A REVIEW

OF

WATER MANAGEMENT

IN

METROPOLITAN ADELAIDE

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INTRODUCTION

1.1 HISTORICAL DEVELOPMENT OF SOUTH AUSTRALIA

The foundation of the State of South Australia and the establishment of the capital city Adelaide was a direct consequence of two great expeditions between 1828-30 which were led by Captain Charles Sturt - the man who has often been described as the father of Australian exploration.[1] The expeditions were undertaken with the support of Governor Darling in an attempt to solve the puzzle of the source and destination of the river system in Eastern Australia, and with the view of seeking out the existence of any well-watered land in the interior of the continent.

The most remarkable journey which was commenced in 1830 was to become perhaps the most important piece of inland exploration in Australian history. It was this journey which discovered the junction of the Murrumbidgee and the Darling with the Murray, and which traversed and charted the whole course of the great river to the great lake at its mouth. Furthermore, the success of this expedition soon led to the chartering of all the main tributaries of the Murray which form the arteries for an enormous array of lesser rivers and streams. These drain the water from more than one million square kilometres of the Australian continent. In this way, the river expedition was also responsible for the discovery and the eventual colonization of vast new, rich and well-watered territory.

Indeed, soon after the completion of this historic journey, reports were enthusiastically received in England that the land near the lower reaches of the river were suitable for settlement. In response to this information a new South Australian Association was soon formed and the British Government was approached to legislate for the foundation of a new colony. In 1834, the British Government finally passed the Foundation Act, and subsequently appointed a Board of Colonization Commissioners to establish the Province of South Australia. Captain John Hindmarsh was appointed as the first Governor to the Province, and Colonel William Light was chosen as the first Surveyor-General.

Colonel Light was instructed to carry out the difficult and urgent task of locating a suitable site for the colony's first settlement, and thereafter to prepare a plan for both the town and the surrounding district. The task was made even more difficult by two additional directives, namely that he was to investigate some 2,400 kilometres of coastline prior to making a choice, and that the settlement should be placed as near as practicable to the mouth of the River Murray. Furthermore, the Board of Commissioners unwisely promised that the work would be completed within a few months.

Despite the enormity of the task and unceasing criticism and hindrance which he received, Light handled it with great ability. After sailing along much of the coastline from Encounter Bay to Port Lincoln and beyond, and having examined several possible sites, Light finally chose the present site of the capital city Adelaide as the one most suitable for the establishment of the first settlement. The final decision was made on the 31st December 1836.

The selection of the site was largely influenced by the physical features of the countryside (see Figure 1). In essence, the city of Adelaide occupies a central and commanding position on the banks of the River Torrens about 40 metres above sea level and some 11 kilometres inland from the Gulf of St. Vincent and a safe port. The Mount Lofty Ranges rise steeply from the Adelaide Plains to a height of over

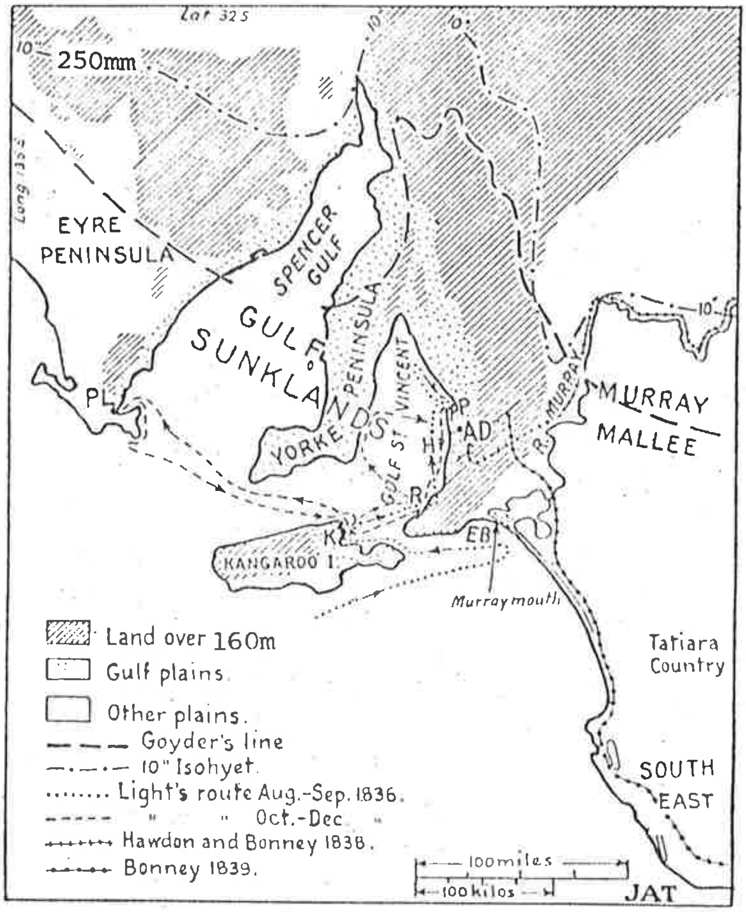


FIGURE 1[2]

Map of portion of South Australia illustrating journeys associated with the founding of the capital and early settlement. AD., Adelaide (Light's choice); P., Port River; H., Holdfast Bay (Hindmarsh's landing); R., Rapid Bay (Light's first landing); K., Kingscote (Company's first station); P.L., Port Lincoln (Samuel Stephens's choice); E.B., Encounter Bay (Hindmarsh's choice).

700 metres, and yet, the foothills of the ranges are within 7 kilometres of the centre of the city. This provides Adelaide with an outstanding natural asset which is visible from the entire metropolitan area.

The justification for the selection of the site can be found in Light's description of the area:[2]

> "... in comparison with all other parts I have seen of this coast the capabilities of the country are so superior, the soil so good, the plains in the immediate vicinity so extensive and the proximity of a plentiful supply of excellent fresh water all the year round ... the probability also of one of the plains extending as far as the Murray River ... and the easy communication with the harbour ..."

Following the selection of the site for Adelaide, Colonel Light proceeded to survey and plan the city. Although this work took only 3 months to complete, the overall concept for the city with its public squares, wide streets and surrounding belt of parklands, has since been widely acclaimed. Moreover, the concept has been widely retained to this very day as the framework for the modern city of Adelaide.

