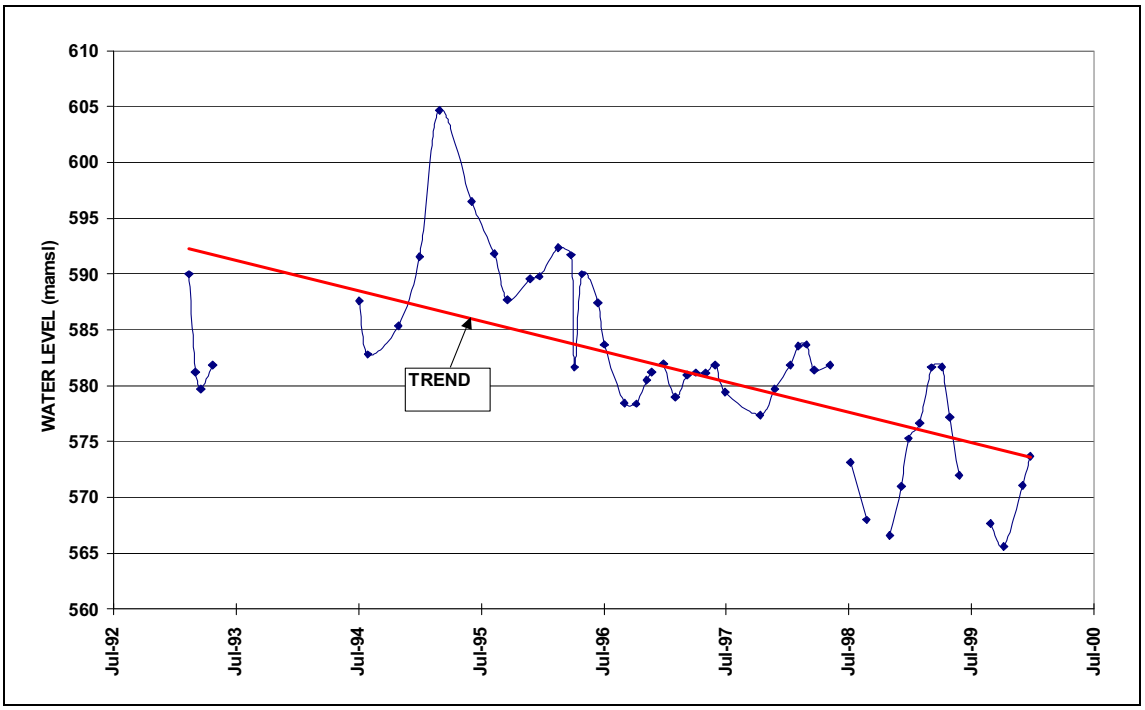
The Lefkara is the oldest member of these two formations and consists of layered and massive chalks, marls, marly chalks, chalky marls and cherts.
The Middle Miocene member of Pachna formation consists of marls, chalks, chalky marls, marly chalks and sandstones.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No.
WATER QUALITY OBSERV. NETWORK: Occasional. Few boreholes
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFERS: Approximately 1200 Km², OUTCROP AREA: 1200 Km².
AVERAGE RAINFALL: 1990-2000: about 450 mm
BOUNDARIES OF THE WHOLE COMPLEX: North, South, East and West: of low permeability. Groundwater outflow to the south.
CONFINED/UNCONFINED: All types are present.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Low to medium.



Hydrograph of borehole Sylikou 24/83 (Appr. elev. 650 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Several hundreds of boreholes operate today in the aquifers both for irrigation and domestic purposes. Their yields vary from 2 to 10 m³/hour. The extraction from the aquifers in the year 2000 was estimated based on water demand data prepared by Loukas Savides, Kyriakos Alexandrou and Gerald Dorflinger. The study was carried out to assess Water Demand in Cyprus, in the framework of the project "Reassessment of the Island's Water Resources and Demand" undertaken in cooperation with FAO.

The total water demand is estimated to be about 10 mcm/year. The domestic water demand is estimated to be 2.5 mcm and the irrigation demand 8.5 mcm/year. Springs and diversion of surface water satisfy part of the irrigation demand. The extraction is very roughly estimated to be in the order of 7 - 8 mcm/year.

Due to the aquifers' general overpumping a depleting trend is prevailing in the area. Extraction in some small, effectively rechargeable aquifers is in balance with the natural recharge.

GROUNDWATER BALANCE TODAY

The very complicated hydrological and hydrogeological conditions and the lack of data do not allow estimation of a reliable water balance. Nevertheless present levels of extraction and the resulting depletion of the aquifer allowed a rough estimate of the permissible extraction which should of course be lower than today's levels.
Recommended extraction: ~ **6** mcm/year.

