GOVERNMENT OF CYPRUS

WATER SUPPLY AND IRRIGATION DEPARTMENT

WATER SUPPLY IN CYPRUS

A GENERAL REPORT

BY

C. RAEBURN, O.B.E., D.Sc., F.G.S., M.I.M.M.
Water Engineer

NICOSIA:

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GENERAL INTRODUCTION.

In the pages that follow, an attempt is made to describe water supply conditions in Cyprus as they are, objectively and realistically. A policy is outlined and consideration is given to all known schemes that have been advanced for increase of available water. It is necessary to discuss both domestic and irrigation supplies, for in a country of deficient water with a long hot summer, the supply taken for the towns and villages is not unimportant and with advancing social standards is definitely becoming more important. The test of any scheme for water supply must be: Is it economically feasible? It is not difficult to justify financially a domestic scheme: the imponderable considerations of public health and social amenity are adequate. But what of irrigation schemes? The acid test of profit and loss must be applied—added crop values weighed against added cost of water, labour, and fertilizer. Naturally, there are also indirect and long-term benefits and perhaps political considerations to be estimated but no scheme unless soundly founded can continue. Eventually, the subsidy or special circumstances supporting it will cease and then comes the reckoning.

2. From early days in the Island, the spring waters were used for irrigation. The ancient city of Salamis on Famagusta Bay, which was destroyed by an earthquake in the fourth century, took water from Kythrea by an aqueduct over twenty-five miles long, traces of which are still to be seen. Little more is known from that time but very ancient wells and aqueducts are common and utilization of water must have increased gradually until the Turkish conquest. After that, there may have been a period of little development followed by the construction, in the seventeenth and eighteenth centuries, of some of the famous chains-of-wells and aqueducts such as the Silikdar, the Arab Ahmet and the Bekir Pasha at Nicosia and Larnaca.

3. Water supply in Cyprus is dependent on rainfall and geology—the latter conditions topography—and these must both be considered if a just estimate of conditions and of possible improvement is to be achieved. Irrigation depends on water supply primarily, but there are the matters of farming methods, crops, markets, finance, indebtedness, inheritance laws and even the general character of the people which affect the solution of this question.

4. Before the British Occupation in 1878, the geology of the Island had been described by Professor Gaudry of Paris University, who gave a full and accurate account. After the British Occupation, the Island was visited by Mr. R. Russell, an engineer, who made a close study of the springs and recorded a series of gaugings. He was chiefly notable, however, for his assertions that the area between the Kyrenia and the Troödos mountains formed an artesian basin and that artesian water could be obtained by deep drillholes. In his report, he gave a cross-section of this basin and on that, the first deep drilling work was undertaken many years later. However, drilling was not proceeded with then probably because of cost. Towards the end of the century, agitation in Britain and locally, led to the engagement of Mr. J. A. Medlicott, an irrigation engineer from India. He made a close study of the Mesaoria and recommended a series of works for impounding water, all in the eastern Mesaoria. His scheme included the diversion of part of the flow of the Merika and Akacha Rivers from the western into the eastern drainage and the construction of a series of reservoirs beginning with a large one at Yerolakkos, near Nicosia, and with others at intervals towards Famagusta. The early failure of these works, only part of which was constructed and which are described later, turned attention to Russell's report and deep drilling was started. About the same time, in 1906, Clement Reid, an eminent British geologist, made an investigation and, while reporting adversely on the chances of artesian conditions, he advocated the construction of adits in the Kyrenia hills. This work started at Pileri, near Kythrea, in 1908, and was continued, spasmodically, at that place until 1934, without any definite result. The site of operations was then shifted to Sykhari, but here again work languished and, by the time of the arrival of the writer in 1937, had ceased.

5. The possible results of the adit-driving seem to have prevented any new developments in prospecting until after the war, though deep drilling was continued at considerable expense and without notable result. In 1921, the question of water supply again came to the fore and Colonel Ellis, another irrigation engineer from India, made an investigation. He was reluctant to make any recommendations but finally re-examined Medlicott's diversion and Yerolakkos reservoir project and reported that, after a careful study of the rainfall and run-off, it might be reconsidered. The next consultants to be summoned were Messrs. A. Beeby Thompson and Partners, and to this company belongs the credit of the discovery that abundant water might be found in the coastal fringes, particularly close to the sea at Morphou Bay. Unfortunately, this led to a premature statement by Government that it would be possible to pump ten million gallons per day from these coastal beds and to raise the water over the watershed distributing it as far as the Karpas. This has become a permanent reproach to Government.

6. In the years after the visit of Clement Reid, interest in the geology had continued and notable advances made by Bellamy and Jukes-Browne, Cullis and Edge, Romanes, Cowper Reed and others, so that, in a general way, the hydrogeology of the Island was known. Many drillholes had been bored and from their records, there was a mass of detail information available.

7. It will be appreciated from the short account given, that there has been, since the Occupation, a constant effort, spurred often by agitation in Cyprus or in London, to increase water supplies but schemes directed either to conservation or to tapping subsurface sources have seldom proceeded beyond the paper stage. The failure of certain schemes may be ascribed to the fact that the consultant who planned the work could not remain to initiate it and to control its execution and so, on arriving at some unexpected obstacle, no advice was available and the scheme was abandoned. When the writer assumed charge of water supply in 1937, the work was at a low ebb both as regards irrigation and domestic supply. It was soon realized that not many new sources remained to be discovered in such a small, closely and long inhabited Island whose people had for centuries themselves been seeking

for water and whose rocks had been carefully prospected by engineers and geologists during the last sixty years. It was not a new colony occupied by primitive people to whom irrigation was a novel method in agriculture but a land scored with ancient irrigation works and with the memory of many efforts to augment supply. It was not a new colony where water is free and without pre-existing rights but a country inhabited from remote times where there are rights, *ab antiquo*, over all the surface water worth having and where much of the subsurface water at reasonable depths is already developed by wells.

8. How is the supply of water to be increased ? There are many suggestions, some advocating obvious methods and others methods not so obvious and these are examined in detail. The main body of opinion nowadays favours works for retention of winter water, particularly in the hills. Dams in the hills are the panacea. It is generally admitted now that conservation of winter water in the Mesaoria has not been successful; so, why not try the hills ? An answer is given below, but the essence of it is that the Island is too small and too lofty. Others favour adits in the Kyrenia hills or deep drilling in the Mesaoria. Official opinion while willingly examining all suggestions, favours the multiplication of small schemes utilizing every possible drop of water, small schemes which, while in themselves of a minor character, will nevertheless be important in the aggregate. It favours the improvement of intake works and channels, and of improved methods of irrigation and farming so that the best use may be made of what water is available.

THE GEOLOGY IN RELATION TO WATER SUPPLY.

9. To appreciate the problems of water supply in Cyprus, it is necessary to have at least a general conception of the geology. Certain groups of beds are to be recognized throughout the Island and their hydrological conditions are generally similar wherever they occur. In this account, the classification of the beds first suggested by Gaudry and amended by Bellamy and Jukes-Browne, by Cowper Reed and Renz has been followed. Later unpublished work by Mr. R. V. Browne, Geologist, Petroleum Development (Cyprus) Ltd., indicates modifications of this classification but does not affect the hydrogeological situation. The old familiar names of Idalian, Kythrean and so on, have, however, been regularized to Dhali Formation, Kythrea Formation, etc., in accordance with these later reports. The succession, nature and thickness of the formations are given in the table on this page. The geological map prepared by Bellamy and Jukes-Browne, although on a small scale, is useful to show the extent of the various formations and, considering the date of its compilation, is fairly accurate.

	Geological Succession.	*Thickness ft.*	*Area sq. miles.*
Recent and Pleistocene :	River and beach gravels : sands, sandy limestones, conglomerates	—	940
	Abundant supplies of water of good quality from coarse alluvials from wells and boreholes : occasional artesian boreholes.		
Pliocene :	Upper : Sandy limestones, green limestones, marls and conglomerates	200	
	Lower : Yellow fossiliferous, calcareous, sandstones and limestones : marls ..	500	
	Fair quantities of hardish water from deep wells.		
	Unconformity.		
Miocene (Dhali Formation) :	Fossiliferous and chalky limestones : marls with flints	1,000	1,275
	Fair quantities of good sparkling, hardish water from springs but poor results from boreholes.		
	Grey, green, blue or black marls with gypsum ..	more than 1,000	
	Very meagre highly saline water.		
	Unconformity.		
Oligocene (Kythrea Formation) :	Felsphathic sandstones, sandy shales and marls : conglomerates and breccias	?	410
	Scanty saline water often with H_2S in all strata except conglomerates which give abundant supplies of moderately hard, sparkling water in association with Trypa limestone beds.		
Eocene (Lapithos beds) :	Green shales	?	—
	Unconformity.		
	Main Period of Igneous Intrusion	—	867
	Many springs of soft water, volume varying with rainfall and degree of faulting and shattering of rocks.		
Cretaceous and older (Trypa Formation) :	Limestones and dolomites	? 4,000	95 with Lapithos beds
	Many springs of bright moderately hard water : occasional small artesian boreholes.		

10. The groups of beds will now be described in more detail, particularly with regard to their water-bearing characteristics.

THE TRYPA FORMATION.

11. From a water supply viewpoint, the limestone of the Kyrenia hills is the important outcrop of this formation. The limestone is first encountered in the west of the Island just over five miles to the east of Cape Kormakiti, whence it extends in an east by south and then in an east by north direction for fifty-eight miles to near Komi Kebir at the root of the Karpas. Peaks rise to over three thousand feet above sea-level but the limestone is at no point wider than two and a half miles. As the median line of the range is never more than four miles from the sea, it will be realized that here is an area of abrupt precipitous slopes drained by short small streams with very heavy gradients, particularly on the north front. As the rocks are folded into a close anticline with almost vertical limbs, great precipices are common and the silhouette of the range is in striking contrast to that of the igneous range in the south of the Island. The limestone is normally blue, brown or grey but there are outcrops of many varying colours. Brecciated and schistose types are also common. The weathering of the limestone produces a rough, cavernous rock which should be a good holder and retainer of water, but the steep slopes and low rainfall act the other way. Nevertheless, the great springs of the Island issue from this limestone. A list of the major springs with gaugings follows but except for Kythrea and, to a less extent, Lapithos, these are based on a few readings only or even on one. It is known that the lesser springs vary considerably in flow from year to year and seasonally. The great springs are found in the western half of the mountains on both north and south sides. In the eastern half east of the Lefkoniko–Akanthou pass, the springs are small and unimportant and some of the smallest are saline. The reason for this is not apparent.

Gaugings of Springs in Kyrenia Mountains.

	Millions of gallons per day.
Kythrea	2.5–4.5
Dhikomo	0.5–1.0
Larnaka tis Lapithou	0.1
Trypimeni	0.05
Ayios Khariton	0.05
Ayios Vasilios	0.004
Lapithos	1.06–1.69
Karavas	0.6
Bellapais (2 springs)	0.17
Boghazi, Kyrenia (3 springs)	0.22
Vasilia (3 springs)	0.3–0.4
Akanthou	0.14
Krini	1.03
Agridhaki	0.014
Keumurju	0.008

12. The origin of the water of these springs is a perennial subject for argument in Cyprus. Does the water come from Anatolia, from rainfall in the subjacent area or from the Troödos hills ? That this query should be solved correctly is important, for it has a definite economic bearing. Thus, if the springs are truly artesian and derive their water from the lofty Anatolian range across the narrow Karamanian Sea, a range with more than adequate rain and snowfall, it is possible that an increased output of water might be secured by boring or tunnelling. On the other hand, were the spring water local or sub-local in origin, the annual draught would be limited by the local rainfall which is relatively low and by the nature of the infiltration area of which the characteristics are, as stated above, by no means all favourable. That the water of the springs should come from the Troödos range is not feasible. The impermeable nature of the rocks of the mountains and of the foothills prevents the percolation of the water into a pervious bed at a sufficient altitude for it to reappear at the height of the springs. There are other valid geological reasons why the water cannot come from the south but these need not be elaborated here, when it is clear that the relative altitudes of possible intake and outflow are wrong.

13. However, the argument that the water may come from Asia Minor is not to be dismissed lightly. Are the springs truly artesian and the water derived, as many people believe, from the Anatolian mountains or is it purely local and dependent on the rainfall on the Kyrenia hills ? Study of the gaugings of Kythrea spring, which have been taken regularly since 1932, seem to indicate a local origin for the water and that the variations from year to year depend on the volume of the winter rains. Furthermore, analyses of spring waters from the Kyrenia hills show relatively little mineralization, much less than would have been anticipated had the water gone to the great depths (with consequent increase in temperature and pressure) required for its passage through the rocks beneath the sea from Anatolia. The sea is 500–600 fathoms deep. The total solids in Kythrea water are only 41 parts per hundred thousand and the water is not excessively hard. Dixey, " Practical Handbook of Water Supply ", p. 193, describing deep-seated artesian waters, says : " The Australian artesian waters are normally high in saline matter, particularly sodium carbonate and common salt : and certain of the Wisconsin flows, as well as certain flows of the Atlantic coastal plain of the United States, are very hard, while others are too saline to be of use." In general, the weight of evidence seems to favour a local origin for the water. The local tradition of a gold pot having been lost in a fissure in Anatolia and found in the spring at Kythrea may be disregarded and also the evidence, often quoted, that when there are floods in Anatolia the springs are affected. Any effect of such flooding would be smoothed out before it could be noted in Cyprus. Movement of water in an artesian aquifer is a slow matter. Thus, it is calculated that the artesian waters of Southern Wisconsin take two to three hundred years to move from the intake outcrops to the point where they are tapped. Recently, it was stated in a Cyprus newspaper that the Turkish earthquakes have caused turbidity in the Lapithos and Kythrea springs and increase of flow. Actual measurement at Kythrea did not bear out the statement, but even had it been so, it is no evidence that the water is other than locally derived.

14. On the supposition that the water is local in origin, it is estimated that an additional volume of about five million gallons per day may be taken from works in the Kyrenia hills, but the question of making this five million gallons available is a difficult one. The limestone range may be regarded as a great reservoir of which the front wall is the impervious Kythrea beds. The springs are the overflow from this reservoir which is full of water. To make use of this extra water, it is necessary to get it into the reservoir in which at present there is no room for it and it is lost by dissipation in a myriad soaks and seepages. In order that this water may enter the reservoir, the rate of outflow must be increased, but this can only be done in a big enough way by lowering the altitude of the springs or by making new springs, for example by driving adits at a lower level than the present springs. This, of course, would make a radical change in the economy of the villages in the area affected and is a course of action very unlikely to be followed. It must be recognized that, generally speaking, the tapping of any large volumes of water in the Kyrenia hills will affect the present springs even although the total volume available may be increased. An adit or borehole, here and there, producing a few thousand gallons a day makes little difference to the big springs despite the protests of their owners, who, rightly one thinks, are quick to object to any water works in the neighbourhood of their property.

15. There is another side to the question of making this water available and that is one of method. It would appear that the big springs are associated with fault lines or major joint planes and so far it has not been possible to locate these. Acoustic methods of geophysical prospecting have been considered and some trials made but without result. It may be suggested that all that is required is to keep on tunnelling but the Sykhari adit showed that behind a creviced, shattered outer skin of conglomerate and limestone, there came a core of very hard dry rock without any crevices to afford a guide towards a main fracture. In this, adit driving became expensive and merely a gamble for there was no surety that water was to be struck finally. Vertical prospecting drillholes were out of the question. It may be asked how the big springs originated. They must have started at a much higher level towards the top of the anticline and as erosion cut down the younger beds on the flanks so the springs lowered their outflow level. There is evidence that the level and place of outflow of Kythrea has changed in relatively recent times and that there is now a tendency for it to break out lower. The actual flow régime of Kythrea is interesting. In most years, the flow increases through the spring season reaching a maximum anytime between May and November but usually about the end of July. The flow then decreases gradually to a minimum later in winter. The greatest recorded flow was 4,429,000 gallons per day during August and September, 1935, and the least 2,381,000 gallons per day in November, 1933, towards the end of the drought. Gaugings taken at intervals from 1880 until 1932, all indicate a flow of just over three million gallons a day.

16. Early workers have stressed the association of the springs with outcrops of igneous rock or with markedly schistose limestone. Recent work in the hills shows that igneous outcrops and schistose limestone are much commoner than originally supposed and it is very unlikely that the occurrence of springs bears any relation to them.

The Igneous Rocks.

17. The igneous rocks occupy a considerable area, some 870 square miles stretching from the coast of the Tylliria, eastward for nearly sixty miles and forming the highlands of the Troödos mountains, the loftiest part of the Island. There is a small detached igneous outcrop further east around Troulli. There are both intrusive and volcanic rocks with beds of ashes and tuffs but, from a water supply standpoint, these igneous rocks need not be differentiated. When fresh, they are impervious and afford drainage areas with great run-off, the only infiltration being along shattered and faulted zones. On the other hand, these rocks, when weathered, give rise to a clayey product, which is equally impervious so that, over the whole igneous area, the rocks, fresh or weathered, favour high percentage run-off. This is mitigated by the fact that here are the main forests and also by the notable development of terracing in recent years, particularly in the Pitsilia. Wells on the igneous rocks give scanty yields and boreholes are unknown. The main supplies are derived from springs arising from fissures and from shattered zones, all probably along fault lines. The springs are for the most part small. These on the road below Amiandos, 11,000 gallons per day or the springs in the forest near Makhera Monastery 4,200 gallons per day, or larger again the Prodhromos spring 48,000 gallons per day may be taken as examples but there are occasional big flows. The Kannoures spring, source of the Karyioti draining the Solea valley, has an output of about a million gallons a day. The water supplies of Troödos and Platres and other important summer hill resorts are derived from numerous relatively small springs issuing from the igneous rocks.

The Kythrea Formation.

18. The Kythrea beds, consisting of breccias, conglomerates, sandstones and shales, outcrop mainly along both flanks of the Kyrenia range and extend from Kormakiti to the end of the Karpas. These beds are overfolded and compressed into acute flexures parallel to the axis of the hills. This produces a series of undulations with the harder beds forming their crests, to which the descriptive term of " Hummocks " has been applied. The Hummocks are almost devoid of trees and on their poor, thin soil meagre crops are gathered from small fields lying between the rocky outcrops. This is a depressing area far gone in erosion. The lowest of the beds are breccias and conglomerates which vary considerably in thickness but are known at Sykhari to be 160 feet thick. In places especially to the eastwards, south of the Kyrenia hills, these basal beds may become quite thin and even be absent. This may be due to faulting and has a definite effect on water supply for these rocks are important aquifers. At points where the conglomerate is absent its place is taken by a dark green or brown grit or sandstone. The remainder of the beds are compact, finegrained felspathic sandstones and grey-green shales.