During the next two years, Light endeavoured to survey the country lands but was subjected to constant frustrations, hindrances and disappointments. Even so, his inadequate survey team eventually laid out the fertile country to the south of the city. Sadly though, Colonel William Light died in October 1839 before his allotted task could be finally completed.

The invaluable contribution of this great pioneer to South Australia and the city of Adelaide has been proven by more than a century of development. Indeed, there could be no finer memorial to Colonel William Light than the preface which appears in the Surveyor-General's own Journal:[3]

"The reasons that led me to fix Adelaide where it is I do not expect to be generally understood or calmly judged at present. My enemies, by disputing their validity in every particular, have done me the good service of fixing the whole of the responsibility upon me. I am perfectly willing to bear it, and I leave it to posterity, and not to them, to decide whether I am entitled to praise or to blame."

The growth and development of Adelaide into a large metropolis of more than 900,000 people in just over 135 years indicates the suitability of the selected site for the capital city of the State. Furthermore, the foresight shown by siting the original settlement away from the harbour, which was most uncommon at that time, has resulted in the principal business district being centrally located in relation to the metropolitan area, thereby allowing less congestion today than is often the case in many other cities of comparable size.

The metropolitan area of Adelaide has also developed in a manner somewhat different to most cities which usually expand steadily outwards. The early development of the Adelaide Plains was not contained within the city or adjacent land. Instead, several smaller settlements were established over the plains and along the coast. In time, the local communities expanded along with the city until after more than 135 years all the individual settlements have grown together to form one metropolitan area, based on the planning framework initiated by Colonel Light. This process of coalescence is now virtually complete, and the city of Adelaide is now expanding in the same way as most other cities in the world - the direction of the expansion being dictated by the physical features or topography of the land.

1.2 TOPOGRAPHY OF METROPOLITAN ADELAIDE

The selection of the site and the plan for the city of Adelaide was greatly influenced by the topography of the area. There are four major topographical features which are of fundamental importance to the post and future development of the metropolitan district. Namely, the wide and fertile Adelaide Plains on which the main part of the metropolitan area is situated, the Mount Lofty Ranges which form a natural barrier to residential development to the east of the city, the Gulf of St. Vincent which prohibits further expansion to the west of the city and established residential areas, and the undulating country to the south of the city which has for some years now been gradually given over to residential development.

The city of Adelaide and its environs are thus flanked on the west by the sea, and on the east by the Mount Lofty Ranges. The ranges are composed of rocks which were initially deposited some 500 to 1,750 million years ago in the Proterozoic period - although rocks from the Archoeozoic era more than 1,750 million years ago have been found. Some 60 million years ago earth movements began which produced the present Mount Lofty Ranges, and these continued until about one million years ago when the ranges had been raised to their present height. The movement which caused this topographical reorganisation occurred along several distinct fault zones which still represent the areas of greatest earthquake risk. Examples of these fault lines are the Eden Fault which extends some 36 kilometres from Golden Grove to Marino, and the Willunga Fault which extends from Mount Bold Reservoir to Sellicks Beach.

The river systems which drain from the ranges and across the Adelaide Plains to the sea have generally resulted from the formation of the ranges. The exceptions are the River Torrens and the Onkaparinga River which were in existence prior to the geological upheaval. During the topographical changes, these two rivers continued to flow sufficiently to retain their character and function, with the result that they gradually incised the ranges and are now seen to flow through gorges which are tens of metres deep. However, the faulting and subsequent erosion created new rivers such as the Gawler River, the Little Para and the Sturt to name just a few.

The many rivers and tributaries which flow from the ranges to the sea have slowly deposited successive and extensive layers of sand, gravel and clay thereby forming the flat areas of the Adelaide Plains which extend from Brighton in the south to Gawler in the north (and beyond). It is on this section of land that the major development of the Adelaide metropolitan area has taken place. This is illustrated by Figure 2.

Along the coast, adjoining the Adelaide Plains, the topography consists of two distinct formations. From Outer Harbor to Marino there is approximately 30 kilometres of sand forming magnificent beaches. These are backed by a narrow belt of sandhills which rise to a height of about 12 metres in the few places which have been left more or less undisturbed. Elsewhere, the sandhills have been flattened to make way for residential development. Beyond the sandhills, the residential sprawl of the city has claimed all available land - even the low lying and once badly drained areas around Glenelg and Port Adelaide. To the north of Outer Harbor, the sparkling white beaches and sandhills no longer predominate. Instead, the coast consists of mud flats and mangrove swamps which virtually extend the entire distance to the head of the Gulf of St. Vincent.

Beyond the Adelaide Plains to the south lie the Noarlunga and Willunga Basins where the land is rich and gently undulating, and where sheer cliffs and sandy bays alternatively predominate the coastline. It is through this area that the Onkaparinga River winds its way from the hills to the sea.

The topographical features of the city of Adelaide and its surrounding metropolitan area have, in the past, been the most important factors which have moulded the development of the city. They will continue to exert the same influences in future years.

1.3 CLIMATIC CONDITIONS

1.3.1 General

The city of Adelaide has a southerly latitude of about 35°. As a result, its climate is characterised by hot dry summers and mild to cool wet winters - which is in reality very similar to the climate found in the Mediterranean area. Indeed, Adelaide's climate can be likened to that of Cape Town, Santiago and Auckland in the southern hemisphere, and Los Angeles, Bermuda and Athens in the northern hemisphere.

As would be expected, the proximity to the city of both the Mount Lofty Ranges and the sea exert a strong influence over local climatic conditions. These will be discussed in the following sections on rainfall and temperature respectively.

1.3.2 Rainfall

The position of the Mount Lofty Ranges with respect to Adelaide and the metropolitan area has a marked effect on the distribution of rainfall around the city. The ranges lie at an angle of about 30° to the direction of the prevailing winds which carry moisture-laden air across the State from the Antarctic Ocean to the south. This has the effect that the rainfall tends to concentrate around the ranges and the foothills rather than to be evenly distributed over the metropolitan area. In fact, the uneven distribution of rainfall is quite obvious by examination of an isohyet chart for the metropolitan area (see Figure 3). This shows that the rainfall varies from as little as 450mm. at the northern limits of the metropolitan area to about 650mm. along the foothills, increasing to about 1,200mm. at the summit of Mount Lofty which is some 727 metres above sea level. The city of Adelaide itself has an average of only 530mm. of rain each year. In fact, Adelaide has often been referred to as the capital of the driest State in the driest continent of the world - a claim which is substantiated by the fact that only about 3% of the State receives an annual rainfall in excess of 510mm. (see Figure 4).