Assuming that 5%-6% of the average rainfall infiltrates into the aquifer total recharge is guesstimated to be of the order of 30 mcm/year. Part of this water discharges into rivers through springs and part of it evaporates from seepages.

TROODOS IGNEOUS MASSIF AQUIFERS

INTRODUCTION

The Troodos igneous massif includes the main Troodos Mountain and the Limassol Forest igneous complex. A great number of aquifers developed in these igneous massifs. They are mainly formed in fractured and weathered zones of these rocks and they are spread out all over the area of these igneous massifs. The best-developed aquifers appear in tectonically crushed zones or in rock complexes where the processes of alteration and weathering are not producing clayey or generally impermeable materials.

The most common aquifers are formed in the superficial, thin, weathered zones of these rocks or in talus materials. They are usually very small transient aquifers formed after the winter rains. They discharge through short-lived springs or seepages. Low capacity aquifers developed in small fault zones are also very common.

The most dynamic and productive aquifers are formed in Gabbros. These rocks are usually tectonically crushed and highly altered forming thick zones of intensely fractured rock or zones consisting of highly permeable coarse “sandy” materials. Other important aquifers are formed in some extensive fault zones such as the one developed in the Arakapas fault zone. Most of the high capacity perennial springs are fed from these fault type aquifers. Favorable conditions for the development of aquifers exist also in fractured zones of Serpentinites and Plagiogranites.

Conditions for aquifer development in Diabase are, generally, not favorable. Some aquifers of local importance in Diabase are developed in the fault zones. The worse conditions appear in Lavas and in Basal group. The clayey material produced by weathering or alteration of these rocks clogs up the cracks and the fractures thus suppressing water circulation and recharge to the aquifers. Successful, high yielding boreholes are rare in Lavas.
Examples of aquifers developed in Lavas are given in this report in separate chapters (see Chapters on the Anglisides and the Pyrgos- Parekklisia aquifers).

The main source of the aquifers’ recharge is precipitation, in the form of both rain and snow. The most important aquifers are the dynamic ones that are effectively recharged every year from rainfall. Many aquifers are not effectively rechargeable.

Aquifers in this area discharge through springs or seepages feeding several rivers. The rivers’ base flow is maintained by these discharges. Troodos is a mountainous area with steep to very steep topography. Generally, the water table gradient follows the topography. The steep gradients of the groundwater table causes a very fast depletion of many shallow aquifers. The most successful boreholes, with relatively stable yields are deeper than 100 m. Yields in zones deeper than 200 m gradually decrease. Water in depths of 200 – 300 meters is of high quality with low mineral content. Appearances of groundwater with high concentrations of magnesium, sulfur or boron are rare.

The remote, western, part of Troodos is not exploited. It is an underpopulated area too far from high water demand centers. The central and eastern Troodos aquifers are intensively exploited. The degree of this exploitation is not clearly defined. The number of boreholes drilled is not known exactly and their yearly extraction is not registered. The extraction is estimated indirectly through the size of the irrigated area and the types of crops irrigated.

In the last fifteen years extraction has gradually increased and today the aquifers are generally overpumped. There are indications that the droughts of the last decade together with overpumping of the aquifers have reduced the runoff factor of some of the rivers thus adversely affecting the water crop in the downstream dams and the water availability in various Government Water Projects.

The general hydrological and hydrogeological prevailing conditions are very complicated. It is very difficult to define the boundaries and the extension of each aquifer, the relation between them, the water interchange, the recharge and discharge conditions, etc. For this reason and looking macroscopically the Troodos is treated as one complex aquifer.