19. From a subsurface water supply viewpoint, except for the conglomerates and breccias which for this purpose are really parts of the Trypa Limestone, the Kythrea beds are unimportant. They are too finegrained either to form aquifers or to allow percolation. In their present condition bare of vegetation, they have a high run-off from rainfall and are therefore important contributors to flood water for winter and spring irrigation. Wells or boreholes in any but the basal beds are disappointing. The water is meagre in quantity, saline and sometimes carries sulphuretted hydrogen in solution. The main use of beds is to form an impervious barrier to contain the water in the older Trypa rocks.

THE DHALI FORMATION.

20. These are predominantly white rocks and form a striking feature in the Island's scenery. They cover nearly half its area and are strongly developed south of the igneous range and eastwards to Larnaca. The beds vary considerably in character from grey or yellow marly clays with gypsum to white limestones which may be marly or chalky and at times hard and full of fossil shells. The lower beds do not form good aquifers and boreholes sunk in them are unsuccessful. From the higher members of the beds, valuable springs flow forth particularly in the area south of the Troödos range. Such are the springs of Ayia Irini, Paramali, Evdhimou, Symvoulo and many others. The volume of these springs varies considerably throughout the year and there is not the steadiness of flow that characterizes the larger springs of the northern range. Thus Ayia Irini may yield a quarter million gallons per day in late winter and spring but by autumn it has shrunk to a tenth of that volume. Minimum daily flows of the order of twenty thousand gallons are common. These waters are thrown out from fissured limestones by harder or more argillaceous bands on valley sides or at streamheads.

21. It has been suggested that this water might be tapped before it reached these springs but this would produce little advantage. It is certain that these springs yield the economic draw-off from the subsurface drainage of the area and any attempt to take the water by wells or boreholes would merely lead to reduction of spring flow. In certain cases, efforts have been made to intercept spring water in these Dhali beds but without conspicuous success. The water probably moves in a series of very small channels until near the orifice of the spring where it flows in a definite channel. The method of improving the volume of these springs is not by excavating to increase the actual flow, which can only lead to increased winter and decreased summer yields, but by improved intake works and channels. Many of these springs are more important as sources of domestic water rather than of irrigation water.

THE PLIOCENE AND PLEISTOCENE ROCKS.

22. The late Tertiary and Quaternary rocks are not easily separated and as regards water, it is not necessary to do so. This does not mean that they are unimportant in water supply for they yield very large volumes of water from wells and boreholes. They form the whole of the Mesaoria and a coastal fringe of varying width bordering almost the whole Island including the notable water-bearing areas of Famagusta, Morphou Bay and the Akrotiri peninsula west of Limassol. The Pliocene rocks can generally be distinguished in the Mesaoria in its higher parts: nearer the coast differentiation from Pleistocene and recent deposits is more difficult. In the western Mesaoria the group includes at the base resting on the grey marly clay of the Dhali formation (the driller's black clay), conglomerates and gravels sometimes loose and uncemented and therefore important aquifers when lying below the watertable, sometimes cemented and compact and devoid of water. These are followed by very fine dark green, glauconite sands which may carry a little water but yield it sparingly. Care has to be taken to distinguish this from the Dhali grey (green, black, blue) clay in samples from percussion borings when the driller may err in announcing " black clay ". The section of drillholes in the Pliocene also includes yellow sandstones, always calcareous, and yellow fossiliferous limestone. Drilling reveals that the maximum thickness of these beds is not less than two hundred feet.

23. The mapping of the Dhali Formation and of the Pliocene in the vicinity of Nicosia indicated in Bellamy's map is not accurate in detail (the scale is too small) and success in drilling depends on striking the Pliocene and avoiding the Dhali beds. The surface configuration gives no guidance and holes within a few feet one from the other may give strikingly different results. The drillings at Messrs. Dianellos and Vergopoulos cigarette factory and the Cyprus Cold Store Ltd. illustrate this. Erosion in the Dhali beds had evolved a topography and alluviation in the Pliocene had commenced by levelling up this topography. These areas, more deeply eroded now, give successful wells: the ridges between yield no subsurface water. South-west of Nicosia, near Lakatamia, in the valley of the Pedias, there is an area mapped as Dhali beds in Bellamy's map, where Pliocene rocks outcrop. The rocks are folded in a syncline and drilling has shown the presence of small artesian flows from fine-grained sandstones at depths to five hundred feet. The Pliocene outcrops along the north coast in patches alternating with the Dhali Formation. This alternation in the vicinity of Kyrenia to the east and west, decides whether a building site on the coast is desirable or not. The alternating belts are relatively narrow and sites on the Dhali fail to find water or find it in very small quantities hardly sufficient for domestic supply. Sites on the Pliocene find adequate supplies.

24. In the eastern Mesaoria, the Pliocene rocks are sandstones, dark-brown to yellow. Where they are coarser in grain and lie below the watertable, they yield fairly well but at times the water is salt. In the north part of the eastern Mesaoria Bellamy's map shows Pliocene but the grey Dhali clay is within a few feet of the surface. The occurrence of an ancient river system cut in the Dhali beds in Pliocene times is described below. Yellow, calcareous sandstones, coarse and cellular and of some thickness, underlie Famagusta where they form the aquifer supplying copious water to the citrus plantations. On the north side of Famagusta Bay by Trikomo and Boghaz, there are further outcrops of the Pliocene; these have thin gravels at the base which yield water sparingly. South of the Mesaoria, there is an area of dissected plateau-land floored with Pliocene rocks and here good yields are obtained from medium depth wells.

25. In the western Mesaoria, the Pliocene beds in the village areas of Paleometokho, Ayii Trimithias and Kokkini Trimithia have coarse gravels at the base which yield water freely. Further west, however, the grain becomes finer and the rocks appear more consolidated and yields from single wells are disappointing. This had led to a considerable development of chains-of-wells which are described later.

26. The Pleistocene deposits which are most interesting in respect of water are the great pebble beds. There is a very good example at Koutraphas formed from detritus swept down from the Troödos mountains. Such deposits floor much of the land from Peristerona to Morphou Bay and the artesian wells at Syrianokhori and the Pendayia spring issue from them, the water having been held below finer-grained, indurated strata. Similar pebble beds are found along the Tylliria and at the south of the Khrysokhou river where small artesian flows have been obtained from boreholes. West of Larnaca and west of Limassol drilling has also revealed pebble beds and gravels of Pliocene or Pleistocene age. In the latter area very great volumes of water are taken from shallow wells and this must be regarded as one of the best watered parts of the Island.

GEOPHYSICAL PROSPECTING.

27. From the account given of the geology, and the discussion below of various methods that might be used for the increase of water supply, it will be appreciated that, in prospecting, certain areas may now be largely dismissed from consideration. These are the igneous rocks, the Trypa, Kythrea and Dhali beds. This leaves the Pliocene and Pleistocene beds which form the bulk of the Mesaoria and the coastal fringes. These coastal fringes have been considerably developed for sub-surface water and except perhaps for Morphou Bay and a small area near Paphos, require little further attention. There remains the Mesaoria which, in earlier days, because it was apparently intractable, received little attention. However, the application of geophysical methods to this area, beginning in the east, has had success.

28. The particular method adopted was a survey of the electrical resistivity of the subterrain. The work began in May, 1938, in the Kouklia area and has since been continued with little interruptions. The work shows that there exists, subparallel to the present rivers, an ancient buried river system of Pliocene age cut in the grey clay of the Dhali formation. This ancient river system is filled with alluvium, ranging from coarse gravels lying on the clay bedrock, through coarse sands to fine sands and silts. The coarser and lower part of the section may be as much as sixty feet thick and is normally uncemented. There is no indication of the old system in the present topography nor any surface indications. Its course runs athwart the present-day tributaries of the Pedias passing under the broad, shallow valleys and the low but well-marked plateaux that characterize this region. Without the use of geophysical methods, tracing would have been a tedious and expensive matter and could only have been done by close drilling. The employment of these methods, followed at once by check-drilling, has enabled satisfactory progress to be made, a progress which is hastened as more and more drillholes are constructed to assist in the interpretation of subterrain conditions. Resistivity measurements have been made at 1,725 points and 30 check-drillholes or wells have been made. Few geophysical surveys of this scope for water with immediate testing of results have yet been attempted. A total area in the eastern Mesaoria of 80 miles has been surveyed.

29. The coarser gravels of the riverbed yield water freely: a ten-inch borehole has produced in excess of half-a-million gallons per day with a drawdown of eleven feet only. There is no doubt that considerable volumes of water are available for use in irrigation. It will be remembered that from these subsurface rivers as from surface rivers there can only be taken a definite volume of water, albeit a large one, and that this water is the downward drainage to the sea of the rainfall that percolates into the soil. Nevertheless, constant and relatively large volumes of water are available for irrigating high-class summer crops. The location of this supply in the eastern Mesaoria enhances its value. These ancient riverbeds are by no means an unusual phenomenon and are well-known to alluvial miners who call them "deep leads", the term being defined as "an ancient, deeply buried, alluvial deposit of which the course cannot be determined by the trend of the present surface because of the deposition of further detritus, of extrusion of lava or of a radical alteration in the drainage." This deep lead was formed by a Pliocene river. After the deposition of the Dhali beds an upward movement occurred in the late Miocene. Cyprus then became a part of Asia, joined to it on the north and east. It was at this time that the river system was formed. As indicated by the lithology of the pebbles in the alluvium, the river drew the larger part of its volume from the southern hills. Later in the Pliocene, the area sank again and the rivers, owing to loss of grade, became overloaded with much deposition of alluvium. Finally, what is now the Mesaoria lay under the sea. A subsequent uplift in the Pleistocene times drove back the sea once again.

30. Prior to this geophysical work, there had been, outside the Famagusta area, very few boreholes in the eastern Mesaoria and few of these were successful. The geophysical work indicates where productive holes may be sited and, in the end, the delimiting, once and for all, of those parts of the Mesaoria under which good and abundant water is to be expected, will be achieved. Check-drilling on sites with favourable resistivities will remain necessary as, until now, it has not been possible to distinguish between fresh and salt waters. Unfortunately, there are areas underlain by very saline waters.

DEEP DRILLING IN THE MESAORIA.

31. The possibility of securing water for irrigation from deep boreholes in the Mesaoria has been intermittently under examination for the past sixty years, Russell first suggesting it in 1880. By deep drilling is meant boreholes penetrating at least three thousand feet. Three British geologists, Russell, Clement Reid and Romanes, have made specific investigations. Russell, presuming that the geological structure of the Mesaoria was a simple basin lying between the Troödos mountains and the Kyrenia hills, favoured the possibility of finding artesian water. With more detailed study, Reid and Romanes were inclined to disagree with him. Certain local opinion, basing argument on false analogy with the Australian deep artesian wells, is convinced that abundant, good water may be obtained at depths of three thousand feet or more.

32. In discussing this question, the possible aquifers and the origin and nature of the water therein have to be considered. The Trypa Limestone of the Kyrenia hills, the Kythrea beds and the Dhali beds are all exposed on the north side of the Mesaoria. From lithological desiderata alone the two last may largely be ruled out as all the strata are fine-grained sandstones, marls, and shales, and useless as aquifers. The limestone might be a good aquifer, if it underlies the area at a reasonable depth. This point may now be discussed and the conclusion depends on the view taken of the structure of the Kyrenia hills. They may be either a greatly compressed anticline or a thrust mass overriding the Kythrea beds. The solution of this question is of first importance in the discussion of the artesian water problem. There is a choice from three sets of possible conditions of which the two last may be considered more likely. The limestones may be a great mass carried over from the mainland along a great thrust plane. If that were so there can be no limestone underlying the Mesaoria and therefore no aquifer nor artesian water. Secondly, the limestones may be a compressed, overfolded anticline originally overlain by the Kythrea and Dhali beds. In this case, the limestone may be expected to underlie at least part of the Mesaoria and, subject to certain disabilities noted below, might function as an aquifer. Thirdly, the limestones may be regarded as a tightly folded anticline afterwards subjected to minor thrusting along its south face. In this case again the limestone might be expected to exist under the Mesaoria but it would be discontinuous with the main mass and water

from the mountains might be unable to percolate into it. Romanes, in an unpublished report to Cyprus Government, favoured the second case but opinion is about equally divided on the matter, Renz and Cowper Reed postulating a certain amount of thrusting.

33. If it is agreed that the limestone does underlie the Mesaoria, whence does it derive any water it may contain ? The water falling on the igneous complex of the Troödos range passes over the impermeable Dhali marls to the Pliocene and Pleistocene rocks and can give no recharge to deep-seated aquifers. This rules out the largest collecting area and leaves only the Kyrenia hills as a local alternative. The Kyrenia hills form a relatively small gathering ground for an artesian basin and only unimportant volumes of water would be available from them. Further, it will be appreciated that if deep-drilling were successful in tapping artesian water in the limestone underlying the Mesaoria, the first effect would be the lowering of the water level in the hills and the drying of the present springs. The question of the origin of the water of the Kyrenia hills has been argued above. However, whatever the origin of the water in the Kyrenia hills it is certain that if water were tapped in the Trypa Limestone beneath the Mesaoria, and allowed to flow, the present springs would be destroyed.

34. The quality of the water that might be found is also of interest. Would it be sweet or saline, suitable or unsuitable for irrigation ? Deep-seated waters are, in general, more mineralized than those of shallow origin and this principle applies in Cyprus. All deep boreholes already constructed have given salt water or been dry. While the occurrence of fresh water underlying saline water is not impossible, it is unlikely in Cyprus surrounded as it is by a very deep sea. Even medium-depth boreholes, 300–400 feet deep in the Mesaoria, have shown dissolved solids in excess of 350 parts per hundred thousand and shallow boreholes with highly saline water are unfortunately common enough. Irrigation with such water is impossible. Even if the limestone does form an aquifer, it is unlikely that enough fresh water has ever reached it to flush out the salt water from it.

35. It is doubtful also that should the limestone be found, it will be creviced or, if creviced, that a crevice will be penetrated by the drill. Crevices may be few at depth and indeed in limestone tend to occur mainly towards the top of the ground-water. This is due to the fact that they arise from solution of the limestone by water carrying atmospheric carbon dioxide. The limestone is changed to calcium bicarbonate and goes into solution. When all the carbon dioxide is used up in this way, solution ceases. Solution, therefore, is most active where new supplies of rain-water are percolating into the ground-water, that is, at the water-table, and this is where water-bearing cavities and crevices most abound. In addition, drilling into a limestone aquifer is largely hit or miss, a cavity or crevice must be penetrated or a dry hole results.

36. Summing up, it is possible that the limestone may underlie part of the Mesaoria but at what depth is unknown : it may not be water-bearing and, if it is, the water will be unsuitable for irrigation : any great draught of deep-seated water would affect disastrously the present springs of the Kyrenia hills whatever the origin of their water. The striking of deep artesian water in the Mesaoria might give the strange phenomenon of boreholes flowing salt or highly mineralized, while the sweet springs of the hills vanished. After consideration of all these factors, it is not possible to advocate deep-drilling in the Mesaoria. Of course, no great harm would be done by drilling one hole to depth, for the borehole could easily be closed, but no economic result would be achieved. The supply of water by rainfall to the Kyrenia hills is limited and the water can only be drawn off in one place.

RAINFALL AND THE RIVERS.

37. The rainfall of Cyprus occurs mainly in the winter from October to March though rain may fall in any month. Precipitation usually comes in heavy, local downpours passing from west to east in rainy squalls. Rain over the whole Island at one time is not common. The rainfall map attached shows three clearly defined zones running from west to east. The first of these includes the whole of the Mesaoria, the main cereal-growing area, with fifteen inches and under per annum. The second covers the Kyrenia hills and the foothills of the Troödos mountains. Here the annual fall is between fifteen and twenty-five inches. The third zone, the higher part of the Troödos range, has a rainfall of over twenty-five inches. The approximate areas covered by these zones are 1,100, 1,900 and 600 square miles. All zones are subject to considerable variation from year to year and from place to place. The Island suffers from periodic droughts which have a particularly disastrous effect in the Mesaoria which finds itself deprived both of rainfall and irrigation water. When a drought occurs rainfall deficiency is noted in each of the three rainfall zones. Rivers carry no water and springs decrease.

38. Rainfall is often of the convectional type which causes very heavy local downpours in spring and summer severely damaging vineyards and washing grain from the threshing-floors. After a period of hot, calm weather, the air close to the land surface becomes heated and laden with moisture while above is a layer of relatively cold, dry air producing an unstable combination. A rupture occurs and the warm wet air moves rapidly upward expanding and cooling. Precipitation then takes place and, owing to the small area involved, very heavy rainfall may ensue. When this process is carried to extreme, great masses of water suddenly descend producing the phenomenon known in Cyprus as a cloudburst.

39. In most winters, there is a considerable snowfall on the southern range, particularly to the west and water from the melting snow is important in spring in the rivers flowing north, west and south from that part of the range. The snowfall decreases in depth towards the east and its contribution of water to the eastern drainage is usually negligible.

40. The rivers of Cyprus, though marked boldly in blue on the maps, are not therefore to be regarded as perennial streams. True, in the mountains, their steep, boulder-strewn beds may show water all the year but once amongst the foothills, the narrow streambeds, still detritus-covered, are dry and arid almost all the year save where for a short distance the water of a spring may show. During winter, in the plains, after heavy rain, they convey a shallow, swift, brown torrent, meandering widely, but only able to possess a small part of the broad pebbly bed and bringing alluvium with all sorts of trash to the lower land. The rain once past, the water soon disappears leaving the bed bouldery and parched, so to continue for months. The longest river is the Pedias which rises in the Makhera hills and flows past Nicosia towards Famagusta Bay. The river channel is sufficiently impressive but owing to irrigation demands it seldom carries any water. Thus, in the winter of 1939–40 the water did not succeed in reaching the bridge at Nicosia until the third week in February and then

the flow lasted only three days. The Yalias, which also flows from near Makhera to Famagusta Bay, is likewise deficient in flow except in years of heavy rainfall. Any water in the lower reaches of these rivers is caught in the Kouklia reservoir, described below. Certain rivers, draining into Morphou Bay, the Serakhis, Ovgos and Vyzakia, at times after heavy rain have a thin stream wandering erratically in their broad beds. They are discussed further below. On the south coast, between Limassol and Paphos, there are a number of streams which have water constantly during winter and even, owing to faulty irrigation works, some summer flow. All the rivers in the west and south are floored, in their lower courses, by thick heavy gravels. The rivers flowing to the north into the Karamanian Sea are short, very steep and torrential. The steepness of the larger rivers should be appreciated. Thus, the Kouris debouching near Limassol, rises on Shionistra (Mt. Troödos), 6,400 feet above sea-level and reaches the sea twenty-two miles away. The Kariotis, rising on the north side of the same mountain, flows into Morphou Bay, seventeen miles distant. The Ezuza river, rising in the Paphos Forest at 4,600 feet, flows south to reach the sea only twenty-four miles distant. These heavy gradients have an important economic effect in respect of conservation of winter flow. This is discussed fully later.