The majority of the rain which falls on the metropolitan area each year comes from a general westerly direction between the months of April and October.[4] During this period of time about 50% of the total annual rainfall is deposited between May and August (see Figure 5). In the summer months from November to March rainfall is low (only about 100mm.) and dry hot sunny days are the norm. Nevertheless, there are occasions when tropical monsoons in the north of the continent so influence Adelaide's weather conditions that heavy summer rains are experienced. It is only during these periods that the humidity rises to unfamiliar levels.

1.3.3 Temperature

Monthly temperature variations[4] are shown in Figure 6. In general, the average maximum temperatures which occur during the summer months vary between 25°C and 30°C, and during winter between 10°C and 15°C. It is not surprising therefore to find that although Adelaide occasionally experiences very hot unpleasant days which are marked by the flow of hot air from the northern interior, very rarely are extremes of cold experienced.

On an average the temperature on the Adelaide Plains exceeds

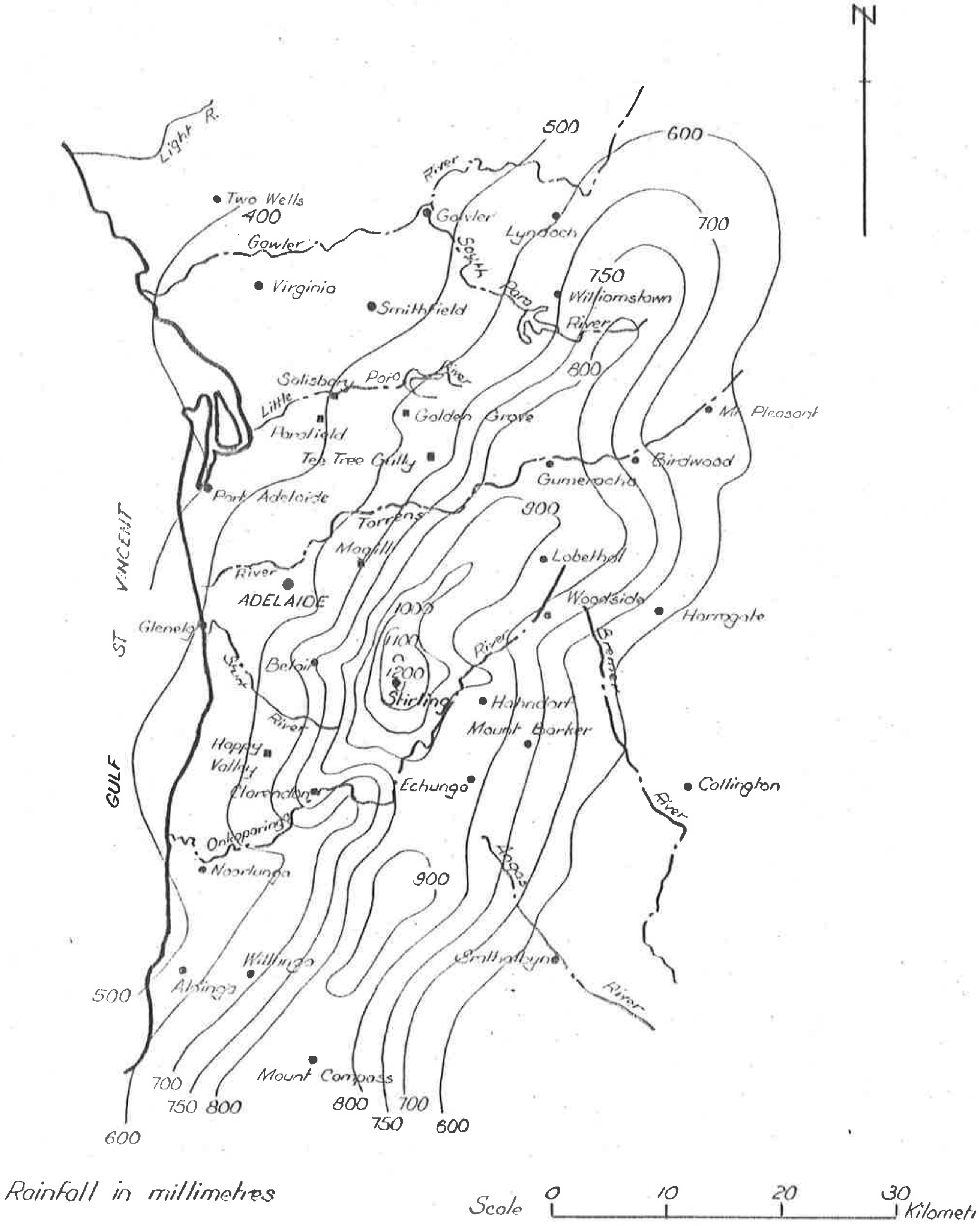


FIGURE 3
RAINFALL MAP OF
METROPOLITAN ADELAIDE

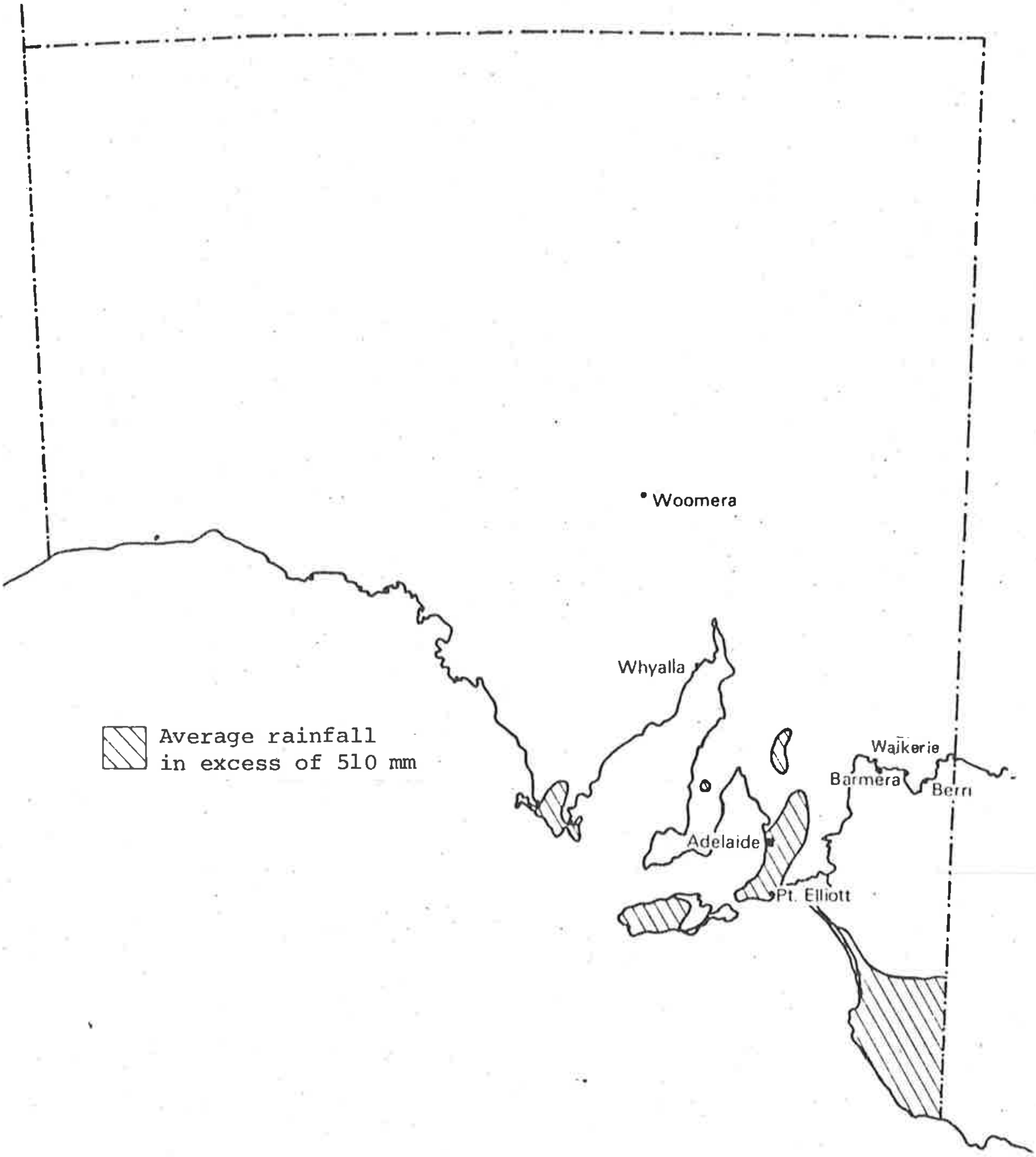


FIGURE 4

Rainfall distribution in South Australia

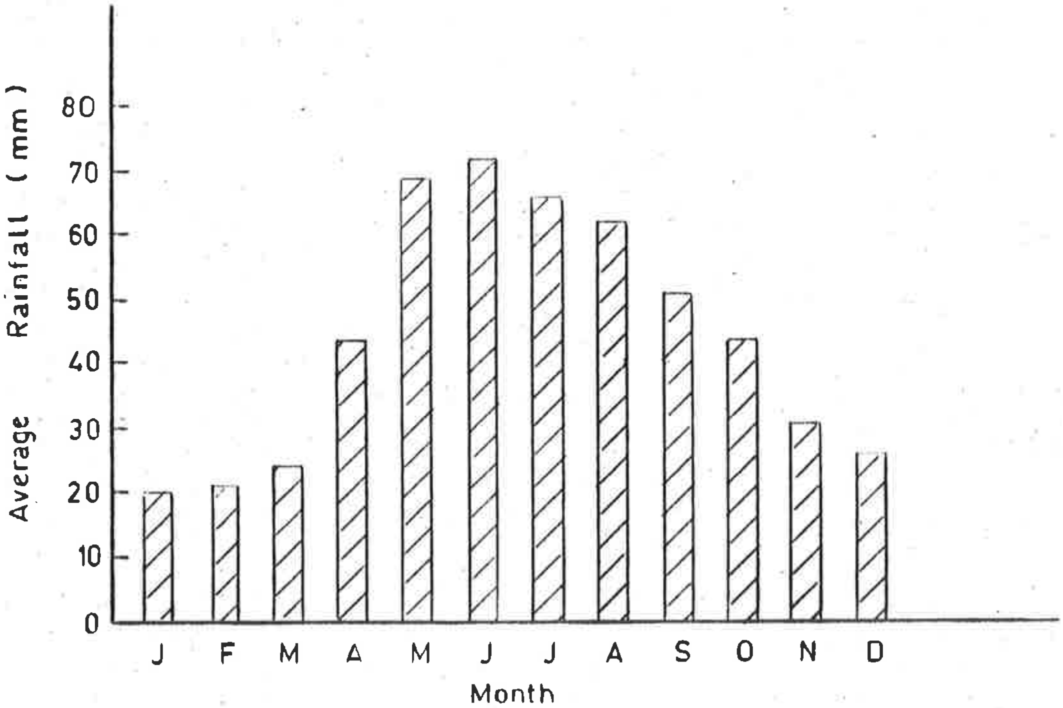


FIGURE 5

Monthly Rainfall Variations (Adelaide)