GEOLOGY

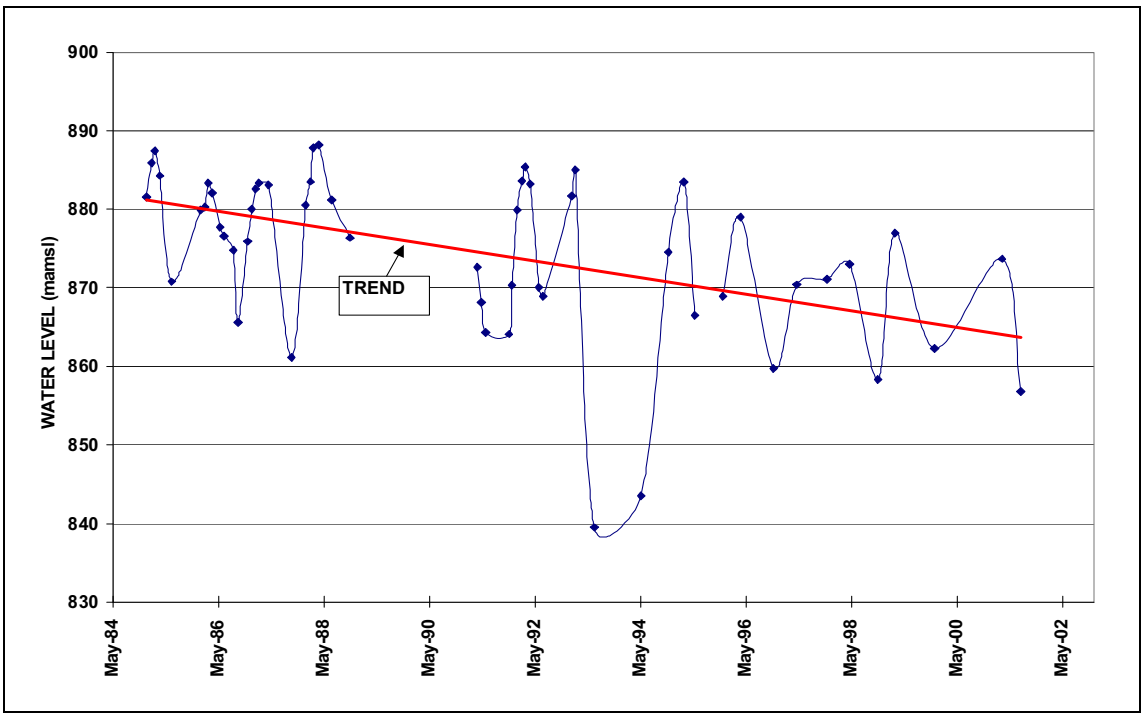
The Ophiolites of the Troodos massif present one of the best examples in the world where a complete series of mafic and ultramafic rocks are present. All the series appear in a homocentric elliptical shape. The Mantle series appears in the center i.e. around mount Olympos. The Mantle series consists of Harsburgites and Serpentinites. The next series i.e. the Plutonic one consists of Dunites, Werlites, Pyroxenites, Gabbros and Plagiogranites. This is followed by the Diabase of the Intrusive sequence. Over this lies the Basal Group which is a transition zone between Diabase and Lavas. On top lies the Lower and Upper Pillow Lavas of the Volcanic series.

GENERAL INFORMATION

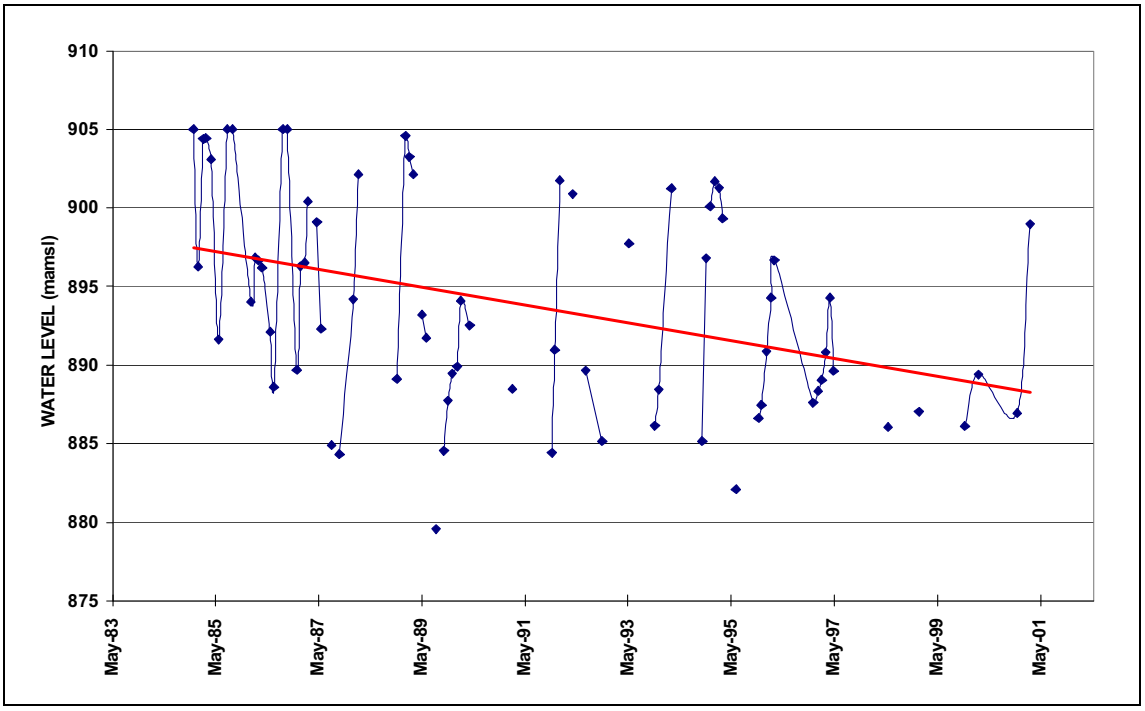
WATER LEVEL OBS. NETWORK: Only few boreholes.
WATER QUALITY OBSERV. NETWORK: Occasional. Few boreholes
ARE ALL BOREHOLES PLOTTED? : No.
EXTRACTION SURVEY: No.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFERS: 2200 Km², WIDTH: 25 Km, LENGTH: 90 Km, OUTCROP AREA: 2200 Km².
AVERAGE RAINFALL: 1990-2000: about 650 mm
BOUNDARIES OF THE WHOLE COMPLEX: North, South, East and West: of low permeability. Groundwater outflow.
CONFINED/UNCONFINED: All types are present.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high.