41. Rivers, with certain exceptions, are owned by the State and the construction of waterworks in them is controlled by the Commissioner. Riparian dwellers enjoy the usual right to take water for domestic use and for watering stock, but the taking of water for irrigation is regulated by ancient customs, ill-defined and unformulated. Water is taken from the rivers by rough brush or gravel weirs and wing dams, sometimes by masonry weirs, and any attempt to improve these works is resisted by all villages lower down the river. This means that while in years of ordinary rainfall, intake works may be able to deal with the proportion of the riverflow to which a certain channel is entitled, yet in years of more than average flow, though the water could be used, the intakes are inadequate to get it into the channels. In addition to this, heavy silting with consequent raising of the level of the irrigated lands presents a constantly recurring problem for, if the intakes and channels cannot be altered, eventually water ceases to reach the higher lands. All this leads to continuous friction between villages which, particularly in the eastern Mesaoria, may flare up in direct action when irrigation works, which are alleged to have been illegally heightened, are thrown down. This happens in years when riverflow is regular with little heavy flooding and in years of low rainfall.

42. Certain rivers in the Paphos District are designated "private". These rivers and all their water are owned by certain persons and are not subject to the laws or customs that govern the other rivers. They form a link with the pre-British administration and were granted in the middle of the nineteenth century, with certain lands and the right to certain tithes, by the Sultan of Turkey. The right to take tithes was purchased by the Cyprus Government but the strange anomaly of these private rivers still remains, though it is receiving attention.

Loss of Water to the Sea.

43. There is a general opinion throughout the Island that very large quantities of water are lost to the sea by surface flow. Persons who have examined this matter in detail do not agree and, relatively to other countries similarly placed, it is doubtful if preventable losses are serious. Colonel Ellis' Report of March, 1922, contains the following (p. 6):—

> "My arrival was timed so as to give me an opportunity of estimating the summer as well as the winter flow of the streams and I have been much impressed by the extent to which all the water available for direct flow irrigation, as contrasted with reservoir irrigation, is being utilized. Except the water running off as a torrential flow of short duration, the only instances I have seen of maintained flow running to waste have been on the coast in Limassol and Paphos, in cases where the steep sides of the river gorges are continued close up to the sea and there is thus no extent of land suitable for irrigation. The irrigation works throughout the Island, although individually small, are very numerous, and the rights of all but flood waters are appropriated either by village communities or private estates—thus while minor improvements to existing works, such as staunching of leakage in channels, may result in minor extensions of area irrigable, the only considerable development of flow irrigation systems feasible must necessarily involve storage of flood waters, that is Reservoir Irrigation."

44. It must be realized that, for irrigation, land suitably placed, as well as water is required and that water flowing to sea in an area where no irrigable lands exist can hardly be regarded as wasted. The greatest loss of water to sea occurs in the west along the Tylliria and in the Akamas. In this area, a combination of heavy rainfall and highlands bordering the sea affords more water than can be used on the small alluvial flats along the rivers and the irrigable coastal fringes which form the only available land. A certain volume of water is still lost along the southern coast, particularly in Paphos and Larnaca Districts, but projected works, some now in hand, will save this. The loss of water from the eastern Mesaoria drainage to Famagusta Bay in a normal year is negligible and will become more negligible as time goes on. Draw-off by pumping in the upper reaches of the Pedias and Yialias is increasing year by year and because of this more water passes into the river gravels and is lost from the surface flow. Along the north coast, water may flow unused to the sea but it must not be forgotten that the mountains line the coast and the configuration of the area makes it generally unsuitable for irrigation.

45. There remains but one further drainage area to discuss, that of the western Mesaoria, and this is the one that mainly interests those who complain of unused water. Medlicott, at the end of last century, proposed the turning of certain of these rivers from the western into the eastern drainage and since then attention has been focussed on them. At that time, it seems likely that these rivers enjoyed greater winter flows than now, though the critics may not realize this. In the last forty years, reafforestation, terracing, new irrigation channels, draw-off by pumping and particularly by chains-of-wells have altered the whole régime of these rivers and there is not now the surplus water of former times. Flooding of a destructive character has practically ceased. With the further development of summer irrigation from pumping wells in the area fronting Morphou Bay, the volume of water lost to sea by surface flow from this drainage area will decrease and by improvement of intakes to irrigation channels will be further decreased.

46. It is certain that were the suggestion made to-day to put Medlicott's diversion scheme into operation, there would be a considerable outcry from the western Mesaoria and it is equally certain that the scheme as originally formulated would fail from lack of winter flood water. A correspondent of the newspaper " Eleftheria " writing on 18th January, 1940, and referring to this scheme, stated that " the rivers of Akaki and Peristerona* are flowing during the whole season of winter until late in spring ". Actually, on that day, the Merika and Akaki (Akacha) were completely dry and there was only a little water at Peristerona. At the bridge at Morphou, the Serakhis river, of which the Akaki and Peristerona with the Merika are tributaries, was absolutely dry. The loss to the sea of substantial volumes of usable water occurred perhaps until the last decade but has not been so serious since and year by year tends to become less serious.

WESTERN MESAORIA DIVERSION SCHEME.

47. References have been made to Medlicott's Diversion Project. It is now briefly described and an up-to-date estimate of cost given. The Project, as amended by Colonel Ellis, proposed the taking of all the flow in excess of 100 cusecs from the Akacha river, near Ayios Ioannis, and the delivery of the water by a tunnel into a tributary of the Merika. Near Ayii Trimithias this water, with the flow of the Merika, was to be directed by a weir into a canal leading to the headwaters of the Ovgos river. Finally, close to Yerolakkos the Ovgos would be stopped by an earth bank and the whole flow turned through a cut in the watershed into the eastern drainage, where it was to be impounded in a large reservoir, three miles east of Yerolakkos. This reservoir was designed to hold 443 million cubic feet and, allowing for evaporation and absorption during storage, was expected to irrigate 9,000 donums in the summer over a five and a half months season, giving a total watering of 2¾ feet. No subsidiary channels were included in the scheme nor was any reduction made for losses of water in distribution. The gross revised cost was £142,000. Nothing further was done regarding this scheme, because of the malarial menace, the high rates then being charged for money, which meant high annual charges for watering, and the general suspicion of conservation schemes. The possible effect of this scheme, as it has been described above, has been much exaggerated. It has been suggested that it would solve the whole water problem of the eastern Mesaoria, but no late suggestion can be traced that the water of the reservoir would be used anywhere except below the reservoir, near Nicosia, and only about four and a half square miles could be irrigated.

48. It would seem a more possible scheme to let the water from the diversion run directly into the Pedias system without the use of a reservoir and for the water to be used for winter and spring irrigation by Irrigation Divisions drawing from the Pedias. In this connection, it will be recalled that owing to heavy and increasing draw-off on its upper reaches, the Pedias carries less water than in former times. The diversion water would help to replace this water and would enter the Pedias river system below this area of heavy draught. However, the possible volume to be transferred to the eastern drainage must be re-examined. Colonel Ellis proposed to allow 100 cusecs for prior rights in the Akacha. He also counted on certain volumes from the Yerolakkos reservoir by direct fall into it and from the Ovgos river. The suggestion is that there should be no reservoir and the Ovgos river cannot be relied on to yield anything. The Merika too is a poor river : its headstreams appear far down the mountains and it carries little water. The whole drainage area contributing to the diversion cannot be taken as more than forty square miles of steep but well-forested mountain country. The average rainfall for the past thirty-one years, taken at Paleokhorio, is 24.6 inches, including only the winter months October to March. Bearing in mind that the first hundred cusecs are to be left to satisfy existing rights, it is unlikely that, in an average year, more than a total of three inches run-off can be diverted. This is equivalent to 7.68 million tons (273 million cubic feet) and, allowing 200 tons per donum, *i.e.*, 6 inches for a single cereal watering, 38,400 donums could be irrigated. In the thirty-one years rainfall period, nine years were short and two of these were very deficient. This area is about two-thirds the total area administered by Irrigation Divisions in Famagusta District. During years of good rains additional land could be irrigated and in poorer years there would be some security of winter irrigation. It would appear, too, that following this reinforcement of the eastern drainage, the Kouklia reservoir would more often be full in spring. The reservoir could then be reorganized as suggested below or another attempt might be made to control the mosquitoes and to retain the water for summer use. The reservoir when full would give a spring watering to 20,000 donums or summer irrigation to 5,000 donums.

49. The net cost of the Project including the Yerolakkos reservoir is estimated at £135,000. The net cost of the scheme without the reservoir, merely delivering the water into the Pedias drainage, is estimated at £77,000. The abandonment of the idea of the reservoir also cuts the annual cost for staff and maintenance to about £800 per annum from £1,600. The scheme is like all those in Cyprus relying on surface flow : its success must depend on the vagaries of rainfall. Thus, in the present winter, despite a rainfall of average volume, it seems unlikely owing to the even distribution of the fall, that any considerable volume would have been passed through the works.

INFILTRATION GALLERIES AND SUBSURFACE DAMS.

50. While the criticisms of lay observers have been directed to the loss of surface water from rivers to the sea, little account has been taken of the subsurface leakage through the gravels of the rivers, which continues throughout the whole year in many cases. Those particularly affected are the large streams from the Serakhis, near Morphou, right round the west and south coasts by Paphos to the Vasilopotamos, a few miles west of Larnaca. Many of these rivers show a surface flow late into the spring which is utilized for irrigation but little attempt has so far been made to intercept the hidden flow in the gravels.

51. The method of recovering this water depends on the geology of the river valley. The valleys may be excised in igneous or in sedimentary rocks. In igneous rocks, which form an impervious bottom to the gravels flooring the bed, the subsurface dam will operate to force this water to the surface. The subsurface dam is an impervious septum constructed across the pervious gravels and keyed to the impervious rocks at sides and bottom. It is relatively cheap to construct as it is supported and protected by the gravels. It is not vulnerable to heavy flooding nor to alluviation. Its water is not

* The rivers involved are the Merika and Akacha : the Peristerona is not concerned.

subject to evaporation nor does it give rise to malarial problems. In the sediments, the use of the subsurface dam in likely to be unsuccessful owing to the absence of a definite impervious rock or stratum into which to key the structure so that leakage under the dam would occur. It is thought that long infiltration galleries penetrating deeply into the gravels would drain this water and bring it to the surface but in certain of the rivers with narrow steep valleys the work will be difficult and wet.

52. The rivers from Morphou along the bay towards Xeros have their lower reaches in sediments and those that are not already tapped by infiltration galleries may be dealt with in this way, where there is a sufficient depth of gravel. Similarly with the Khrysokhou, Ezuza, Xeros, Dhiarrizos and Kha, the other big streams flowing south. The subsurface dam may be used in the Marathasa, near Lefka, in the Limnitis and other sufficiently large streams in the Tylliria. That this method of water salvage is practicable has already been proved by the subsurface dam constructed in the Pyrgos valley about five miles upstream from the sea. This was completed late in 1939 and will afford, in 1940, valuable data regarding the actual volume of water to be made available by these works. Until these data, which will give a relation between rainfall, drainage area, and subsurface percolation through the gravels, are examined, it is not possible to give a close estimate of the volume such subsurface dams and infiltration galleries will provide, but it will be important.

IMPOUNDING OF WATER.

53. The only works constructed in Cyprus for impounding water on a large scale were designed and executed about forty years ago by Mr. J. A. Medlicott. These works, the eastern Mesaoria reservoirs, were intended to form part of a much larger scheme to cost about £400,000. As, however, regarding the first part of the scheme, the somewhat sanguine expectations of the engineer were not realized, nothing further was done. Many reasons are given for the failure of the eastern Mesaoria reservoirs to do what was expected of them, but the main reason is the unreliability of Cyprus rainfall. No firm scheme for waterings could be laid down in advance. In one year, the reservoirs would be full, in the next almost empty. Farmers preferred to do what they could with cereals in the winter rather than risk waiting to put in a summer crop for which there might be no water. Had it been certain that the reservoirs would be full for use each summer, little difficulty would have been experienced in making the project a success and in inducing the farmers to grow summer crops. In addition to the uncertainty of the rainfall, the malaria menace has crippled the scheme and so far no economic method has been evolved for dealing with the mosquitoes in and about the works despite continued efforts by the medical authorities backed by experts of the Rockefeller Foundation.

54. In 1921, Colonel Ellis reported on the possibilities of impounding water in Cyprus. Ellis' Report, paragraph 17, gave a succinct account of the position regarding impoundment:—

> " The quantity of water required for irrigation is so great that reservoir irrigation, even where favourable sites exist, is a very expensive system and it is but seldom that an irrigation reservoir can be constructed as a remunerative public work unless on a very large scale; for the smaller the reservoir the greater proportionately is the cost. The general fall and contour of the country in Cyprus, except in some places in the eastern Mesaoria, is not favourable for the construction of reservoirs, the cubic content of the dams necessary being great proportionately to the capacity for impounding obtainable. This connotes expensive storage while the torrential character of the run-off entails the carriage of a high percentage of solid matter in suspension, which is a factor rapidly reducing by silt deposit the effective capacity of reservoirs."

His conclusions regarding impounding are summarized thus (*loc. cit.*, page 9, paragraph 25B) :—

> " . . . . . that generally the configuration of the country is unfavourable to the construction of cheap reservoirs and in most cases the cost of construction of reservoirs for irrigation would be out of all proportion to the revenue leviable for the use of the water."

55. With regard to impounding water in the hills, it will be appreciated that works must be constructed at high altitudes in narrow valleys, and on steep slopes. Some idea of the steepness of slopes has been given above in the discussion of the river system. Where the thalweg begins to flatten, alluviation has taken place and the fertile flats and terraced valley sides bear orchard trees and vegetable crops of great value so that dams cannot be constructed at such points even if suitable sites could be found. Around and on these flats are built the village homes of the orchard-keepers and nurserymen. Dams on these steep slopes will have to be very high to store any reasonable quantity of water and would require deep foundations to ensure stability. Further, in view of the terrific destruction any failure would cause both to life and property, an extra factor of safety would be necessary.

56. Dams in the hills may consist of single major structures or of a series of smaller step dams. Examples of possible sites have been chosen in the Solea and Yermasoyia valleys and costs and volume that would be retained have been estimated. For the step dams, gravity type structures of masonry, forty feet high above the streambed are postulated. The depth of alluvium to bedrock is twenty feet and the length at the sill four hundred feet. The average cost of masonry would be one pound per cubic yard. The dam therefore would cost £25,000 without allowance for spillway, controls, take-off, counter-alluviation works, or for any channelling. The slope of the streambed is one in fifty and of the valley sides one in one so that four million cubic feet would be impounded, capable of giving a full summer watering to no more than thirty-seven acres which is futile. This is by no means a particularly unfavourable site, but representative of these hill gorges. A site selected for a single large barrier across the Yermasoyia valley has been examined in more detail and the estimates of cost and volume retained, with a description of the works, are given in the appendix.

57. Impounding schemes in the hills must suffer from the capriciousness of the rainfall as reservoirs on the plains though in a much less degree. Thus, the water available for storage would be the run-off that is left after percolation, evaporation and transpiration by vegetation which would be approximately an annual constant. The amount available for storage would not therefore be in proportion to the annual rainfall and in years of diminished rainfall would be small indeed. It will be remembered that there are existing rights to the clear water flow of all rivers and that little of this water, except in a few rivers in Paphos District (due to difficulties of ownership), is lost; most of it is used for valuable early crops and orchards and not for cereals. The only water available for storage

is that from flooding. When heavy downpours do occur, the resulting flash flood brings down great masses of coarse alluvium and considerable quantities of trash. Checking of flow would cause blocking of the dam and consequent decrease in effective volume. That this movement of material really occurs is demonstrated by the débris encumbering any hill-road after a rain storm and by the fact that the coarse gravel in the riverbeds and beaches is largely composed of igneous material from the Troödos mountains. Where streams are not too wide, the movement of heavy alluvium can be considerably retarded by the construction of dry stone dykes across the riverbed so that, eventually, the river descends over a series of flats and falls with its velocity much reduced. The control of fine alluvium coming from eroding farmlands is more difficult and to remove it would require the use of dirt-moving machinery and also the existence in the neighbourhood below the dam, of an area on which to dump the spoil. All this is fairly simple from an engineering aspect, but it raises the price of the water considerably. If water be impounded in dams on igneous rock and recharge of aquifers by winter flood-water be prevented, then there will be no surety that supplies from wells will be maintained in quantity. If dams were constructed on the headwaters of the eastern Mesaoria drainage, the effect would eventually be felt by all the multitudinous summer irrigators from the hills to the sea. The use of ground-water ensures that there is a balance between years of good and deficient rainfall, a cushioning of the effects of drought such as cannot be achieved by impounding. It is a fact that rainfall is the source of all water in Cyprus, and that it cannot be used twice. If it is impounded in dams on igneous rock or on Kythrea or Dhali beds, it cannot be available for subsurface recharge. It is unlikely that any one will suggest further dams in the eastern Mesaoria drainage, but it must be recognized that dams in the western Mesaoria will prejudice to some extent the many wells and chains-of-wells already constructed and will hinder the development by irrigation of the area round Morphou Bay. It is felt, too, that in order to reduce the cost of channels and loss through theft, percolation and evaporation, water that might be stored in such projects would be used as close as possible to the projects themselves so that persons far removed, now enjoying some benefit from the flood-water of the rivers, either on the surface or through subsurface recharge, would get nothing.

58. To summarize this question of impounding, the following are the main necessities for an impoundment scheme :—

(*a*) A water-tight reservoir bed.
(*b*) Sufficient water impounded to irrigate a reasonable area.
(*c*) A site that will enable a small dam to impound a large volume.
(*d*) A reasonable gradient on the river bringing the water so that alluviation is not too severe.
(*e*) Depth of impounded water high in proportion to area of reservoir to reduce evaporation losses and area over which counter-alluviation measures are required.
(*f*) A sufficiently large area of good land suitably disposed for irrigation and not too far from the dam.
(*g*) Control of mosquitoes at a reasonable cost.

Dams may be constructed in the Troödos Mountains, either high in the gorges or lower in the foothills, in the Kyrenia hills, or on the eastern and western Mesaoria. Those in mountain gorges are impracticable because they would be very costly and hold little water. Considerable expense would be involved in keeping big detritus away from them. The first two drawbacks are to be observed in foothill sites, but there are in addition, as sites are located below farmlands, increasing difficulties with silt. Difficulties arise with conditions (*b*), (*c*) and (*e*). The Kyrenia hills are unsuited in practically every respect and need not be further considered. Conservation has been tried in the eastern Mesaoria and the results are described in detail below. In the western Mesaoria, the supply of water would be more certain but the slopes are twice as great as in the eastern Mesaoria so that similar works would hold half as much water and be silted twice as rapidly.

The Reservoirs.

59. The present state of the reservoirs is a melancholy one. Of the works originally planned, only three ever came into serious operation. For various reasons—legal, lack of success with the first works completed and lack of water—the greater part of the plan, which included a series of reservoirs from Yerolakkos near the watershed west of Nicosia, to the sea at Famagusta, was abandoned. The three works completed were the Akhyritou, Kouklia and Syngrasi reservoirs.