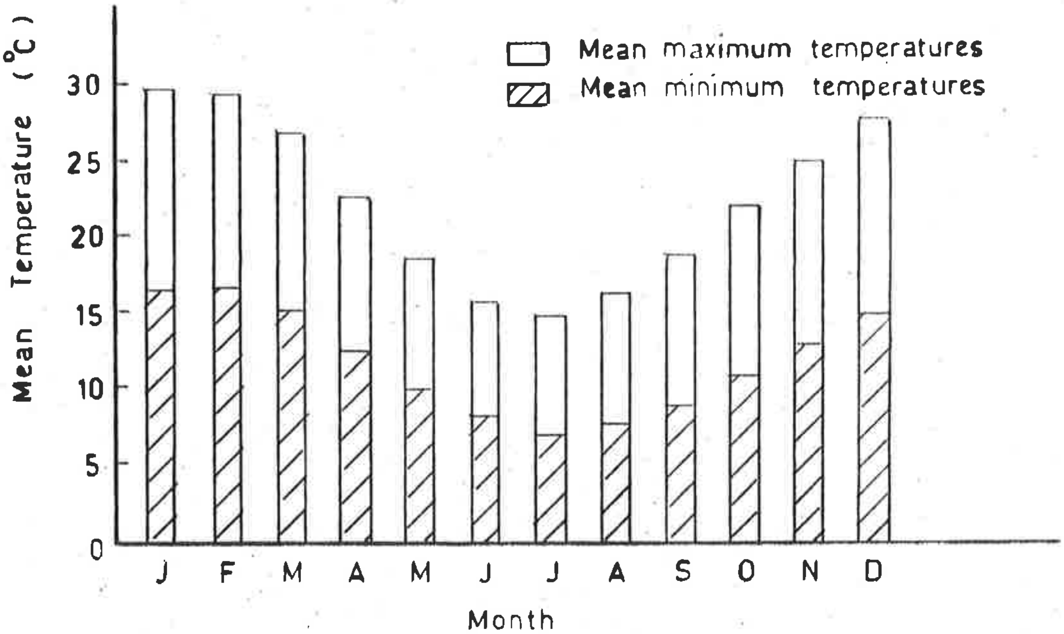


FIGURE 6

Monthly Temperature Variations (Adelaide)

32°C between 30 and 40 days each year, while only on 2 or 3 days each year is the temperature less than 2°C. However, in the ranges less than 15 days have a temperature more than 32°C, but more than 30 days have a temperature less than 2°C.

In addition to the actual extremes of temperature which Adelaide experiences, the mild nature of the climate is also illustrated by the limited variation in the temperature on any day. On average, the daily variation in temperature is only 10°C to 15°C during the summer, and is even less during winter - being only 5°C to 10°C on average.

1.3.4 Evaporation

Obviously the rate of evaporation is controlled by a number of factors including rainfall, temperature, cloud cover, etc. In Adelaide there are about 2,513 hours of sunshine each year with an average of 10 hours per day in January reducing to only 4 hours per day in June. The average evaporation rates vary conversely. In January the average evaporation rate is 235mm., reducing to only 35mm. in July. The average annual evaporation is 1,465mm.

CHAPTER 2

WATER - THE INVALUABLE RESOURCE

2.1 THE IMPORTANCE OF WATER

Water has always been recognised as the most basic and vital resource required to sustain life - be it human, animal or plant life. However, in our modern day urban societies, water is important not only for the sustenance of physical life, but also for the propogation of society itself as we know it today. Water is in fact a necessary commodity for many purposes - including food production, efficient industrial operation, waterborne sewerage systems, maintenance of parks, gardens and ovals etc., and many recreational functions - namely aquatic sports, etc. It is therefore imperative that the water resources which are available to man should be carefully and wisely managed so that they can be conserved for the use and enjoyment of future generations.

Although the natural distribution of water supplies is governed by physical characteristics of an area (such as climate and topography) the process of urbanization and the endeavours of men to harness water for their own needs, has modified the natural distribution. The creation of large cities with the concentration of large numbers of people has demanded huge amounts of water to satisfy the domestic and industrial needs. These needs which were once met by local sources such as streams and wells, are now met in many ways, and often at great cost. They include the impoundment of water in reservoirs and rivers and the subsequent diversion of the water into the city - often over long distances, and the recovery of good quality water from bad by the use of modern desalination techniques. It is therefore obvious that the aspect of water supply planning in the scope of total water management is an extremely important urban planning function - even though it has often been considered as a mere adjunct to the normally recognised urban planning processes such as city and urban design, land use planning, aesthetics, etc.

The second important aspect of water management has only risen to prominence during the last few decades. This aspect is the conservation of the existing water resources and the maintenance of water quality. The realization of the importance of these functions has grown out of a public concern for the quality of the environment and the conservation of our natural resources. However, this aspect of water management is the most difficult to plan and control. Indeed, the very structure and operational processes of the urban society tend to hinder rather than aid the objectives needed to maintain a good quality and hygienic water supply.

In our modern day societies, water is used as the disposal medium for both domestic and industrial wastes. These wastes are discharged into rivers, lakes, oceans as well as into the land itself. The result of these actions are polluted rivers and other water resources, rapid eutrophication of lakes, the endangerment of plant and animal life, and the degrading of recreational and aesthetic benefits of the water resources. The extent of pollution, however, is largely dependent on two factors. Firstly, the degree of treatment which is given to the waste prior to its discharge to the environment, and secondly, the quantity of waste discharged in comparison with the receiving body of water and the dilution effect which is then possible.

In addition to these major and generally obvious causes of pollution, a further cause can result from the physical arrangement and structure of the urban area itself. Stormwater discharges can be highly contaminated with pollutants which have been washed from urban streets and other paved or impervious areas. The land disposal of both solid and liquid wastes can contribute to the biological and chemical contamination of valuable groundwater resources. The destruction of natural vegetation during urban and other development increases the rate of stormwater and wind erosion which can in turn cause a build-up of silt and sediment in water courses and larger water bodies. This aids the process of eutrophication and severely limits the benefits of the water resource.

It is therefore apparent that the water resources for urban areas are not only altered, but are also endangered by the urbanization process. Nevertheless, it is possible to control and minimize the effects of urbanisation of the water resource by a process of comprehensive water management and water quality planning. Indeed, the study of water management should be considered as a basic factor in any urban planning process to ensure the provision of a safe and adequate supply of potable water which is essential to the health and welfare of the urban population, and to the possible growth and prosperity of society itself.