Hydrograph of borehole Pelendria 53/76 (Appr. elev. 900 m amsl)



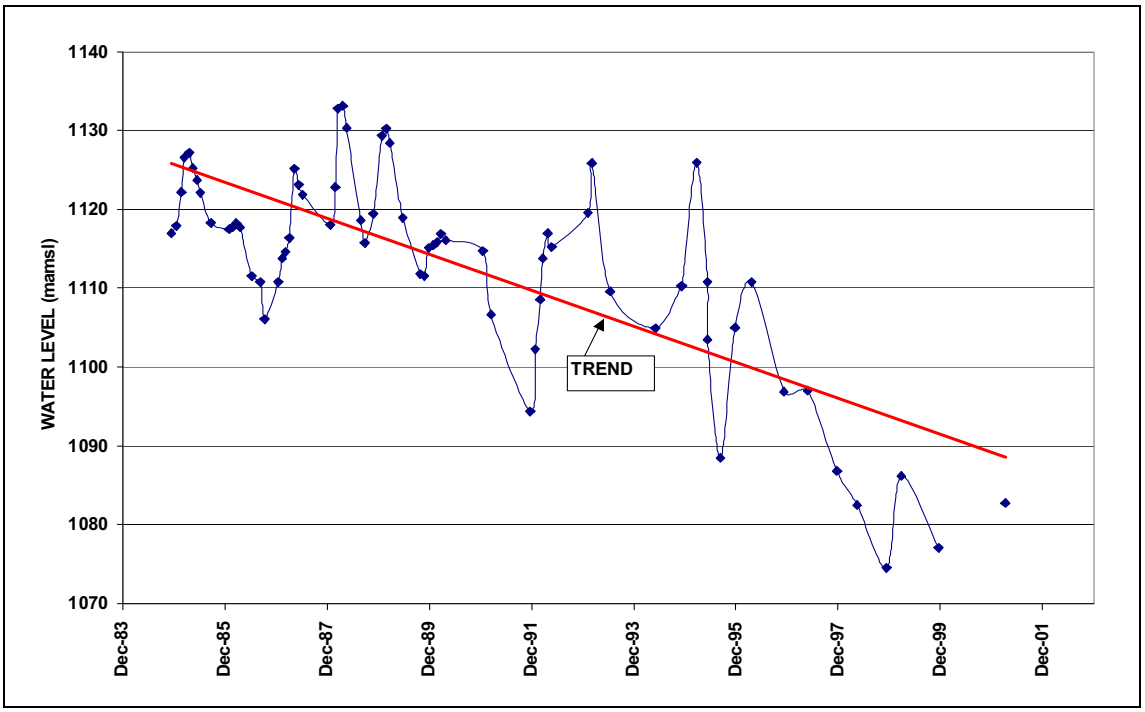
Hydrograph of borehole Askas 98/80 (Appr. elev. 905 m amsl)

HYDROGEOLOGICAL CONDITIONS TODAY

Several hundreds of boreholes operate in the aquifers today both for irrigation and domestic purposes. The yields of these boreholes vary from 2 to 60 m^3/hour. Extraction from these aquifers in the year 2000 was estimated based on water demand data prepared by Loukas Savides, Kyriakos Alexandrou and Gerald Dorflinger. The study was carried out to assess Water Demand in Cyprus, in the framework of the project

“Reassessment of the Island’s Water Resources and Demand” undertaken in cooperation with FAO.
Domestic water demand was estimated to be 2.5 mcm and irrigation demand was estimated to be 15.5 mcm/year. Part of the irrigation demand is satisfied by springs, diversion of surface water as well as from dams and ponds (Pitsilia Project and other water works). Extraction is roughly estimated to be in the order of 12 -13 mcm/year.