60. The Akhyritou reservoir is the largest of the works and covered an area of nearly two thousand acres. The catchment was 61 square miles and the capacity of the reservoir eight hundred million cubic feet. This presupposes a fifty per cent. run-off from the catchment, which is far from possible. However, in any case, there was no demand for water and only about 600 donums near Engomi was irrigated. Gradually, more and more of the reservoir bed came under cultivation and so, gradually, to save the crops in the years water did collect, the level of the spillway was reduced until in 1938 it was cut to bed level at the request of the cultivators and any attempt at storage ceased.

61. The Kouklia reservoir was an equally ambitious work designed to hold nearly four hundred million cubic feet and commanding ten thousand acres. The actual annual average storage has been 83.2 million cubic feet and in certain years, this year for instance, no water reaches the reservoir. This average volume could irrigate 1,500–1,700 acres of cotton (the land below the reservoir is very absorbent) but due to the possibility of malaria, the water cannot be kept for summer waterings and must be out of the reservoir by the 15th April. Also the great annual variation in volume is an unfavourable point and prevents effective crop planning by farmers. The reservoir is shallow and unprotected so that in summer considerable losses would occur from evaporation. It is known that, when water is stored for summer use, it tends to become somewhat saline but remains sufficiently fresh for watering cotton. Rotting vegetation in the bed makes the water evil-smelling and discoloured but from an irrigation standpoint that is unimportant. The position with regard to spring cereal waterings is paradoxical. When there is adequate water in the reservoir there has been adequate rainfall and farmers, although they know that a watering would be beneficial, will not use the water. Indeed, the tendency is to irrigate only when the drying-out of the whole crop is imminent. When water is required in seasons of deficient rainfall, the reservoir is empty or the water level in it too low to reach the higher irrigable lands. Irrigation fees have been reduced to 2*s*. 4½*p*. for wheat and

1*s*. 4½*p*. for barley per donum but there is no response. Before the custom of irrigation payments in kind collected on the threshing-floor, was discontinued, there was a bigger demand for waterings, but now that cash has to be paid, even if credit until crops have been sold is given, the demand has lessened. The average area irrigated when water was paid in kind was 3,878 donums : since cash payments were instituted it is 2,201 donums. Hitherto, the water that has remained unused has been discharged tamely to the sea, but under present conditions this cannot be allowed and it is unlikely to recur. Inquiries are being made as to the possibility of making regulations for this reservoir under the Government Waterworks Law, 1928, or of bringing it under the Irrigation Divisions (Villages) Law, 1938.

62. Syngrasi reservoir is a smaller work with a bed of 200 acres and was designed to retain seventy million cubic feet. The site chosen was close to the Kyrenia hills and near the junction of the Dhali and Kythrea beds. The rivers supplying the reservoir, short hill torrents of high grade flowing over easily eroded strata, brought down great loads of silt and alluviation was intense. The capacity of the reservoir rapidly decreased but, although holding little water, it acted as a great silt trap so that the farmers below the bank complained constantly of the loss of fertility in their lands. The present régime of this reservoir is that water be passed freely through it until the 31st January, after which the sluices are closed, but there is generally little water and the reservoir presents the appearance of a well-cultivated alluvial flat. There is considerable competition to secure leases of the reservoir bed for summer cultivation. A stage has now been reached when it is futile to regard Syngrasi as an irrigation work : it must be treated as 200 acres of desirable agricultural land and suitable measures should be taken to protect it from erosion. These measures will consist mainly of a spillway at the level of the present bed.

CHAINS-OF-WELLS.

63. The " chain-of-wells " is a sort of infiltration gallery extended by a conduit at a less inclination than the land surface above it, which thus eventually allows the water to flow forth at the surface. The wells are actually shafts to give ventilation and easy disposal of spoil during construction. They are situated about 40–60 feet apart and the water is tapped by the gallery joining these shafts. The lower parts of such chains are usually unproductive and are mere conduits. These chains-of-wells have certain advantages. They are relatively cheap and within the power of the villagers to construct and maintain. By the fact that they penetrate a considerable distance into the aquifer, large volumes of water are salvaged from fine-grained, slow-yielding rocks that would give no result from a single well or borehole. In fact, though it has been the habit to disparage such works because, owing to lack of control, large volumes of water are lost in winter, they make available water that could not be recovered economically in any other way. The question of control is a difficult one and would probably entail the lining of a considerable length of each conduit with concrete which would be much too costly. Unfortunately, the chains have in many cases been dug too closely together, with the result that the available water is divided between a number of them and there is considerable loss and waste. In the past, while it has been difficult to secure the interest of the people in schemes sponsored by Government, they have been ready to subscribe large sums for digging chains-of-wells, usually along lines indicated by water diviners. Certain of these efforts have proved failures and when the cause has been investigated, it has been found that levels have been wrong or that the area chosen was not water-bearing and no prospecting holes had been dug to test it. Closer supervision of these matters is now exercised and steps have been taken to protect chains already constructed.

64. Chains-of-wells are most common in the western Mesaoria and some reach considerable length. That of Morphou, constructed by Government for the domestic supply of the town, is about 2¼ miles long with 234 shafts, and yields half a million gallons per day. Another famous chain is the Arab Ahmet which supplies a large part of Nicosia with domestic water. It is over 2½ miles long. Equally well known is the Bekir Pasha chain, yielding a minimum of a million gallons per day to supply Larnaca Municipality. It is about two miles long. In the eastern Mesaoria, owing to the more gentle slope of the surface, chains are less common. There is an old one with a very regular flow at Kouklia, providing about 6,000 gallons per hour for irrigation.

65. There is a tendency to consider these chains as unsuitable as sources of domestic water supply, but when the shafts are properly covered and protected and there is a regular patrol maintained along their length, consistently good bacteriological analyses may be obtained. It is not denied, however, that during periods of very heavy rain they may be susceptible to contamination. Nevertheless, in a land where all water is required, they supply large volumes that could not be made available in any other economical way. However, in the future it is unlikely that there will be any further considerable construction of chains-of-wells. Most of the good sites have been exploited and legal difficulties regarding entry on private land, except on payment of heavy compensation, also tend to prevent new undertakings of this kind.

IRRIGATION.

66. The problem of utilizing the water of the winter flowing rivers of Cyprus has claimed attention for hundreds of years. Wherever surface water exists and land is available, attempts have been made at sometime or other to utilize it for irrigation. Throughout the Island are to be found the remains of structures, long since fallen into disrepair and disuse, which have at one time or other been constructed to control the waters of the rivers. The types of structures vary from crude brushwood, earth and stone barriers thrown across the bed of the stream, to well designed and constructed control weirs of dressed masonry complete with screw operated sluice gates, flood water controls and training walls. The corresponding irrigation channels, the lines of which can still be traced, in places seem to wander aimlessly without any definite plan or scheme to use the water to advantage. In others a detailed system of open channel irrigation has been carefully laid out, with parallel distributaries leading from main channels each with individual control. Many of these old irrigation systems are still in operation either partially or in whole.

67. At first sight it seems strange that so few of the irrigation schemes and projects in the Island should be successful and trouble free, but there are many diverse reasons which make the smooth working of any system of irrigation difficult. Natural causes for their breakdown are the high fall of the ground and riverbeds with the consequent rapid run-off, which means that the water carries

with it a heavy proportion of solid matter, both in suspension and rolling along the bed of the rivers. Any obstruction or barrier in a streambed means an immediate reduction in velocity and the stream drops its material. This is why all weirs become silted and useless in a very short time. The same argument holds for irrigation channels and take-off works where no barrier is erected to impede the flow. The channels are naturally cut with a gentle slope so reducing the velocity of the water causing it to drop its load of suspended material. Underscouring and end-scouring of weirs occur owing to the fact that works have usually to be constructed in soft friable alluvium. To insure against scour would mean very deep foundations and long extended wing walls, the cost of such works being out of proportion to the increased value of land irrigated. Apart from these physical difficulties, there is the difficulty with estimates of cost and financing. Every estimate, prepared for an irrigation scheme is met by the objection that it is too high, that it could be done for much less. And so the estimate is pared down, essential details are omitted and the scheme fails. There are cases, where works have been constructed, that never functioned, for the channels to use the water were never dug. Finally, these schemes fail for want of regular maintenance. Silting of channels is allowed to go on year after year until at last they are useless and it is difficult to find capital to re-dig them. The bane of all irrigation works in Cyprus is silt, alluvium, waterborne detritus. The slopes are too steep and the rivers carry too much material. The silt acts adversely in two ways : by burying the works and by raising the ground-level.

68. A description is given below of the state of certain schemes, some private, some sponsored by Government, all executed prior to 1937. This is followed by a description of schemes that have been prepared since that date.

Schemes executed prior to 1937.

69. A large privately-owned chiftlik at Akhelia in Paphos District which has an irrigable area of 1,700 acres draws its irrigation water from the Ezuza river of which it has the whole water rights. The water is drawn from the surface flow only of the river by channels about a mile upstream from the chiftlik boundary. There are no works of any description in the river to control the flow or to ensure that no water flows to waste. The gravels in the bed are cleared at the mouth of the channels to swing the water. The main take-off channels are cut in earth and unlined and badly silted and meandering. Where they exist, the distributaries are mere scratches in the surface of the land. The formation and quality of the land makes it particularly suitable for planned and systematic irrigation but absent landlords and consequent lack of interest in the development of the area has meant that the existing channels are neglected so that at the present time only about 200 acres are consistently irrigated.

70. The same may be said of the large privately-owned chiftlik of Kouklia, Paphos, which consists of two large blocks of land on the right and left banks of the Dhiarrizos river from which it draws its irrigation water. The Dhiarrizos river has a mountain catchment of 95 square miles and the whole water-rights are owned by the owners of the chiftlik. About 600 acres are irrigated of which 135 acres lie within the chiftlik whose irrigable area is 965 acres. Nothing has been done to improve or extend the irrigation of these two areas since the original system was laid down which must have been well over 60 years ago.

71. A good example of a planned and detailed open channel irrigation scheme, which is still in operation after many years, is the Idalias river scheme, which irrigates lands belonging to five villages in the central Mesaoria, namely, Aphania, Asha, Strongylos, Mousoulita and Vatili. A large earth channel takes water from the Idalias river and the system of irrigation channels, main and distributary, extends for miles downstream. The system is laid out in rectangular blocks and earth dykes are thrown up to keep the water within specified bounds. These dykes are fitted with spillways and sluice gates to control any excessive storm water and to allow the irrigation water to pass back to the river if the rains are sufficient for watering purposes. There are no control works in the river at the head of the main take-off channel but this is unnecessary as far as the efficient working of the system is concerned. Heavy silting takes place each time the river is in spate as can be seen by the large banks of soil which have been thrown up parallel with all the irrigation channels from cleanings and also by the considerable difference in level between the upstream and downstream of the training dykes, but the efforts of the people to keep their channels, both main and distributary, clear, has meant that the scheme, other than the impounding, has been kept in efficient working for all the years since its inception.

72. In the Skylloura river innumerable remains of works are to be found, many of which are no more than memories to the oldest inhabitants. Others have been constructed since the British Occupation but all are now in extreme disrepair and no use is made of them. Between 1½ and 2 miles upstream from the village a series of low step weirs have at one time been constructed. The idea was and still is excellent. Each small weir was intended to divert only a portion of the water flowing in the river to irrigate the valley land between it and the next weir downstream. The maintenance of these structures would be practically negligible but every one of them is now a ruin. The masonry is weathered and scoured, the wing walls are crumbled and fallen and the toes and aprons of the weirs are practically non-existent. No take-off or irrigation channels are to be found in use. Immediately upstream of the village the remains of a beautifully designed weir of shaped masonry still stands. The structure is practically untouched by wear and time but the river has scoured out an entirely new channel for itself around one end of the weir. No efforts seem to have been made to extend the wing walls to prevent this end-scour. The reason may be that it was seen after the first run of the river that the site chosen was entirely unsuitable for any type of control works. At that spot, any barrier which was high enough to raise the water to the land to be irrigated would of necessity drown much good cultivated land above the weir. If this land were not to be flooded, the height of the barrier would have to be restricted, which would mean that an infinitesimal quantity of water would be diverted for irrigation purposes.

73. Spanning the Trimithias river near the village of Sophtadhes, Larnaca District, there exists a large well constructed weir 350 feet long and 15 feet high, of shaped block masonry together with the remains of flood control gates. Indications of a carefully designed system of open channel irrigation covering a large area are to be found, but these have been so neglected that only the larger main channels

remain in existence. The weir itself is in good condition but the upstream reach of the river and the head of the main take-off channel are silted to a level above the sill of the weir. The débris so collected is coarse gravel which on examination showed about 25% igneous material although the nearest igneous rocks are five miles away and for 2–2½ miles the river flows through a flat featureless plain which has a fall so slight that it cannot be detected by eye.

74. Near Klavdhia, there are certain irrigation works which were originally constructed, as far as can be ascertained, early in the period of the Ottoman Occupation. The works originally consisted of a tunnel which took the water from the river and conveyed it through the hill to the head of the lands to be irrigated. It had fallen into disuse and been lost with no record long before living memory. This old tunnel was discovered about ten years ago and a scheme was proposed to utilize it again for its apparent purpose. A masonry weir was constructed with a sluice gate to control the flow into the head works leading to the tunnel. Great expectations were held about the efficiency of the project, but these were doomed from the beginning. The tunnel has an extremely tortuous course and also varies in cross section. These, combined with the quick drop in velocity of the water passing from the river to the tunnel, which has a slope of considerably less than the riverbed, gave rise to rapid and complete silting of the upper lengths of the tunnel. The backing of the water due to the stopping of the flow through the tunnel set up back scour and the river cut a passage for itself around the end of the weir. This was repaired but the following winter saw a recurrence of the trouble.

75. A modern irrigation scheme which has been a source of worry and trouble ever since its inception is that of the pipe-borne water which is taken from the Kafizes river to irrigate the orange groves of Lefka. Water is drawn from the gravels of the river by means of a perforated breeches pipe. It is then conveyed through victaulic-jointed, eight-inch steel pipe for over 6 miles to an irrigation tank which commands the irrigable area. So far so good, but this was an expensive scheme and failed because no provision was made for lining the main channels : the losses between the tank and the field are extremely heavy and probably average fifty per cent. The fall in citrus prices discourages for the present any further expenditure on this scheme.

Irrigation Policy and Schemes Proposed.

76. The general policy being followed regarding irrigation is to put all existing irrigation works into a good state of repair so that they may function efficiently ; to salvage by subsurface dams and infiltration galleries, particularly for summer use, the water now being lost from river gravels ; to develop, by pumping from boreholes or wells, subsurface water where prospecting by drilling or geophysical methods has indicated its presence ; to improve intakes and channels to ensure further use of winter water ; to continue prospecting for new sources and to prepare new schemes.

77. The war policy aims at completion of gravity schemes which require little maintenance and no imported equipment, as against pumping schemes which require imported equipment and fuel and lubricating oils. In addition, the great rise, nearly 100%, in price of fuel oil has made these schemes less attractive.

78. Regarding the financing of these projects, Government has been generous. Before the war, approved schemes were receiving a free gift of half the capital cost and a loan from Government of the other half. As a war measure, to enable schemes to be completed without delay, the whole cost of what may be described as permanent parts of schemes, has been provided. Expenditure, however, has been restricted.

79. The schemes proposed are now described :—

Idalias (*Famagusta*).—This scheme, now in operation, serves the lands of Aphania, Asha, Strongylos, Mousoulita and Vatili. It is well designed and maintained but requires certain additional minor works, particularly for controlling flow. These will be completed in 1941.

Aradhippou and Livadhia (*Larnaca*).—Proposals have been made for a series of weirs to divert water from the Aradhippou river to irrigate cereals and orchards in the village areas of Aradhippou and Livadhia. Certain works were completed in 1939. Total area 2,000 donums.

Palekythro (*Nicosia*).—Heavy silting of works constructed about forty years ago has involved heightening of the weir taking water from the Pedias river, a measure which has aroused resentment in the villages lower down the river. New works to divide the water equitably are proposed.

Menoyia (*Larnaca*).—This scheme, which will be completed in 1940, consists of a weir raising the waters of the Gromithia-tou-Shaka river into a channel to irrigate a thousand donums of cereals and olive trees.

Mersiniki (*Famagusta*).—This scheme, which was completed early in 1940, transfers water by a long masonry channel from the Karamanian Sea drainage into that of the eastern Mesaoria. The water is used about Lefkoniko, mainly for cereal irrigation augmenting supplies from the Yerokolymbos river.

Maroni (*Larnaca*).—In 1939, two irrigation weirs and controls were completed at Vasilika and Asvestado but these are not in full use owing to the necessity for a complete reconstruction of the irrigation channels and the digging of certain new ones totalling in all eight miles. This matter is under discussion. Area 2,100 donums.

Kiti (*Larnaca*).—Certain small works were completed at Stephanaki in 1939. Certain further works are still required but are awaiting a decision on the proposals for Sophtadhes. Area 800 donums.

Sophtadhes (*Larnaca*).—Investigations are in hand regarding a weir on the river. Former works have failed through severe alluviation and considerable care has to be taken in designing new works.

Ayios Theodhoros (*Larnaca*).—This consists of a weir and channels taking water from the Pendaskinos river and commanding eleven hundred donums. Although there have once been irrigation works here, they are in total disrepair and the location of the old channels is not apparent.

Kalavasos (*Larnaca*).—Considerable water is available in the Vasilopotamos river in winter and spring easily adequate to water three thousand donums. The construction of a weir and channels has been proposed but the matter is held up pending analyses of the water into which mine water is discharged. The winter analyses do not show any contamination and it is considered unlikely that the volume of mine water discharged will have an appreciable effect.

Psematismenos (*Larnaca*).—This scheme calls for the construction of a weir and channelling on the Maroni river for spring irrigation of cereals and orchards. Area 400 donums.

Kivisil (*Larnaca*).—To provide winter irrigation for 2,500 donums of cereals, a weir, one hundred feet long, is required across the Pouzi river, directing water into a main channel, five feet by three feet, and over four thousand feet long. From this channel the water will be conveyed in earth distributaries. It is expected that this work will be put in hand in 1940.

Klavdhia and Alethriko (*Larnaca*).—There are badly designed existing works which include an old tunnel, perhaps of pre-Turkish times, which was discovered and put into use some years ago. The tunnel wanders in a zigzag fashion underground and the rapid changes of direction cause silting so that the tunnel is useless. To get the water round the hill would require a masonry channel. It is doubtful if this scheme is economic.

Khirokitia (*Larnaca*).—An existing channel system, much silted, takes water from the Ayios Minas river by means of a temporary dyke of gravel. No permanent weir nor headworks exist. Immediately after the take-off the stream enters a gorge which is crossed by the channel on a masonry aqueduct. A masonry weir is proposed in the gorge downstream of the present take-off and to construct new channelling. This work will be undertaken in 1940 or 1941. Area 2,500 donums.