2.2 THE SOURCES OF WATER FOR MAN'S USE

2.2.1 The Total Water Resource Situation

It has been estimated[5] that of all the water in the world, more than 97% is in the oceans. It is further estimated that more than 2% is locked up in the ice formations of the Arctic and Antarctic. The remaining 1% or less of the world's water resource make up the only fresh water resources which can easily be used by man (without resorting to complex and expensive processes such as sea-water desalination). Moreover, these sources of water are continually replenished (albeit sometimes slowly) by the natural chain of events known as the hydrological cycle[6] which is illustrated in Figure 7. The series of events which make up the earth's water cycle consists of:

(a) The evaporation of water into the atmosphere from the earth's moist surfaces including rivers, lakes, soil

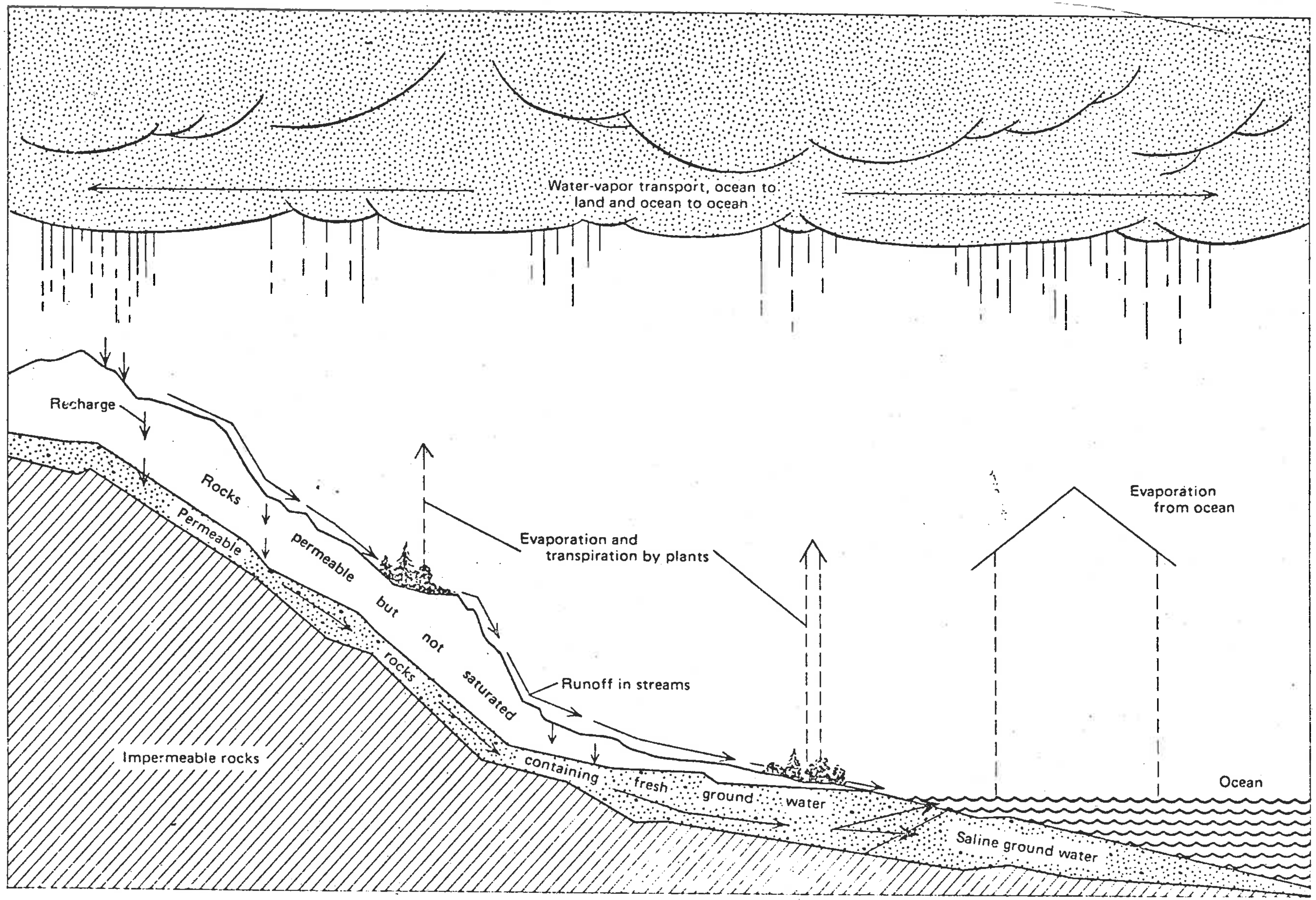


FIGURE 7
The hydrological cycle

and the oceans. This is the largest source of water vapour. The release of water vapour into the atmosphere by plant transpiration and by animal respiration.

(b) The cooling and condensation of the water vapour onto nuclei to form liquid or solid water, and the collection of these tiny droplets into larger drops.

(c) The precipitation of this fresh water back to the earth as rain, hail, snow or sleet.

(d) The return of the water back to the sea again, and to the rivers, lakes, icefields and soil from whence it came.

However, it is considered that this seemingly low percentage of useful water will be sufficient to satisfy the requirements of man far into the twenty-first century, provided that suitable measures are taken to conserve the available supplies by maintaining the water quality and by recycling wherever possible.

Table 1[6] shows an estimate by the U.S. Geological Survey of the distribution of the world's total supply of water.

TABLE 1 - World's estimated water supply

Location	Surface area (square kilometres)	Water volume (cubic kilometres)	Percentage of total water
Surface water:			
Fresh-water lakes -----------	855,000	125,000	0.009
Saline lakes and inland seas ---------------	690,000	104,000	.008
Average in stream channels --	-----------	1,250	.0001
Subsurface water:			
Water in unsaturated zone (includes soil moisture) --)		(67,000	.005
Ground water within a depth of half a mile ------)	130,000,000	(4,170,000	.31
Ground water - deep lying ---)		(4,170,000	.31
Other water locations:			
Icecaps and glaciers --------	17,900,000	29,000,000	2.15
Atmosphere (at sea level) ---	510,200,000	13,000	.001
World ocean ----------------	361,300,000	1,321,000,000	97.2
Totals (rounded) --------	-----------	1,359,000,000	100

2.2.2 Groundwater Resources

It is noticeable that most of the fresh water available to man exists in the form of subsurface water or groundwater. However, there are a great many problems associated with the extraction and use of this water. The main problem areas are the cost of extraction, the suitability of the water for man's use, and the rate of recharge of the source. It is for this reason that the estimate for groundwater has been divided into two parts - namely, groundwater within a depth of 800 metres of the surface and deep lying groundwater.