Due to overpumping of the aquifers a depleting trend prevails in the Troodos area. It has been estimated that water levels in the area have dropped by an average of 1.5 m/year over the last decade. Only in few small and effectively rechargeable aquifers extraction is in balance with the natural recharge. It is assumed that many other aquifers will partly recover under normal hydrometeorological conditions.



Hydrograph of borehole Agros 21/82 (Appr. elev. 1200 m amsl)

GROUNDWATER BALANCE TODAY

The very complicated hydrological and hydrogeological conditions and the lack of data do not allow estimation of a reliable water balance. Nevertheless, the present levels of extraction and the resulting rate of aquifers’ depletion allowed a rough estimate for permissible extraction which of course should be lower than the present levels.

Recommended extraction in the central and eastern areas of the Troodos massif: ~ **10** mcm/year.

Several methods have been employed to estimate total recharge resulting from precipitation. Tentative values of 110 – 150 mcm/year have been reached. These numbers have been given as an indication only. They are by no means accurate figures. Some of this water discharges into rivers through springs, some of it evaporates from seepages and some of it is consumed by the extensive Troodos forest.

PENTADAKTYLOS LIMESTONE AQUIFER

INTRODUCTION

Pentadaktylos limestone is a complex aquifer developed along the Keryneia Range. It is a phreatic Karstic aquifer. Its main source of recharge is rainfall. Even though it is the biggest and the most dynamic limestone aquifer in Cyprus it has not been studied properly. The aquifer area is under Turkish occupation since 1974. There is no Government control in the aquifer and the data available dates earlier than 1974. Until 1974 the aquifer discharged through about twenty major springs. Only a few boreholes operated at that time.

The aquifer was overexploited for several years before 1974 and as a consequence spring yields reduced significantly. It is believed that overexploitation of the aquifer is still going on. Information obtained from newspapers published in the occupied area confirm that many major springs have already dried up. Low rainfall during the last decade most probably resulted in even greater water deficits in the aquifer.

GEOLOGY

The limestone aquifer is a very complex one. It consists of various geological formations and interconnected and isolated complex water bearing members. The main aquifer members are developed in Kantara, Dikomo, Syhchari, Hilarion and Lapithos formations of Permian – Carboniferous to Palaeogene Periods.

GENERAL INFORMATION

WATER LEVEL OBS. NETWORK : No information available.
WATER QUALITY OBSERV. NETWORK: No information available.
ARE ALL BOREHOLES PLOTTED? : No information available.
EXTRACTION SURVEY: No information available.

AQUIFER'S GENERAL INFORMATION/CHARACTERISTICS

AREA OF THE AQUIFER: 170 Km² (85x2 km). OUTCROP AREA (around): 100 Km².
AVERAGE RAINFALL: 1971-2000: 500 mm.
HYDROGEOLOGICAL PARAMETERS: Average K = 20 m/day (roughly estimated).
Average S = 1 % (roughly estimated).
BOUNDARIES: Mainly impermeable.
CONFINED/UNCONFINED: Unconfined to semiconfined.
SUSCEPTIBILITY (NATURAL VULNERABILITY): Very high.

HYDROGEOLOGICAL CONDITIONS TODAY

There is no reliable information about the hydrogeological conditions in the aquifer today. However, having in mind the droughts of the last decade and the fact that the aquifer is one of the major sources of water in the occupied part of Cyprus it is almost certain that the aquifer is overpumped. Low natural recharge and overpumping of the aquifer must have resulted to even lower than 1974 water levels. It is certain that most of the major springs have dried up.

HISTORIC GROUNDWATER BALANCE

Period before 1974. Christos Ioannou “Η ΥΔΡΟΛΟΓΙΑ ΣΤΗΝ ΚΥΠΡΟ “ (Hydrology in Cyprus), WDD, Lefkosia 1976). Total area of the aquifer: 82 km

Replenishment (mcm/year)	
	Total
Average	13 - 14

Outflow (mcm/year)				
	Abstraction irrig/dom.	Spring outflow	Subsurface outflow	Total
Average	2 - 3	8 - 9	(2 – 3)*	(13 – 14)*

* = Estimated by A. Georgiou i.e. the author of this chapter.

GROUNDWATER BALANCE TODAY

Not available.