Yermasoyia (*Limassol*).—The proposal for a dam on the river is dealt with fully in the appendix. It seems probable that this scheme is too uneconomic to be acceptable. In that case, the scheme may be restricted to the construction of a subsurface dam and the conveying of the water by lined channelling. This is a good river and even at the end of summer an important volume of water, say, half a million gallons a day will become available. Area about 1,000 donums.

Pyrgos (*Nicosia*).—About five miles upstream from the sea, a subsurface dam has been constructed in the bed of the Pyrgos river forcing the subsurface flow to the surface whence it is conducted down the valley in pipes. One line of locally-made concrete pipes will be completed early this summer but as no bigger size than six-inch concrete pipes could be safely laid in this rough type of country, it is thought that a further line on the left bank will be necessary. If so, imported pipes will have to be used, as experience has shown that the concrete pipes are not quite suitable for this terrain. Very considerable volumes of water are obtainable in spring and early summer, but these may be taken in the open irrigation channels. Piping is required for the water in mid and late summer. Area 900 donums.

Limnitis (*Tylliria*).—This scheme is similar to that of the neighbouring valley, the Pyrgos. It will tap the underground flow of the gravels in the riverbed and force it to the surface whence it will be conveyed down the valley by a pipe line. Area about 900 donums.

Marathasa (*Lefka*).—This scheme aims at the improvement of the intake works of the Marathasa supply for the Lefka citrus gardens. At present during spring and summer, much of the surface water in the river escapes from the rough weir which should direct it into the channel. This will be achieved by a subsurface dam which will also make available the water flowing in the gravels flooring the river.

Polis (*Khrysokhou*).—The Khrysokhou river carries considerable volumes of water in winter and spring, much of which runs to waste owing to poor intake works and lack of channels. With regard to winter and spring water, new intakes and channels are being considered. It is known that there is abundant water at all seasons in the great gravel beds through which this river wanders but it is not yet certain what is the best method of salvaging the water. It is so near the sea that an infiltration gallery may be impracticable and it will be necessary to pump the water into a pipe-line or a lined channel.

Gastria (*Famagusta*).—Considerable water that could be used goes to waste from the Gastria river. A weir and a channel are proposed which will divert all the water. Area 500 donums.

Ezuza River (*Paphos*).—Large volumes of water run to waste from this river in winter and spring owing to inefficient intake works and channelling. It is proposed to improve the Great Channel which runs towards Yeroskipos and the Mill Channel which flows westwards, and to extend them. Much land is available for irrigation.

Dhiarrizos River (*Paphos District*).—As with the Ezuza, there is great loss of water in winter and spring and action will be taken to improve intakes and channels. Land is available.

Kha River (*Paphos*).—Investigations are in hand to ascertain if it is possible to divert water in summer from the gravels of this river into the Dhiarrizos valley where land is available for watering.

Ayios Nikolaos (*Paphos*).—The proposal is to take the water of the stream, a tributary of the Dhiarrizos, near Ayios Nikolaos and lead it by a channel to the lands below Philousa and Pretori. Water is available throughout the summer. Area about 300 donums.

Akhelia Chiftlik (*Paphos*).—The Ezuza river, the property of the chiftlik, has abundant water in winter and spring and it is proposed to improve the intake works and channels that serve the area within the chiftlik. With regard to summer water, a long infiltration gallery, delivering to a masonry-lined channel, and drawing from the subsurface supply in the gravels will augment the present meagre summer flow. Area 5,000 donums.

Kouklia Chiftlik (*Paphos*).—Similar works are proposed as for Akhelia chiftlik. The river concerned is the Dhiarrizos which carries abundant water in winter and spring and is capable of having the summer supply considerably augmented. Area 2,800 donums.

Xeros River (*Paphos*).—Investigation by drilling in this river has shown that as in the two cases described above, there is subsurface water available for summer use. It has not yet been decided what means are best suited to the recovery of this water.

Skylloura (*Nicosia*).—As described earlier, many efforts have been made to use the flow of the Skylloura river for irrigation. Works have been badly sited and ill-designed and have failed. The present proposals are for the reconstruction of one of the old weirs and the digging of a thousand yards of difficult channel. This will serve in excess of a thousand donums. The work will be executed in 1940.

Styllos, Limnia, Ayios Seryios (*Famagusta*).—Due to lack of maintenance, a series of three valuable irrigation weirs have been allowed to become scoured at the sides and useless. Considerable repairs are required to bring these works into use once again. The construction of one new weir is required. The work will be done in 1940. Area 2,200 donums.

Kodja Deré (*Famagusta*).—Due to heavy flooding and scouring the water in the Kodja Deré river has been captured by a parallel stream so that no water passes into the main irrigation channel. It is necessary to construct a masonry wall to swing the water back into the main channel and to provide a storm-water take-off. Area 360 donums.

Morphou.—There has been a considerable amount of prospecting in the area bordering Morphou Bay and indications are that considerable volumes of water can be made available by pumping from boreholes. It appears that about three square-miles in all of irrigated land might be commanded. Water could also be taken from the flowing boreholes of Syrianokhori and run back for use at higher levels. Considerable improvement could be made in the arrangements for winter water from the rivers and infiltration galleries constructed in the river gravels. This is the largest area still remaining for development and, while water supply conditions regarding depth of aquifers are not as favourable as, say, west of Limassol, yet for potential volume of water, it is unsurpassed. It is thought that development of underground water should be by large boreholes finishing at eighteen inches diameter and reaching to depths of about three hundred feet. Such boreholes have not yet been attempted in Cyprus but there is no reason why they should not be successfully constructed. These large boreholes would afford great volumes from single pumping units. The swamps fronting this area, which gave rise to much malaria, would require to be drained. That done, they would support good crops. The remainder of the land is not of the highest class but with careful cultivation could be much improved. This area affords scope for a land settlement scheme.

Lysi (*Famagusta*).—This scheme, which is in hand, is an effort at providing pumped water for use by the peasant farmer. Pumping will be by a vertical spindle centrifugal pump from a ten-inch borehole into a distribution reticulation of precast concrete pipes. It is an attempt to apply relatively expensive water to ordinary crops such as maize, potatoes, flax, lucerne, and to vines. Government is providing the capital cost and the running charges for the first year. This scheme is quite novel for Cyprus and it is not anticipated that its operation will be trouble free. Area 350 donums.

Makrasyka (*Famagusta*). *Paleometokho, Kokkini Trimithia and Ayii Trimithias* (*all Nicosia*).—These are schemes similar to that of Lysi and await the result of that scheme. There are also further areas in the eastern Mesaoria that are underlain by abundant water which may be exploited in the same way. Area 350 donums each.

Livadhia (*Pendayia*).—The water of the Livadhia spring which flows about a million gallons a day into the sea near Karavostasi will be intercepted by a large diameter borehole close above the point of issue. The water, which without excessive drawdown should reach a million and a half gallons per day, would be elevated a little and distributed in the vicinity of Pendayia. Area about 800 donums.

Lapithos (*Kyrenia*).—Useful volumes of water are lost to the sea from springs on the shore near Lapithos. It is proposed to raise the water back a short distance for use in the orchards.

Syrianokhori (*Nicosia*).—The artesian boreholes of this area still run wastefully to the sea : the scheme of pumping the water back for a little distance is being re-considered. There is an area nearby that is not underlain by water and it may be possible to pump the water back to it.

Prodhromos (*Polis*).—Prospecting near Prodhromos in the Khrysokhou valley has revealed a coarse aquifer showing a good yield from medium depth. The water may be developed by pumping and distributed to the land immediately adjacent.

Lakatamia (*Nicosia*).—The proposal is to develop the small artesian flows of this area by boreholes with gravel screens and experiments in the technique have been made successfully.

Trakhoni (*Nicosia*).—The development of the sub-artesian water encountered at about fifty fathoms and rising to four fathoms below surface is proposed. The water is hard and contains dissolved sulphuretted hydrogen. It is not certain whether it would be preferable to develop this water by pumping or by a chain-of-wells. It is likely that the latter will be favoured as the passage through the chain would reduce hardness and allow the sulphuretted hydrogen to pass off.

Eylenja (*Nicosia*).—This work is designed to form the lower, downstream, part of the drainage scheme for the Government Farm at Athalassa. To prevent flooding on the farm, straightening of the river and a long outfall are required, and from the outfall a considerable area will be irrigated.

80. These are the schemes that have been investigated in some detail to date. Each one is small but the Island is small and the schemes are therefore important and must not be dismissed merely because large areas and much money are not involved. The sources of water are small and the schemes therefore cannot be large, which means a great deal of detailed work in preparation. Many more are on the list for investigation and the available staff is fully employed on prospecting pumping schemes and on construction works. Construction work keeps pace with the sums allocated.

Water Required for Irrigation.

81. The volume of water required to water a given area, that is the duty of water, naturally varies with the crop, season, soil and amount of cultivation. Good soils well cultivated and well manured with organic manure require less water than poor badly cultivated, unmanured soils. The Cyprus figures given compare well with the American records but they are not truly representative as they come from large well-managed farms. Deep soils, long, very hot days, drying winds and shallow cultivation call for heavy waterings. The soils of the Mesaoria, unless heavily watered or deeply cultivated, tend to develop deep cracks and enormous quantities of water, if available, are absorbed. This is particularly noticeable in winter watering of cereals and, it is considered, acts as a sort of water-spreading and brings reinforcement to deeper subsurface supplies. There is little doubt that in the main irrigation areas deeper ploughing would increase the duty of the available water and bring added crop yields but holdings are small and are not able to bear the expense of deeper ploughing.

82. The following comparative table gives records of actual volumes of water used on certain crops growing on well-managed farms. The peasant farmer tends to use much greater volumes if he can get them.

Table shewing Water Requirements per Acre in Acre-Feet for Various Crops.

Crop.	Agricultural Department, Cyprus.	U.S. Dept. of Agriculture, *Tech. Bulletin*, 185.	Cyprus Farming Co., Kouklia.
Apricots	0.49	—	—
Beets (table)	—	0.87—1.37	—
,, (sugar)	—	1.77—2.72	—
Broad beans	0.94	—	—
Broom corn	0.77	0.97—1.15	—
Cabbage	—	0.94—1.49	—
Carrots	—	1.27—1.60	—
Cauliflower	—	1.43—1.77	—
Cereals (winter)	0.59	—	0.97—1.30
Citrus	—	—	1.93
Clover (berseem)	—	—	1.48
Cotton	2.36	2.35—3.51	2.18—2.91
Cow peas	1.54	—	—
Figs	0.33	—	—
Flax	0.81	1.23—1.59	—
Forest trees	0.55	—	—
Fruit trees	—	—	1.23
Haricots	2.43	—	—
Lettuce	—	0.72—1.35	—
Linseed	0.59	—	—
Loquots	0.66	—	—
Lucerne	2.31	—	—
Maize	3.08	1.44—1.99	—
,, (early crop)	—	—	2.47
Melons	1.50	—	—
Olives	0.49	—	—
Onions	1.15	0.73—1.52	0.97—1.30
Peas	—	1.21—1.56	—
Plums	0.66	—	—
Potatoes	3.71	1.59—2.04	1.94—3.23
Rhodes grass	—	3.49—4.43	—
Sesame	0.77	—	—
Soya beans	1.92	1.66—2.81	—
Sultaninas	0.44	—	—
Sunflower	1.32	—	—
Sudan grass	0.77	2.88—3.16	—
Table grapes	0.55	—	—
Tomatoes	—	0.95—1.42	—
Vegetable garden	4.24	—	—
Vetch with oats	—	—	0.65
Vines	0.34	—	—

Acre-foot = 272,250 gallons per acre.

,, = 88,780 gallons per donum.

,, = 400 tons per donum approximately.

Cost of Water and Return from Irrigation.

83. There has been a tendency, mainly due to lack of data regarding the peasant farmer's production costs and results, to base estimates of irrigation costs and return on figures from Government farms and the big chiftliks. In the latter cases there is a much higher standard of husbandry and better marketing, both as regards disposal of produce and purchase of seed and fertilizer. Big units managed by one man in a scientific manner suiting the crop to land and water

available are obviously more profitable than a collection of small plots each farmed according to the ideosyncrasy of the owner. It is reasonable to suppose that the large estates and Government farms are able to pay twice as much for water as peasant farmers. On the Government farm at Morphou, a pumping charge of three shillings and four pence per donum for irrigating cereals was given, whereas ordinary irrigators are reluctant to pay two shillings and six pence for wheat and one shilling and six pence for barley per donum and very little water can be sold at this price. Co-operative handling of sales and purchases will tend to make the small farmer's profits larger but it is difficult at this time to see how, except very gradually over a long period, greatly improved husbandry is to be achieved.

84. For large areas with first class farming, the following table prepared by the Department of Agriculture, gives the return from certain irrigated crops taking a cost of 15 *paras* a ton for water and making no deduction for labour. The crop yields are high.

Crop	Expenses paid by farmer not including cost of irrigation or labour	Average cash income per donum	Number of waterings	Quantity water used (tons per donum)	Cost of water assuming rate is 15/40*p.* per ton	Profit per donum less cost of water and expenses	Remarks
	£ *s.* *p.*	£ *s.* *p.*			£ *s.* *p.*	£ *s.* *p.*	
Wheat ..	– 4 0	1 9 0	1	240	– 10 0	– 15 0	Value of straw and stubble grazing 5*s.* Production 8 kilés per donum.
Barley ..	– 3 0	– 19 4½	1	240	– 10 0	– 6 4½	Value of straw and stubble grazing 5*s.* Production 12 kilés per donum.
Cotton ..	– 5 0	3 6 6	6	1,000	2 1 6	1 0 0	—
Linseed ..	– 7 0	2 10 0	2	240	– 10 0	1 13 0	—
Vegetables	1 8 4	8 17 7	16	1,200	2 10 0	4 19 3	Green food for live stock valued at 5*s.*
Legumes ..	– 4 0	1 17 7	2	240	– 10 0	1 3 7	Soil fertility improved.
Vines ..	1 6 0	4 8 8	2	140	– 5 7½	2 17 0½	1,000 okes grapes at 1*p.* per oke.

Here is another table which was prepared for a scheme which did not mature, using two million gallons per day and charging 15 *paras* a ton for water.

Crop	Area in donums	Irrigations given	Quantity of water in tons per donum	Irrigation times	Total cost of water in £	Seed, horsework, fertilizer	Total produce in tons	Gross income in £	Net income without labour charges
Barley ..	1,000	1	120	15/2–26/2	252	150	150	750	348
Wheat ..	1,000	1	120	4/3–16/3	252	200	120	1,080	628
Vicos & Oats ..	250	2	240	(1) November (2) 27/2–3/3	—	125	150	450	199
Clover (Birseem)	250	5–6	600	(1) Nov.–Dec. (2) 27/2–3/3 (3) 17/3–20/3 (4) 10/4–12/4	315	205	2,250 (green)	1,125	605
Maize (early crop) ..	1,500	2	300	(1) 20/3–10/4 (2) 10/5–25/5	—	220	375 (as fodder)	2,250	1,400
Potatoes ..	500	6–8	600	August–December	—	875	1,250	5,000	3,495
Lucerne ..	500	8	1,000	March–November	1,050	260	4,000 (green)	2,400	1,090
Fruit trees	1,000	4–6	500	Spring & Summer	1,050	—	—	—	—
Total ..	6,000	—	—	—	—	—	—	—	—

In this case too no separate charge is included for labour. To succeed, this scheme would require to be managed on collective lines. In both tables, the return from cereals is very low and it is more than doubtful that they can bear such charges for water.

85. For summer irrigation, it would seem likely that in pre-war circumstances a charge of 5–9 *paras* per ton for a full season's watering of 1,000 tons per donum is about as much as the crops will stand. This makes it very difficult for schemes with mixed crops using pumped water. The cost of pumping alone (fuel, lubricant, spares, maintenance and attendant) is shown in the following table :—

Rate of pumping galls./hr.	Depth of well ft.	h.p.	Price of fuel oil £ per ton	Cost per ton of water—*paras/ton.*				
				Fuel oil	Lub. oil grease	Main'ce. spares	Labour	Total
12,000 ..	50	7	5	1.05	0.12	0.21	2.30	3.68
,, ..	,,	,,	7–10	1.58	0.18	0.32	2.30	4.38
,, ..	,,	,,	10	2.10	0.23	0.42	2.30	5.05
,, ..	,,	,,	12–10	2.63	0.30	0.53	2.30	5.76
,, ..	100	14	5	2.10	0.23	0.42	2.30	5.05
,, ..	,,	,,	7–10	3.15	0.35	0.63	2.30	6.43
,, ..	,,	,,	10	4.20	0.46	0.84	2.30	7.80
,, ..	,,	,,	12–10	5.25	0.58	1.05	2.30	9.18
18,000 ..	50	10	5	1.00	0.11	0.20	1.53	2.84
,, ..	,,	,,	7–10	1.50	0.16	0.30	1.53	3.49
,, ..	,,	,,	10	2.00	0.22	0.40	1.53	4.15
,, ..	,,	,,	12–10	2.50	0.27	0.50	1.53	4.80
,, ..	100	20	5	2.00	0.22	0.40	1.53	4.15
,, ..	,,	,,	7–10	3.00	0.33	0.60	1.53	5.46
,, ..	,,	,,	10	4.00	0.44	0.80	1.53	6.77
,, ..	,,	,,	12–10	5.00	0.55	1.00	1.53	8.08

Note.—Fuel oil consumption as ½ lb. per h.p. hour.
Lubricating oil and grease as 11% the cost of fuel.
Maintenance and spares as 20% the cost of fuel.
Labour is taken as £150 p.a. Running time 24 hours per day.

The pre-war cost of fuel oil was a little over £5 per ton ; it is now a little over £10. The comparable pre-war cost of pumped water at Morphou Central Experimental Farm was 6.5 *paras*. To the bare pumping costs must be added costs for a waterman and for interest on capital invested in channelling and pumping equipment. If underground distribution is favoured a capital charge (pre-war) of four pounds per donum must be incurred. A vertical turbine borehole pump with a suitable engine, all of British manufacture, costs not less than five hundred pounds and adding the cost of borehole, casing, tank, and distribution main, this part of the scheme will cost nearly fifteen hundred pounds. A scheme covering three hundred and fifty donums will cost £3,120. Here are the details and they are actual costs :—

	£
Pump and engine installed	550
Irrigation tank (60′×60′×5′)	700
Distribution main (laid)	235
Distribution reticulation (laid)	1,067
Irrigation ports	288
Contingencies 10% approximately	280
	£3,120

The actual pumping charges (pre-war) on this scheme are 7.5 *paras* a ton and it is obvious that in the beginning, the irrigators will be unable to do more than pay that amount. Capital and depreciation charges cannot be paid. This explains the delay in initiating schemes to use the water found by geophysical prospecting in the eastern Mesaoria. Generous subsidy was necessary to meet capital charges.