The deep lying groundwater is not generally considered as a useful water resource as it is often salty, not easily recharged even over hundreds of years, and is very costly to extract and use. On the other hand, the shallow aquifers more often contain fresh water and can be recharged more rapidly than their deeper counterparts. Nevertheless, the rate of recharge can be highly variable depending on the source of recharge, the surrounding rock formations and the climatic conditions in the area. In regions which experience heavy rainfall, the recharge rate can be very rapid, whereas in semi-arid regions, the recharge rate may be extremely slow and result in the eventual drying-up of existing sources.

Despite the problems associated with the extraction and use of groundwater, this source of water is extremely valuable to man. However, it should be recognised that the location and movement of groundwater is very complex and depends on many other factors which must be clearly understood if these resources are to be managed successfully.

2.2.3 Surface Water Resources

Although the surface water resources make up only a very small proportion of the total water in the world, they are the most commonly recognised water sources for our cities and towns. This is undoubtedly due to the fact that it is the water which is visible in rivers, lakes and reservoirs, and it is also the cheapest to procure. As a result, the surface waters have traditionally been the first to be used and the most eagerly sought for water supplies.

The rivers, lakes and reservoirs are replenished with water mainly by rainfall on the one hand, or by melting ice and snow on the other. However, the natural processes leading to the precipitation of rain or snow are far more complicated than is generally imagined due to the constant movement of the moisture laden air masses and the continuous mixing and transfer of water in the hydrological cycle. A further source of replenishment for rivers is the adjacent groundwater sources. These aquifers fill during periods of high river flows, and then during times of low rainfall water is discharged from the aquifers back into the river system. It is therefore obvious that rivers and aquifers are interdependent and should be considered as such during the planning and management of surface water resources.

Insofar as the distribution of surface resources is concerned, it is known that most of the fresh surface water is to be found in the large lakes on three continents. Many of the major lake sources of surface water are on the North American continent (e.g. The Great Lakes). It has been estimated that this continent holds about 26% of all the liquid fresh water surface water in the world. Likewise, the African continent is estimated to contain in its lakes about 29% of the world's fresh liquid water. Finally, the Asian continent contains about 21% of the total - mainly in Lake Baikol. In total, therefore, these three continents hold approximately 75% of the fresh water in the world in their large lakes.

In stark contrast, the other three continents of Europe, South America and Australia contain only about 2% of the world's fresh water in large lakes. The remaining 23% approximately of fresh water in the world is found to exist in the many thousands of rivers and smaller lakes which are scattered throughout the continents and sub-continents of our globe.

2.3 THE WATER RESOURCES IN AUSTRALIA

Before looking at the water resources for South Australia it is relevant to briefly examine the wider Australian resource. The Australian Water Resources Council has divided the Australian Continent into 12 surface water drainage divisions, which are shown on Table 2 with details of area and average annual run-off.[7]

TABLE 2 - Australian Drainage Divisions

Drainage Divisions		Area sq. kilometres	Average Annual Run-Off	
			Million Megalitres	Millimetres
I.	North-East Coast	454,000	83.1	182
II.	South-East Coast	268,300	36.5	136
III.	Tasmania	68,400	47.3	690
IV.	Murray-Darling	1,056,700	23.7	22
V.	South Australian Gulf	75,400	0.5	7
VI.	South-West Coast	140,100	(a) 7.2	52
VII.	Indian Ocean	519,800	(b) 6.2	12
VIII.	Timor Sea	539,500	74.5	138
IX.	Gulf of Carpentaria .	640,800	63.3	99
X.	Lake Eyre	1,143,700	4.5	4
XI.	Bulloo-Bancannia	100,800	0.4	4
XII.	Western Plateau	2,679,300		0
	AUSTRALIA	7,686,800	347.2	45

NOTES - (a) Not less than 3.4 million Megalitres saline - unsuitable for normal use.

(b) Not less than 1.17 million Megalitres saline - unsuitable for normal use.

In summary we can say that Australia is the driest continent in the world as substantiated by the following information: about one-third of the continent is desert; more than half of it receives an average annual rainfall of less than 380mm.; and the average annual rainfall on the mainland is 430mm., compared with 660mm. for all land areas in the world. Australia's average annual volume of run-off has been estimated at 350 million Megalitres, which represents an average depth of 45mm., compared with 248mm. for all land surfaces.

2.4 WATER RESOURCES IN SOUTH AUSTRALIA

2.4.1 General

The major surface water resources for South Australia, and Adelaide in particular, are to be found in the South Australian Gulf Drainage Division V which lies totally within the State and contains all the important reservoirs, and the Murray-Darling Drainage Division IV which extends across the three States of New South Wales, Victoria and South Australia. Figure 8 indicates the extent of these and other divisions in South Australia.

The remainder of the State is covered by three divisions which have little significance for surface water resources. They are the Lake Eyre Drainage Division in the north-east, the Western Plateau Drainage Division in the west and the South-East Coast Drainage Division in the south. Although these divisions are not important to the State as surface water resources, the latter two in particular have great importance as underground water resources.

2.4.2 South Australian Gulf Drainage Division

The following commentary which describes the South Australian Gulf Drainage Division has been extracted from the Atlas of Australian Resources.[7] However, the technical information has been converted to the metric equivalent where appropriate.