86. In certain circumstances, very high rates are paid for single summer irrigations, seven or eight shillings per donum and even as much as thirty shillings but these are freakish occurrences. Proprietors of water in some places are able to get in payment for water, half the gross crop of the area irrigated. In general, irrigators will pay water rates to private individuals far in excess of what they are prepared to pay in Government-sponsored schemes.

Waste of Water in Irrigation.

87. Waste may occur before the head of the field and in the field itself. Under ordinary Cyprus conditions, the loss in the channel is serious and may exceed 40% in the summer. It is caused by bad alignment and grading of channels, by the use of earth channels which are very inefficient and leak everywhere and by the fact that there is little maintenance of channels. Silting alters the grade of the channels and encourages evaporation. Abundant luxuriant weeds border the channels and large volumes of water are lost by transpiration. The loss of water is so great sometimes that almost all is lost in the channel ; thus it is recorded that the whole flow of a division at Kythrea, about 10,000 gallons per hour, only sufficed at certain times to irrigate six or eight olive trees over two hours run.

88. The loss on the field is also very great. This is due to overwatering, to irrigation by flooding, to undercultivation and to general carelessness. Overwatering and undercultivation go together. This has occurred in other places and has been gradually eliminated. The Year Book of the United States Department of Agriculture, 1910, page 140, states : "When the irrigators of the San Joaquin Valley, in California, first began to apply water on what had been dry-farmed grain fields they frequently used over nine feet. Now, about one-third of that amount is found to be ample. The water users of Greeley and the neighbouring districts of Colorado used to think their crops would

burn up unless they had a ' miner's inch ' of water to the acre. Now they are raising crops on the same ground that are worth about four times as much with one-fourth of the water formerly used. They are learning that cultivation takes the place of irrigation to a large extent." In summer, the soil is often deeply cracked and the shallow ploughing practised cannot fill these cracks. Such soils absorb enormous volumes of water. Irrigation of large undivided fields is common, the water being allowed to flow from the channel at the highest point of the field and to spread itself over the area. This causes great loss which could be considerably reduced by dividing large areas into smaller units served by separate furrows. Irrigation by flooding is practised in certain of the citrus-growing villages with consequent waste. There is in many cases a lack of care in the use of water. Large flows are taken from rivers and left to run much longer than necessary so that irrigators lower down have to go short. Complaints of this kind are common from the south-west of the Island and down-stream irrigators say that at times they have to bribe those upstream to cease wasting water and to allow it to pass downwards to them.

89. An irrigated crop survey in the summer of 1939 at Kythrea has shown that in this area at least, the loss of water is approximately a third and it may be taken that the loss of summer water all over the Island is much more than this. It is not contended that all this could be saved but it is held that a reasonable amount of maintenance of the channels would effect an immediate improvement. Channels are silted, weedgrown, tortuous and leaky. Masonry lining of the larger channels would bring considerable savings but the expense is heavy and beyond the capacity of the ordinary association of irrigators. Losses in the field may be countered by distributing water in concrete pipes or channels but here again costs are high and can only be borne by well-organized concerns with a high standard of agriculture. There are many examples of careful use of water to be seen in the Island, particularly near Limassol and Famagusta where water is pumped from boreholes and distributed by concrete pipes or channels.

Irrigable Land in the Mesaoria.

90. It is obvious that some criterion must be set up defining irrigable land as distinct from cultivable land and for the purpose of this account, the definition is : Such good quality arable land as may be commanded at a reasonable cost by channels taking water from rivers in which adequate water exists or is underlain by free-yielding aquifers at a reasonably shallow depth. Thus it is useless putting water on to areas of stony land or shallow soil or to attempt to pump water from great depths or to dig more channelling than a river would normally supply.

91. In the western Mesaoria, it is calculated that there is an area of about 65 square miles of irrigable land and the greater part of this could enjoy winter irrigation from the rivers which drain from at least 100 square miles of highlands in the zone of highest rainfall. The rivers debouch directly into the Mesaoria and there is no great draw-off before they reach it. Some of this is plateau land in the neighbourhood of Kokkini Trimithia and Paleometokho which is underlain by medium-depth water. The tracing of this aquifer is in hand and a certain amount of summer irrigation by pumped water will be possible. Further west, about Peristerona, Avlona and Kato Kopia almost as far as Morphou, there is considerable winter irrigation from the river and from chains-of-wells and this continues, though to a less degree, in the summer. This area is practically fully developed regarding irrigation. Further west along Morphou Bay, there is considerable winter irrigation but summer irrigation has not yet reached full development. Big volumes can be made available from boreholes and infiltration galleries. In the western Mesaoria, there is, usually, sufficient water to give most of the irrigable land, allowing for fallowing, a watering during the winter although perhaps not at the most favourable season. Further development for summer water has still to be undertaken in the east and near the sea on the west side.

92. The eastern Mesaoria is in rather a different position for the land that could be irrigated is in excess of the water that could possibly be made available by any means. The arable land that could benefit from irrigation, were water available, is about 190 square miles. The water that may be used consists of the drainage from about 50 square miles of the Makhera highlands conveyed by the Pedias and Yalias and from 100 square miles of the northern range. The Pedias and Yalias do not flow directly from the hills to the Mesaoria but pass through an intermediate area where large volumes of water are used. The Pedias supplies Politiko, Pera, Episkopio, Argates, Psomolophou, Dheftera, Lakatamia, Strovolos and Nicosia, and the Yalias, Kochati, Pera Khorio, Nisou, Dhali, Potamia, Pyroi and Margo, so that before reaching the Mesaoria their volumes are much diminished. The drainage from the northern range comes in innumerable short, steep hill torrents, mostly tributaries of the Pedias, which derive the bulk of their water from the Kythrea beds rather than from the limestone. There is no sustained flow in these streams and they carry water only after heavy rain, flow ceasing almost immediately the rain stops. The whole volume of water available in the eastern part of the Mesaoria is much less than that in the west, while there is a greater area demanding irrigation. The area under irrigation consists of 60,000 donums organized under Irrigation Divisions and these may expect winter irrigation yearly : of 7,000 donums, mainly citrus, in the Famagusta area, irrigated by pumped water : of 12,500 donums, average, that can be commanded by Kouklia reservoir for winter watering and of 4,000 donums irrigated below Syngrasi, a total of 83,500 donums. To this must be added the areas near Ornithi, Asha, Vatili, Lysi, Kondea, and between Salamis and Trikomo, where there are very many wells, some equipped with pumps and some with Persian wheels, and a certain number of chains-of-wells. This is estimated at 10,000 donums. The total is about 93,500 donums. In years of good rains, a much greater area is covered.

93. The problem of increasing this water supply is difficult. Irrigation works may be improved and pumped supplies developed from the aquifers discovered by geophysical prospecting. The possibility of putting into effect Medlicott's Diversion Scheme may be considered once again. Water may be saved by better cultivation and by putting land under olives and timber, eucalyptus say. The holdings of individuals in this area are unfortunately scattered in small plots here and there so that mechanized farming even by the bigger landowners is not feasible. The lie of the land, which is by no means so fertile as is generally thought, makes it ideally suited to some sort of pooled farming though the sentiment of the people would be against this. Tractor-drawn ploughs would then be

available to ensure deeper cultivation, not necessarily every year, and harvesting could be done by combines avoiding the dire effects of the early summer rains which inevitably fall when the grain is lying unprotected on the threshing-floors. This method of farming would ensure that such water as did exist would be used to the best advantage. Until land use plans are made for this area and consolidation of holdings is arranged, it seems impossible that any substantial advance can be made, especially in those villages, like Prastio and Gaidhouras for instance, which are largely cereal producers and where the prospects of increased water supply are poor.

Irrigation Water and Erosion.

94. In an area that is dependent on flood irrigation, as is the eastern Mesaoria, it seems likely that any attempts to check erosion must necessarily reduce irrigation water. The main counter-erosion works are afforestation, terracing and contour-ploughing. Each of these is designed to reduce the rate of run-off and, in so doing, will reduce the total quantity of water yielded by any drainage area, for they allow added time for transpiration and evaporation and, as in Cyprus many such works must be sited on impermeable rocks, they also prevent percolation to subsurface storage. Anti-erosion works also decrease the proportion of silt carried by the rivers and in Cyprus, where farmyard manure is not very abundant and fertilizer little used, this may finally be serious. It is not, however, thought that any anti-erosion works that could be executed would have any serious effect on irrigation supplies except perhaps after a long period of work and much expenditure on the eastern drainage.

DOMESTIC WATER SUPPLIES.

The Six Principal Towns.

General.

95. In Nicosia, the main supply is administered by the Nicosia Water Commission under the provisions of Law No. 22 of 1919, as amended by Laws No. 21 of 1933 and No. 1 of 1939. In Larnaca, the only supply which exists is Evcaf property and as such is managed by that Department, in accordance with the terms and conditions of the Deed of Dedication. The supplies of the remaining four towns, Limassol, Famagusta, Paphos and Kyrenia, are under the direct management of the Municipalities and are governed by the provisions of bye-laws passed by the respective Corporations.

96. The measure of water in all the towns is the *massoura* (subdivided into four *saccoraphia*) which denotes the size of an opening into the aqueduct or main. A *massoura* or a *saccoraphi* does not give to its owner any definite quantity of water but merely the amount of water which will pass through the relative opening, the volume of water actually delivered varying according to the quantity of water in the mains. Although the massoura does not legally entitle its owner to a fixed quantity of water, it has been reckoned in practice and under normal conditions to deliver a supply at the following rates :—

In Nicosia	1⅓ gallons per minute.
In Larnaca	4 ,, ,,
In Limassol	1⅔ ,, ,,
In Famagusta	1⅓ ,, ,,
In Paphos	2⅔ ,, ,,
In Kyrenia	1⅓ ,, ,,

97. With the exception of Larnaca and Famagusta, where the supply is given for 24 hours daily throughout the year, in the other towns the flow from the sources diminishes to such an extent towards the end of summer, that the supply to the houses has to be shut off during certain hours daily.

Nicosia Town.

98. The part of Nicosia which lies within the ancient walls depends for its domestic water almost entirely on the supply administered by the Nicosia Water Commission. The part of the town outside the walls, is mainly served by private companies: (*a*) the Greek Cemetery Water Supply; (*b*) the Bernera Water Company; (*c*) Messrs. Christodoulos and Demetriades' Supply; (*d*) the Cyprus Irrigation Co. Ltd.; (*e*) the Voudomandra Water Company, and in places where none of these companies has laid mains, supplies are obtained from wells in yards and gardens. The Nicosia Water Commission, in addition to the town of Nicosia, supplies the neighbouring villages of Kaimakli, Omorphita and Palouriotissa.

99. Until 1935, the Arab Ahmet and the Silikdar chains-of-wells which were put down by two Pashas of those names after the Turkish conquest of the Island, formed the sources of the supply of the Nicosia Water Commission. The length of the Arab Ahmet chain-of-wells, which runs in a south-west direction along the Pedias river, is approximately 2½ miles. The Silikdar chain-of-wells, now disused, runs parallel to the Arab Ahmet chain-of-wells for about a mile. Some twenty years ago the flow of water from these chains commenced to diminish considerably, especially during the summer months, due to increased draught for irrigation purposes in their catchment area, and two pumping units had to be installed in 1923 near the outlet of the Arab Ahmet chain to supplement the supply. One pump is installed on a borehole in one of the wells of the branch to the Silikdar chain, while the other is fed from an independent short chain-of-wells which crosses the Pedias river at the same locality. Each chain-of-wells served particular sections of the town by means of masonry aqueducts. When the administration of the supply passed to the Nicosia Water Commission, the question of its improvement began to receive serious consideration. After gaugings had been made it was apparent that a very large amount of the available water was being lost by leakage in the aqueducts which had already fallen into a state beyond repair. Another important fact emerging was that the Silikdar chain was serving little useful purpose and that generally, when there was water in this chain, it was not required since at such times the supply from the Arab Ahmet chain was adequate. It was, therefore, decided in 1933, when a loan of £8,000 was contracted for replacing the aqueducts by pipes, to use only the flow of the Arab Ahmet chain so long as it is sufficient and to supplement it, when necessary, by means of the two pumping units. The usual house supply in Nicosia consists of one *saccoraphi* which is the smallest share held. Calculating on the minimum

daily supply of 8 hours and assuming that the household of the shareholders consists of five persons on an average, it will be seen that at least 32 gallons per day per head is assured by one *saccoraphi*. On this basis it is reckoned that the quantity of water given to the shareholders during the period in which the supply is on for the minimum period of 8 hours daily, is 400,000 gallons per day. The water is distributed from a series of distribution boxes where the water is divided into the appropriate share enjoyed by each house by a series of small sheet copper weirs. The water rate payable is one pound per *saccoraphi* per annum. The quality of this water has been greatly improved in recent years by effecting alterations and repairs and by strict supervision.

100. The private companies are small concerns and supply water as under :—

(*a*) The Greek Cemetery Water Supply	309 *saccoraphia*.
(*b*) The Bernera Water Company	240 ,,
(*c*) Messrs. Christodoulos and Demetriades	45 ,,
(*d*) The Cyprus Irrigation Company	42,000 gallons per day.
(*e*) The Voudomandra Company	155 *saccoraphia*.

101. It is generally admitted that the present water supply system of the capital of the Colony cannot be regarded as satisfactory and a better supply, adequate for all the requirements of the town, has become an urgent necessity. For this purpose part of the water of the Kythrea spring would have been very useful. Unfortunately, however, the numerous private rights attached to this water have, so far, been a complete obstacle to such a scheme being put into effect. As the works undertaken in recent years at Sykhari did not yield the quantity of water required, the successful boreholes near Kokkini Trimithia, on the Troödos road, and at Psomolophou, have been suggested as sources of supply. A detained scheme has already been prepared and considered by the Consulting Engineers. The pre-war cost was estimated at £100,000.

Larnaca Town.

102. As in the case of Nicosia, Larnaca also obtains its supply from a chain-of-wells, approximately two miles in length, which was constructed in 1745 by Abu Bekir Pasha and donated by him for the use of the town. Under the terms of the Deed of Dedication, the administration of this supply is vested entirely in the Evcaf Department. The minimum supply is estimated at 980,000 gallons per day giving an average of 80 gallons per head of the population per day, but over a great part of the year it is greater by half. From the outlet of the chain-of-wells at a point over three and a half miles from Larnaca, the water was conducted to the town in masonry aqueducts of which the sections across the three valleys were carried on arches. In course of time the system fell in to such a state of disrepair that not only were large volumes of water lost by leakage, but the supply was liable to contamination almost at any point along the whole length of the aqueduct. Under these circumstances, the need for immediate improvements having been agreed upon between the Government, the Evcaf Department and the Municipal Authorities of Larnaca, a scheme was prepared in June, 1938, which provided for the replacement of the aqueduct as well as of the present distribution system in the town by asbestos-cement pipes at an estimated total cost of £24,000. The money was provided by a low interest loan from the Government to the Evcaf Department in arrangement with the Larnaca Municipality in April, 1939, when an order was placed for the necessary pipes and fittings. Work on the first part of the scheme commenced in June, 1939, and was completed in February, 1940. This consists of the construction, at the intake, of a large underground settling tank and of the replacement of the main aqueduct by a 15-inch diameter pipe line : this has cost £8,200. The laying of the distribution pipes in Scala and Larnaca, which forms the second and third parts of the scheme, is now proceeding. When the work is complete, Larnaca will boast the finest water supply of any Municipality in the Island, a supply that will be adequate in quantity for any reasonable or anticipated expansion in population and will be excellent in quality. Should the demand arise for softening or for chlorination, the lay-out is such that these can be installed without difficulty.

Limassol Town.

103. The supply of this town is derived from three separate sources, viz. :—

(i) The overflow from the storage tank in the Military Camp at Polemidhia which is supplied from Ayia Irini spring.

(ii) The chain-of-wells called Kitromili in the bed of the Garyllis river.

(iii) The chain-of-wells at Chiftlikoudhia to the west of the town and not far from the coast.

From Ayia Irini spring the water is conveyed to the storage tank at Polemidhia by a 10-inch diameter earthenware pipeline, 28,000 feet in length, of which a few short sections have from time to time been replaced by iron pipes. As is the case with the majority of similar supplies, the flow from this spring increases during the winter and the amount of water in excess of the capacity of the main pipeline overflows to waste near the intake. On the 10th January, 1940, the quantity of water delivered into the storage tank at the Camp was 86,400 gallons per day while the overflow near the source was estimated at 130,000 gallons per day. In the summer months, however, the flow diminishes considerably. The surplus from the Camp is led to a reservoir behind the town. During the periods when no troops are stationed at Polemidhia, practically all the water delivered to the storage tank is available for the use of the town. The Kitromili chain-of-wells is about half-a-mile long in the bed of the Garyllis river. The flow from this chain is also conducted to the town supply cistern. It is stated that the discharge from the Ayia Irini spring and the Kitromili chain combined has in a dry season fallen as low as 52,800 gallons per day. So long as there is water flowing in the Garyllis river, the supply to the town from these two sources is adequate. Pumps raise the water from the Chiftlikoudhia chain and deliver it either to the tower reservoir or to the town direct. This installation was erected some 44 years ago but has been almost completely replaced in recent years by new engines and pumps.

104. As regards an increased supply, substantial improvement may be achieved for a part of the year by conveying the overflow near the intake at the Ayia Irini spring which, as stated earlier, now flows to waste because the present main to the storage tank in the Camp is not large enough. The supply now obtained from the Chiftlikoudhia chain may be augmented by extending the tunnels further west.

Famagusta Town.

105. In Famagusta, water has been developed by small schemes in a haphazard way in different parts of the town, which now depends on the following four sources :—

(i) The Panayia spring.

(ii) The two boreholes at the locality Stavros.

(iii) The well on the Ramparts.

(iv) The well near the English Club.

The first two sources mainly serve the part of the town known as Varosha, the third source supplies the old town of Famagusta while the fourth and fifth serve a small area round each. The Panayia spring produces what is potentially the best water in the area. From this spring the water is conveyed to the town by means of an old masonry aqueduct, stated to be Venetian, which is almost ten miles long. The aqueduct has a minimum input of 55,000–60,000 gallons per day. In the summer, a considerable proportion of the original input is lost by theft, leakage, evaporation and by the transpiration of plants. On the 14th July, 1937, the input was gauged at 97,200 gallons per day and on the same day the output was about half that figure. The discrepancy is important, amounting as it does to six gallons per head of the population. The two boreholes at Stavros form the main source of the town's supply, about 155,000 gallons being pumped daily into the tower tank erected nearby. It is unfortunate that buildings should have been allowed within a few feet of this pumping station, thus creating an easy source of pollution, which can only be avoided by enforcing strict sanitary conditions in and about the houses in proximity to the station. Approximately 97,000 gallons per day are pumped from the well on the Ramparts, which is the third important source of supply. From the remaining well near the English Club water is pumped by a windmill and, therefore, the actual quantity delivered varies according to the prevailing winds. It may, however, be assumed that a minimum supply of 13,000 gallons daily is made available from this well.

106. With regard to the possibility of improving the present supplies, the Panayia spring is already fully developed. The quantity of water delivered to the town by the old masonry aqueduct could, however, be doubled by replacing it by a pipeline. This is a costly project on account of the great length involved. At pre-war prices, the cost was estimated at £10,000. The output from the two wells at Stavros might be increased by the installation of electro-submersible pumps. In the case of the other sources no improvement would justify the necessary expenditure. On the whole, it is considered that the time has come for the provision of a new source of supply altogether on modern lines which would do away with the several supplies at present in use.

Paphos Town.

107. The Kourgas and Kalamos springs together with the chain-of-wells at Mesoyi form the sources of supply of this town. The minimum daily flow from each may be reckoned as 22,000, 18,000 and 30,000 gallons, giving a total of 70,000 gallons per day or an average of over 15 gallons per day per head of the population (Paphos and Ktima combined, 4,500). The water from Kourgas spring is conducted by a pipeline to Kalamos spring whence a single main conveys all the water into the storage tank near the Government nursery garden. A separate main from the outlet of the Mesoyi chain conveys the water to the same tank. So long as the supply is given for 24 hours daily, a regular flow to the houses is possible, but as soon as the flow from the sources diminishes during the summer, making it necessary for the supply to be shut off for certain hours every day, irregularity in the supply to the houses is unavoidable owing to defective distribution system. This could be remedied at no great cost.

108. The Mesoyi chain is situated practically within the village of the same name. Therefore the supply from this source can be protected from pollution only by strict supervision. As soon as additional supplies may be procured from the springs higher on the hills, this source should be abandoned.

Kyrenia Town.

109. Until February, 1936, the supply of water controlled by the Municipal Corporation was that derived from the following three chains-of-wells :—

(i) The Thermia chain.

(ii) The Hospital chain.

(iii) The Nicosia road chain.

The total flow from the three chains was 48,000 gallons per day, as measured on the 17th October, 1938 ; this may be taken as representing the minimum flow. As from February, 1936, the supply known as the Boghaz water, which was originally installed by the Government for the offices, the Fort and the Hospital, was also handed over to the Municipality by an agreement for a period of five years, renewable thereafter from year to year. The minimum supply obtained from the Boghaz source is 38,000 gallons daily. This is the one-fourth share owned by the Government in the Platanos spring, one of a group of three springs situated at the Boghaz pass between Nicosia and Kyrenia, the remaining three-fourths share being the property of private mill-owners and irrigators. The total minimum daily supply of 86,000 gallons available from the three chains-of-wells and Boghaz together, gives an average of 38 gallons per day per head of the population (2,279). All the three chains are situated inside the town, surrounded by buildings. As such they are liable to pollution and therefore unsuitable for domestic use. Serious consideration should be given to the suggestion already made for acquiring, if not all the remaining shares in the Boghaz water, at least another fourth, making one-half of the whole supply, when the water from the chains could be used for house-gardens. This arrangement, together with the installation of a proper distribution system in the town, ensuring a daily average of 34 gallons per head, would afford a substantial improvement.

Village Water Supplies.

110. The question of providing improved water supplies in the villages started to receive consideration soon after the British occupation of the Island. In the early days, the assistance rendered by the Government to the communities was in the shape of grants towards the cost of the necessary works. As the benefits derived from improved domestic supplies were realized, applications for similar assistance grew considerably in number and gradually the whole work, both as regards the financing and execution of the scheme, took a definite form. At present, the villages are required, as a rule, to provide one-half of the estimated cost of the scheme in order to qualify for a free grant of the remaining one-half, whereupon the work is undertaken and executed by the Water Supply and Irrigation Department. Government's aim is the eventual provision of a good-piped water supply for all villages, and no community is regarded as too small to merit attention. On the contrary, subject to the recommendation of the Commissioner of the District, very poor villages receive special favourable treatment by way of a Government grant of more than 50% of the total cost of the scheme. Also, a satisfactory chemical and bacteriological analysis is a pre-requisite for all water brought into use as a result of these schemes. In the majority of cases mountain springs form the sources of supply. These are enclosed and secured against contamination and the water is gravitated by galvanized steel pipes into a reinforced concrete storage tank, constructed at a suitable site, whence it is distributed within the village by means of standpipes. Where springs do not exist, wells and boreholes are constructed outside the villages and protected from pollution. From these water is raised either by windmills or engine-driven pumps.

111. Many of the large villages now being provided with water had previously no near-at-hand source of supply in summer and water had to be brought in carts from long distances and at great expense. Such villages are Lefkoniko, Kathikas, Phiti, Prastio and Gaidhouras. It is a mistake to suppose that because a big village has grown up, there must necessarily be adequate water nearby. From 1930 to end of 1939, 149 villages have had piped supplies provided and it is expected that 12 more schemes will be completed in 1940. At least 50% of the 212 villages dealt with prior to 1940, owing to the use of wrought iron pipes, may be regarded as requiring substantial replacements in the next few years. Therefore, the total estimated number of villages at the end of 1940, with an up-to-date good, piped, potable water supply is 267 out of the 641 villages in the Island. During the four years from 1937 to the end of 1940 works were put in hand in 66 villages with a total population of 35,661 and investigations were carried out for 27 villages with a total population of 19,009. A total of £30,704, which included £3,759 from the Colonial Development Fund, £14,560 from the villages and £13,385 from the Cyprus Government, was spent during the period. The cost of individual schemes depends on the size of the village and more particularly on the distance of the spring from which water will be conveyed, steel pipes representing the greater part of the expenditure. The single scheme for Lefkoniko, estimated to cost about £4,200, and the combined scheme for Phiti–Ayios Dhimitrianos–Kathikas, which will cost approximately £8,300, are the biggest schemes of their kind yet undertaken in Cyprus. Both will be completed in 1940. In the case of Lefkoniko, water will be conveyed from the Mourra and Hodja's springs and from an artesian borehole beyond Platani, all situated in the Kantara Forest. For this purpose, 42,000 feet of galvanized steel tubes will be used. The first section of the important combined scheme for Phiti, Ayios Dhimitrianos and Kathikas, involving the laying of 23,300 feet of 3-inch main from the Papa Louka spring to Phiti was completed in 1939 at a cost of £3,500. Water is now laid to the first two villages, and work on the last stage, which consists of laying water to Kathikas from Phiti by a 3-inch galvanized steel main, ten miles in length, will be commenced as soon as the pipes arrive.

112. These schemes have all been enthusiastically welcomed by the village people and have resulted in added consumption of water for all purposes. The anxiety generally felt about water supply towards the end of summer has been alleyed. Certain schemes provide a surplus which is used for kitchen gardens, particularly at the schools, where the boys and girls can be taught gardening. It is thought that, with an expenditure of about £140,000 spread over nine years, there would remain few villages unsupplied with good water. To enable the work to proceed evenly and without obstruction, it is considered necessary to obtain powers: (1) to acquire, on payment of compensation, water for village water supplies from sources situated either inside or outside the village area concerned; and (2) to make it lawful, on the advice of the Director of Medical Services, to proceed with the construction of a village water supply and to assess the village for half the cost or such part thereof as the village is able to bear.

LEGISLATION CONCERNING WATER SUPPLY.

113. Cyprus is well equipped with legislation covering most aspects of water supply and, in cases where no law can be found to apply, the Mejellé (Ottoman Civil Code) is available. Control of water supply operations is now relatively strict, but there has been a long period of laxity. The lack of any law requiring villages to provide a domestic water supply is also strange though it has caused no serious inconvenience. Generally speaking, water rights, whether private or communal, are given adequate protection, provisions to this effect existing both in the Ottoman legislation and the Statute Laws—e.g. *vide* article 124 of the Ottoman Land Code, sections 1 (2) and 6 *et seq* of the Government Waterworks Law, 1928, and section 41 of the Irrigation Divisions (Villages) Law, 1938. The following is a summary of legislation dealing with water and irrigation :—

The Mejellé (Ottoman Civil Code):

114. *Articles* 1234–1239.—The provisions of these articles define the extent of the right which a person has to water, be it water which flows underground or in wells habitually used by the public, or in seas and big lakes, or in public rivers. They lay down that water which flows underground is not the *mulk* (freehold) property of any one (*cf.* the Government Waterworks Law, 1928).

115. *Articles* 1262–1269.—These articles define the extent of the right which a person has to divert water for irrigation from public rivers or streams or from rivers or streams held in common as *mulk* property, and the right to drink water, which is unlimited, be the water from a spring or well or river, etc., publicly or privately owned. There is no provision in these articles authorizing a person to construct a dam or weir or other barrier in a public river, stream, channel or watercourse for the purpose of diverting water for irrigation.

116. *Articles* 1281–1291.—These articles define the rights of the circuit (*harim*) of wells, springs, big rivers and small rivers. The rights of the circuit of—

(*a*) wells is 80 feet;

(*b*) a spring, 1,000 feet;

(*c*) a great river not requiring frequent cleaning, half the breadth of the river on each side;

(*d*) a small river requiring frequent cleaning, land sufficient on each side to throw the stones and mud upon;

(*e*) water pipes or underground conduits of which the water flows on the surface of the earth, 1,000 feet.

Wells may be sunk on *mulk* property irrespective of the rights of circuit of a neighbouring well or spring. In connection with the provisions of the above articles, *cf.* the Wells Law, 1896, Statute Laws of Cyprus, Vol. I, page 943.

117. *Article* 1675.—In accordance with this article no person can acquire possession of a public river by prescription, irrespective of the number of years during which he has had exclusive and undisputed use of the river. In this connection, *cf.* article 102 of the Ottoman Land Code and the definition of land known as *Arazi Metruké* which means: (*a*) places left for the use of the public in general, and (*b*) places left for the use of a particular community or group of communities; also, *cf.* clauses 5 and 7 of the Immovable Property Bill published in the *Cyprus Gazette* (Extraordinary) of the 28th February, 1939. In clause 5 of this Bill, however, in virtue of which all not privately-owned rivers, etc., are vested in the Crown, nothing is said about not privately-owned springs or other water flowing to the surface of itself.

118. *The Wells Law*, 1896.—This law was enacted for the better protection of wells and water rights. It confers right of action for compensation if damage is caused to existing wells or chains-of-wells or springs by the sinking of new wells on land other than *mulk* within certain distances, viz. 80 feet from any well or 600 feet from any chain-of-wells or springs. Municipal or Village Authorities may, in certain circumstances and on payment of reasonable compensation, sink wells, etc., within the distances specified above for the public use of the inhabitants. An order has been made (page 817 of Vol. II of the Statute Laws) under section 8 of this Law requiring that all wells shall be protected by means of a masonry covering or stone parapet at least 2 feet high so that they may not be a source of public danger.

119. *The Construction of Buildings, Streets and Wells on Arazi Mirié Laws*, 1927 *to* 1938.—Under section 9 of these Laws no well may be sunk on Arazi Mirié land unless a permit to that effect is obtained from the Commissioner, who may impose such terms and conditions as may seem necessary or desirable. A permit, which is granted under the Government Waterworks Law, 1928, is also required for the utilization of water found in a well. Penalties are prescribed for sinking a well without a permit, amongst which the filling in or closing of the well so sunk is mandatory, unless the Commissioner concerned gives his covering approval. Arazi Mirié land is land the real ownership of which is vested in the State but which may be held in virtue of a title-deed issued by the authority of the State. Agricultural land is usually of the Arazi Mirié category.

120. *The Government Waterworks Law*, 1928.—This Law—

(i) vests in the Government the ownership of—

(*a*) all underground water (including sub-artesian water) for which no measures had, by the date of the publication of the Law, been taken enabling such water to be brought or raised to the surface or to run on the surface; and

(*b*) all water running to waste from any river, spring, stream or watercourse; and

(*c*) all other waste water;

and prohibits the taking or utilization of such water except with a permit in writing from the Commissioner, and

(ii) gives power to the Government—

(*a*) to undertake and carry out waterworks in respect of water in any river, spring, stream or water-course, or any other water, whether the subject of private rights or otherwise, which water, subject to provision being made for the satisfaction of existing water rights, thereupon becomes the absolute property of the Government; and

(*b*) by regulations to administer such works and levy charges or rates in connection with the financial side of the administration.

Land may be compulsorily acquired and any obstruction removed or interfered with in connection with the execution of any waterwork. The Eastern Mesaoria Irrigation Works come under this Law for administration, but, with the exception of the Irrigation Charges Regulations, 1931 and 1937, which empower the Director of Agriculture to prescribe, within certain minima and maxima, charges for the irrigation of winter and summer crops from the above works, no other regulations have been made.

121. *The Irrigation Divisions* (*Villages*) *Law*, 1938.—This Law enables the formation of an Irrigation Division for all or any of the following purposes:—

(*a*) The construction, improvement, maintenance or repair of any irrigation works (the definition of which is of a sufficiently wide scope) lying wholly or in part within the lands of a village or quarter or group of villages;

(*b*) The protection of common waters or watercourses and for the regulation of the use thereof;

(*c*) The maintenance or protection of the water rights of the land owners.

The formation of an Irrigation Division is determined by the majority of the owners of land which is benefited or is capable of being benefited by such Irrigation Division, who may be present at a public meeting convened by the Commissioner for this purpose, either at his own instance or on the application of not less than ten of the land-owners concerned, and presided over by him, and so are all questions or resolutions relating to an Irrigation Division.

122. The Law provides for the election of a Committee under the chairmanship of the Commissioner. The Committee has the general supervision and control of the irrigation works and, in this connection, is empowered to contract loans and incur expenditure. The Law further provides for the framing of Rules for the administration of an Irrigation Division, and under these Rules rates or charges may be levied. Upon the payment of reasonable compensation land required in connection with the construction of any irrigation work may be compulsorily acquired.

123. *The Public Rivers Protection Law,* 1930.—This Law enables certain measures to be taken from time to time for the purpose of protecting public rivers. The object of these measures is to prevent people from damaging or destroying any bank or wall of a river, or from removing earth, shingle, etc., from a riverbed or dumping rubble, rubbish, etc., therein, and they are taken by a public river being declared, under a Governor's Order-in-Council, to be a river for the purposes of this Law, and by the publication in the *Cyprus Gazette* of prohibitive notifications by the Commissioner in whose district the river is situate. Only two rivers have so far been declared to be rivers for the purposes of this Law, namely, the Pedias and the Garyllis, and of these the portions near Nicosia and Limassol, respectively, are affected.

124. *The Polis tis Khrysokhou Water Law,* 1900.—This Law was enacted to enable a water supply to be provided for the town of Polis tis Khrysokhou for drinking and domestic purposes. For this purpose it empowered the Government, on paying compensation to the persons having an interest in the water of the Fortini spring at Pelathousa village (Paphos District) and on provision being made for the drinking and domestic requirements of the inhabitants of that village and their animals, to acquire the exclusive right on the water of the above-mentioned spring. The water of this spring has since been conveyed to the town in question.

125. *The Nicosia Water Supply (Arab Ahmet and Silikdar Vaqfs) Management Laws,* 1919 *to* 1939.—These Laws institute a Water Commission, which is entrusted with the management and control of the Nicosia water supply (Arab Ahmet and Silikdar Vaqfs). For the exercise of the powers and obligations vested in and imposed on them the Water Commission may—

(*a*) with the approval of the Governor appoint the necessary officers and servants ;
(*b*) make rules for conducting its business and meetings ;
(*c*) make bye-laws respecting the distribution of the water and for levying water rates ;
(*d*) incur expenditure and, with the consent and authority of the Governor, contract loans.

Land, springs or water may, on the payment of reasonable compensation, be acquired upon agreement or compulsorily, for the requirements of the water supply. The Law provides for penalties upon offenders against both the Law and the bye-laws.

(*e*) above has been implemented by the Nicosia Water Supply Bye-laws, 1924 to 1932.

126. *The Nicosia Water Supply (Special Powers) Laws,* 1932 *and* 1933.—These Laws were enacted for the purpose of relieving a water shortage in Nicosia and protecting drinking water supplies from being contaminated. They establish a Board, which the Governor may by Order in Council authorize, *inter alia*—

(*a*) to take, manage and control, for a period not exceeding 12 months from the date of such order and subject to certain provisos, the Nicosia water supplies or any part of them ;
(*b*) to establish a fund into which all the Board's receipts from whatever source shall be paid ;
(*c*) to incur expenditure for the above purposes and to contract loans, and
(*d*) to make regulations concerning the carrying out of the above objects and for fixing the scale of charges to be levied.

The Laws impose upon the Municipal Corporation of Nicosia the obligation to pay into the Board's fund such money as may be required for the purpose of relieving the water shortage, and empower it to contract loans for this purpose and to impose a special *ad hoc* levy in order to recover such money. It is provided that pipes purchased and works executed at the expense of the Corporation shall be handed over to the Corporation free of charge for the permanent benefit of the inhabitants. These Laws were enacted to deal with an emergency in 1932–1933 brought about by the drought, but have never been applied.

127. *The Kythrea Water Supply Improvement Law,* 1928.—This Law was enacted to enable the town of Kythrea to convey, with the authority of the Governor and upon complying with certain conditions and formalities, a piped water supply from the Kephalovriso spring at Kythrea for the domestic requirements of the inhabitants. The Law provided for the compulsory acquisition, on payment of compensation, of land required for the above purpose. Under section 15 of the Law, the Municipal Corporation of Kythrea, may, with the approval of the Governor, make bye-laws for the management and control of the Kythrea water supply. Such bye-laws were made and published in the *Cyprus Gazette* of the 28th July, 1933, and a piped water supply has since been provided for Kythrea.

128. *The Kephalovriso Water Supply Improvement Law,* 1932.—This Law, which is on the same lines as the Kythrea Water Supply Improvement Law, 1928, was enacted to enable the undermentioned villages to convey, with the authority of the Governor and upon complying with certain conditions and formalities, piped water supplies from the Kephalovriso spring for their domestic requirements, in quantities not exceeding those shown opposite them :—

Bye Keuy	665 gallons per day.
Epikho	5,600 ,, ,,
Exometokhi..	6,550 ,, ,,
Neokhorio	9,850 ,, ,,
Palekythro	7,600 ,, ,,
Trakhoni	3,200 ,, ,,
Voni	4,400 ,, ,,

As in the case of Kythrea, the Law provided for the compulsory acquisition, on payment of compensation, of land required for the installation of the water supplies. All the villages have since installed piped water supplies. The Village Commissions may, with the approval of the Governor, make bye-laws for the management and control of their water supplies and for levying fees or charges and incurring expenditure. None of these Village Commissions has made any bye-laws in this respect.

129. There is no special legislation dealing with the provision of a water supply to a village for drinking and domestic purposes. In accordance with an advice from the Law Officers to Government, the Land Acquisition Laws, 1899 to 1936, cannot be made to apply to small local schemes benefiting particular communities. Village water supply schemes, being of this nature, are affected, and, consequently, no privately-owned water, whether in the village concerned or in another village, can be compulsorily acquired for the benefit of the community in general. As matters now stand, the provision of a potable water supply entirely depends on administrative measures and on the initiative of the village concerned. There is no law empowering the Government to proceed with the installation of a water supply in a village where health and sanitary conditions make such installation immediately necessary.

130. In the financing of village water supply schemes, the Government usually contributes half the cost and the village concerned the other half, but with regard to villages which are poor, the Government, on the recommendation of the Commissioner, is prepared to and usually does contribute more than one-half of the cost. In connection with the provision of their share of the cost villages are afforded facilities by the grant of long-term loans at a low rate of interest from the Loan Commissioner's Fund. Such loans are contracted in accordance with and secured under the provisions of the Village Obligations Laws, 1901 to 1937.

131. In the proposed *Immovable Property Law*, the draft of which was published in the *Cyprus Gazette* (Extraordinary) of the 28th February, 1939, the following clauses are concerned with water and irrigation :—

Clause 5, which vests in the Government the ownership of all not privately-owned lakes, rivers, etc. Provision is made for the respect of water rights which—

(*a*) have been exercised for 30 years before the commencement of this Law ;

(*b*) have been conferred by a *Firman* or other valid document made before the 4th June, 1878 ;

(*c*) are exercised under any law in force for the time being.

Clause 12, which provides that the course of a channel irrigating land belonging to more than one owner shall not be altered without the consent of all the owners, and that each owner, with a view to preventing waste of water, is under obligation to clean and keep in proper repair the part of the channel which affects his land.

Clause 13, which provides that no new channels for the diversion of water from a public river can be constructed except under a permit from the Director of Land Registration and Surveys, who may impose such terms and conditions as to him may seem necessary, and that in the issue of such a permit regard should be had to existing rights.

Clause 14, which provides that a right of irrigation shall extend to a right in or over a channel, watercourse, aqueduct, well, or chain-of-wells to which such right relates, each such work being deemed to include a space of not less than 2 feet and not more than 5 feet from its edge for cleaning and protective purposes.

RESULTS OF THE LAST THREE YEARS.

132. *Prospecting.*—(1) A definite result has been secured regarding the adit works started in the Kyrenia hills in 1908, and a conclusion has been reached regarding the prospects of any similar works in these hills.

(2) The question of deep-drilling in the Mesaoria has been re-examined and the probable results revealed.

(3) The Morphou area has been re-examined and it is known that the water available there is greater than was originally thought.

(4) The question of the loss of water to the sea by surface and subsurface flow from the rivers has been examined and measures proposed to deal with these losses.

(5) The whole problem of impoundment has been examined not once but several times and sites have been sought for such works in all possible parts of the Island.

(6) The question of chains-of-wells in the western Mesaoria has been examined.

(7) The western Mesaoria Diversion Scheme has been re-examined.

(8) Almost every irrigation scheme in the Island, whether now in existence or defunct, has been examined to indicate possible improvements or to find the causes of failure.

(9) In the eastern Mesaoria, new aquifers have been discovered by applying modern methods of geophysical prospecting and a geophysical prospecting unit has been in the field most of the time.

(10) In the higher part of the western Mesaoria, a new aquifer has been found in the Kokkini Trimithia–Paleometokhi area.

(11) Investigations have been made for domestic water supplies for more than 130 villages and a solution has been proposed for such chronic cases as Kathikas, Lefkoniko, Gaidhouras and Prastio, Orta Keuy and Geunyeli.

(12) Prospecting in the Nicosia area has led to the submission to the Consulting Engineers of the first complete scheme to supply Nicosia.

(13) A new scheme for Larnaca has been proposed.

(14) In addition to all this, very many small prospecting jobs of a specific nature have been done for Government and for private companies and individuals.

(15) Four drills, and latterly five, have been kept constantly employed in the field and careful sampling done and logs recorded.

133. *Construction.*—Actual construction of irrigation works has not made such strides as the prospecting work. This has been due to many factors, not the least of which is that much of the earlier prospecting work gave negative or unfavourable results. Thus, deep drilling and impoundment were shown to be unlikely to prove successful, so no actual works were undertaken. The war has had an effect in delaying matters but the main retarding influence has been money. In the beginning when schemes were submitted, Government insisted on their being relatively self-supporting. This attitude has been gradually modified over the period so that schemes not directly self-supporting have become admissible. These are more particularly schemes involving pumping or the use of imported pipes and, but for the war, a vigorous construction programme would have been put in hand towards the end of 1939. As it is, a moderate sum is being devoted to financing irrigation works.

134. Work, too, has been retarded by the number of people who have to be considered in any scheme. Thus a small area of 240 acres had 250 owners and plots were of all shapes. Owners too are not all keen on more intensive irrigation which requires extra capital, different agricultural methods and crops, and entails additional hard work. Of course, legal means exist to force schemes through, but without the co-operation of the irrigators success is doubtful. A description of irrigation schemes has been given.

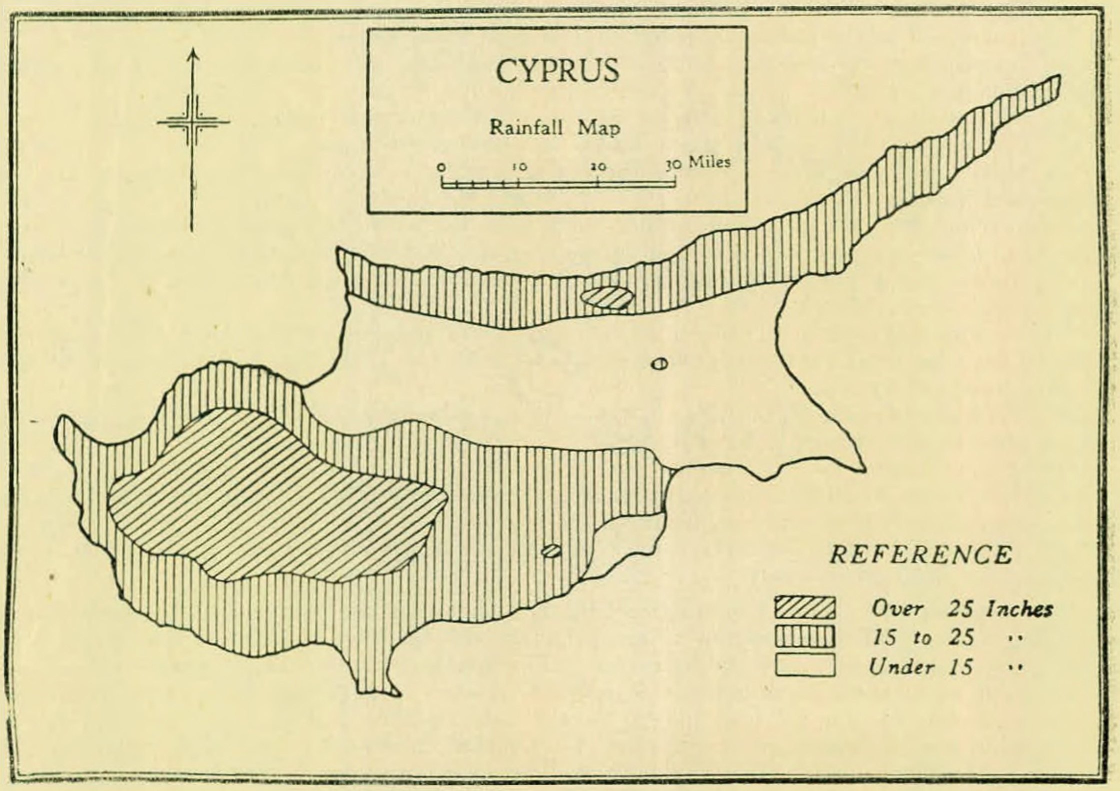
135. This account would not be complete without reference to the Government Subsidized Scheme for providing boreholes for irrigation on private land. For a payment of £15, *plus* £5 for transport, Government undertakes to drill a borehole in any reasonable place. In the last three years, fifty-three boreholes have been sunk with a total footage of 9,450 and an estimated available volume of 6,700,000 gallons per day.

136. The work of finding domestic supplies has gone well and without hitch. In the three years, work has been completed in fifty-four villages involving a total population of 29,590 people. The supply of domestic water is a popular service and the people in the villages make no difficulty about paying half the cost. A start has been made with the new scheme for supplying Larnaca and more than a third of the work is completed.

CONCLUSION.

137. Water supply in Cyprus depends on rainfall. Supplies for irrigation are to be augmented, from the engineering standpoint, by the repair and careful maintenance of existing works and by the construction of new works outlines of which have been given above. But the engineering standpoint is not the only one. Increase of water is stated time and time again to be the major Cyprus problem, but it is inextricably involved with questions of agriculture, with methods of farming and crops. Where water is available it must be conserved by increased cultivation and its usefulness augmented by planting crops that require little water. These crops are fruit and timber trees. The policy of laying temporary watering lines to areas planted to timber and requiring water for two seasons only may be adopted. Timber is a remunerative crop but it takes time to come to bearing. The same is true of olives. Where water is plentiful, fodders to feed green are indicated with increase in stock and in farmyard manure which is so scarce in the Island and so important. In the dry areas there is room for increased planting of carobs to feed stock. Bound up with the question of water supply is also the question of rural indebtedness and the inheritance law. Peasants living on the bread line have no capital to undertake works, nor to change to new crops, nor often much desire to do so. The inheritance law causes land to be split into smaller and smaller units so that eventually so many people are concerned in a little irrigation project that agreement on details is impossible and failure results. Water supply can be increased, but it is not to be regarded as something separate: to secure a full measure of success from works, there should be a forward move in agriculture and in general social conditions and that must take time. " We face a condition, not a theory."

30*th March*, 1940.



APPENDIX.

DAM OF YERMASOYIA RIVER.

A possible site for a dam was found in the Yermasoyia river, preliminary investigations have been made and a preliminary estimate prepared. There is a drainage area of steep highlands in igneous rock, 44 square miles in extent above the dam site. The rainfall is between twenty and thirty inches. The equivalent of a three-inch run-off will easily fill the dam and make allowance for evaporation and will easily be achieved. There is a gap in one side of the proposed reservoir and this is closed by the secondary dam. Masonry structures are used in preference to any other because they are cheaper. Detritus barriers in the river, a silt-pit with grab at the head of the reservoir and a short length of light railway for disposal of alluvium are included.

ESTIMATE.

(1) *Main dam in masonry :*

Top water level		520 feet.
Freeboard		5 ,,
Crest level		525 ,,
Stream bed level		443 ,,
Foundation level		420 ,,
Spillway length		60 ,,
(*a*) *Excavation :*		
1. Bottom cut-off concrete trench—		£
600 cubic yards in rock @ 10*s*.		300
2. Side cut-off trenches—		
420 cubic yards in rock @ 10*s*.		210
3. Side keying into rock—		
13,800 cubic yards @ 6*s*.		5,140
4. Remove alluvium to bedrock—		
40,000 cubic yards in gravel @ 3*s*.		6,000
		£11,650
(*b*) *Concrete :*		
1. Cut-offs bottom and side—		
1,000 cubic yards @ £2		2,000
2. In spillway—		
850 cubic yards @ £2		1,700
3. In 6′ dia. tunnel to irrigation channel—		
260 cubic yards @ £5		1,300
4. In 15′ dia. emergency and diversion tunnel—		
1,100 cubic yards @ £5		5,500
5. In control tower 20′ dia. 110′ high—		
570 cubic yards @ £5		2,850
		£13,350
(*c*) Masonry 80,000 cubic yards @ £1		80,000
(*d*) Underdrains 250 cubic yards @ 10*s*.		125
(*e*) Control gear		5,000
(*f*) Drilling and grouting foundations		2,000
(*g*) Transport (84,000 tons masonry and concrete)		4,000
(*h*) Pumping		2,000
(*i*) Upstream detritus barrier 800 cubic yards @ 10*s*.		400
(*j*) Upstream silt catch-pit 160′ × 160′		
Floor 480 cubic yards		
Walls 880 ,, ,,		
Spillway 90 ,, ,,		
1,450 ,, ,, @ £2		2,900
Excavation 4,800 cubic yards @ 2*s*.		480
(*k*) Silt grab for above pit		500
(*l*) Light railway for disposal of silt		2,000
(*m*) Engineer @ £450 for 1½ years	£675	
Passage return	60	
		735

(2) *Secondary dam in masonry :*

(*a*) *Excavation :*	
1. Cut-off trench—	
1,000 cubic yards @ 10*s*.	500
2. Side-key into hill side—	
1,400 cubic yards @ 5*s*.	350
3. Excavation to bed rock—	
22,500 cubic yards @ 2*s*.	2,250
(*b*) *Concrete* 1,000 cubic yards @ £2	2,000
(*c*) *Masonry* 28,000 cubic yards @ £1	28,000
(*d*) *Transport* 20,000 tons × 4 m. @ 3*p*.	1,350
	£34,450

(3) *Channels* :

	£
4 miles of 5′×3′ @ 30*s*. per linear yard, lined	10,560
3 miles of 4′×3′ @ 20*s*. ,, ,,	5,280
1 mile of 3′×3′ @ 17*s*. 6*p*. ,, ,,	1,540
14 miles of 1′×1′ @ 8*s*. ,, ,,	9,856
Add for distribution 5,000 donums @ £3. 15*s*.	18,750
	45,986
10% contingencies	4,598
	£50,584

SUMMARY.

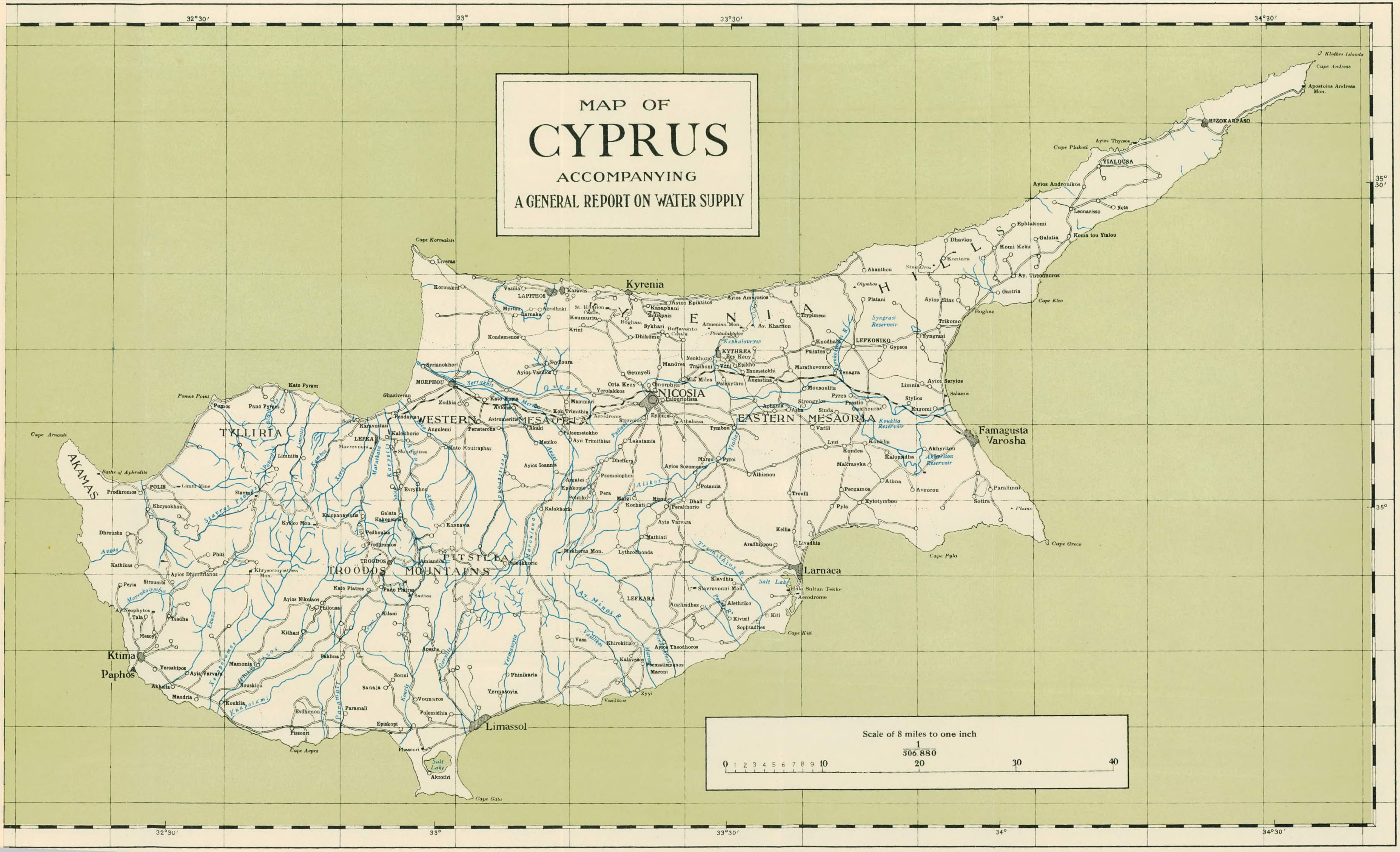
Main Dam :	£
(*a*) Excavation	11,650
(*b*) Concrete	13,350
(*c*) Masonry	80,000
(*d*) Underdrains	125
(*e*) Control gear	5,000
(*f*) Drill and grout foundations	2,000
(*g*) Transport	4,000
(*h*) Pumping	2,000
(*i*) Upstream detritus barriers	400
(*j*) Upstream silt catch-pit	3,380
(*k*) Upstream silt catch-pit grab	500
(*l*) Light railway	2,000
(*m*) Engineer (supervision)	735
	125,140
Secondary Dam	34,450
	159,590
10% *contingencies*	15,950
	175,540
Acquisition of land 370 *donums*	4,000
Channels	50,584
Total	£230,124

2. The dam will impound 4,770,000 tons of water and, allowing for inflow during spring and early summer, a total of five million tons would be available for irrigation. This would give a full summer irrigation to 5,000 donums. There is adequate good land available.

3. The recurrent expenses for management and maintenance would be :—

	£
Manager, £180—240	240
Watermen (3) @ £50 p.a.	150
Maintenance of dams and channels	250
Counter-alluviation work	1,000
Anti-malarial measures, say	500
Contingencies	210
Total	£2,350 p.a.

In such a scheme it might be possible to charge one pound per donum for a full season's watering, leaving £2,650 to repay capital expenditure and interest. At 3% over 50 years this would repay £68,180, which is not quite a third of the total expenditure. The scheme is quite uneconomic. Any suggestion that the capital expenditure might be reduced by savings in channelling and distribution will merely reduce the irrigable area in a greater proportion.



Government Railway