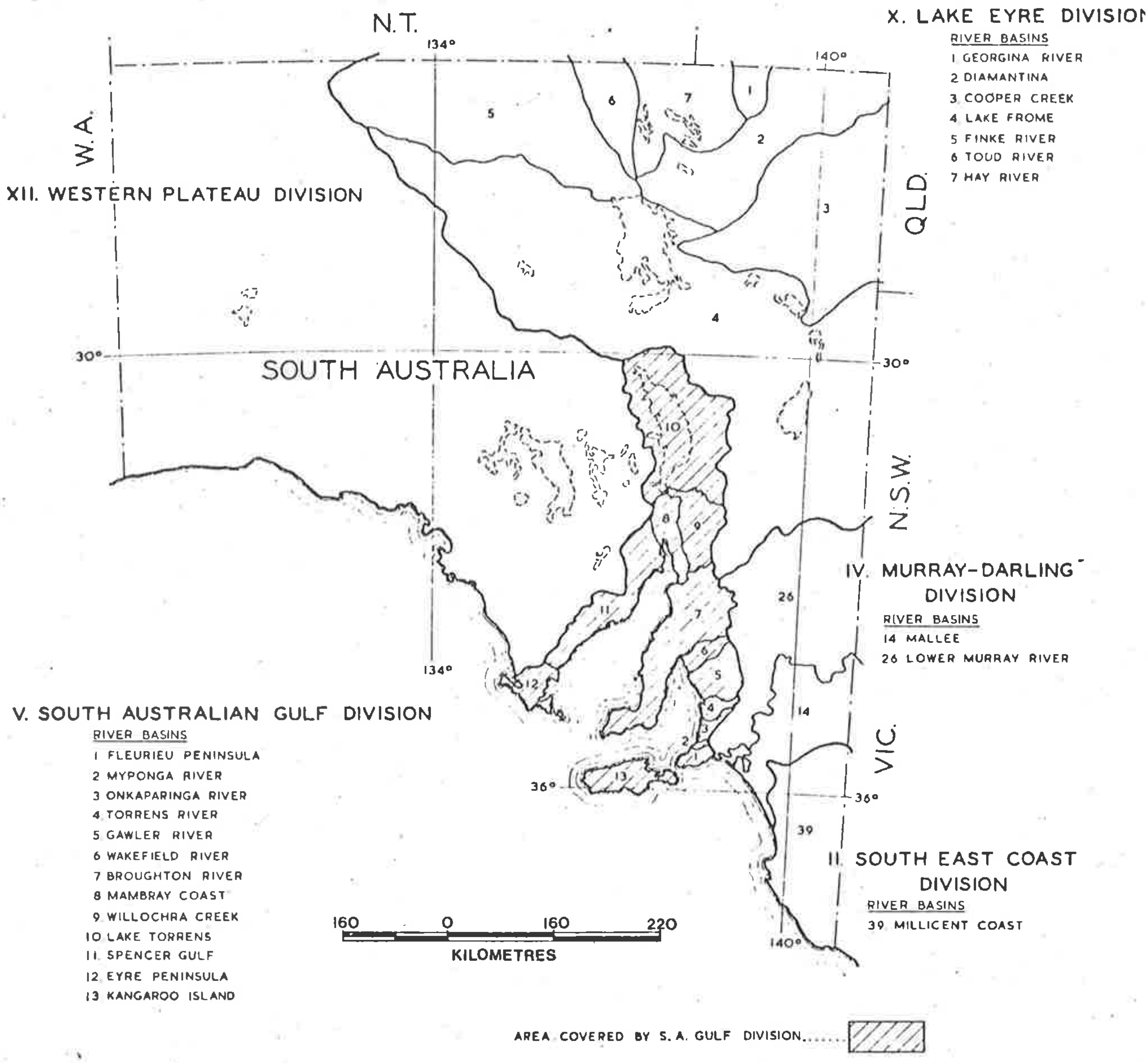


FIGURE 8

South Australia - Drainage Divisions and River Basins

"The Division is the second smallest of the drainage divisions and is the driest of the divisions (I-IX) which drain to the coast.

The eastern boundary of the division is formed partly by the Mount Lofty Ranges, which rise to nearly 730 metres east of Adelaide and to over 910 metres north of Burra, and further north it follows the Flinders Ranges, which reach a height of 1,160 metres at St. Mary Peak. The boundary then rounds Lake Torrens and, further south, the western boundary of the division is formed by a discontinuous line of hills on Eyre Peninsula. Kangaroo Island is also included. The division contains striking contrasts in topography, with the large flat area around Lake Torrens close to the rugged Flinders Ranges.

The individual river basins in this division are small. The largest, the Broughton, which includes Yorke Peninsula, has a catchment area of 16,600 square kilometres.

Rainfall in excess of 760mm. per year occurs only on a very small area in the Mount Lofty Ranges, and in the north-west of the division the average is less than 150mm. per year. In the south apart from the more elevated areas, average precipitation exceeds evaporation only during the four winter months, May to August, and over most of the division monthly evaporation rates exceed rainfall throughout the year.

The average annual run-off from the division is only some 530,000 Megalitres or 7mm., which is about a ninth of the average for the rest of Australia, excluding the Western Plateau. The division has very little run-off outside the vicinity of the Mount Lofty Ranges. (The area with run-off exceeding 125mm. per annum is less than 1,300 square kilometres.) With the tendency for concentration of rainfall in the winter months and the very high summer evaporation, there is a markedly seasonal winter run-off pattern. Although there is significant summer rainfall in the south-eastern part of the division, the antecedent conditions are usually so dry that little or no run-off results. Even the main streams, the Onkaparinga and Torrens, occasionally cease to flow in the summer.

Development of the streams in the Mount Lofty Ranges, mainly for municipal water supply, has in most cases reached the practicable limit and there seems to be little scope for further development of surface water elsewhere in the division. In fact, the division has long been an area of net import of water, supplies coming by pipelines to Adelaide and Whyalla from the Murray River."

2.4.3 Murray-Darling Drainage Division

The Murray River is the only major river that discharges to the ocean in South Australia, and even this river has its origins outside the borders of the State in the drainage basins of New South Wales and Victoria. Notwithstanding this, the River Murray and its tributaries form what is the largest river system in Australia. The division is just over 1 million square kilometres in extent which is, in effect, about 14% of the total area of the Australian continent. However, in comparison with world rivers[8] of comparable size, the flow to the river from the drainage area is extremely low as Table 3 indicates. This is due to the fact that less than 5% of the catchment for this river system receives an annual rainfall in excess of 760mm. - which is extremely low in comparison with other major rivers in the world.

TABLE 3

Country	River	Catchment area (square kilo-metres)	Average annual run-off (million Mega-litres)	Average Annual run-off per square mile (Megalitres)
Europe	Danube	830,000	282	340
India	Ganges	1,520,000	181	120
Australia	Murray	1,060,000	15	14

The variability of flow in the River Murray system also constitutes a relatively unusual feature for rivers of this size. Not only does the flow vary widely during any one year, but yearly variations are also quite extreme. Because of this fact, and because the river system passes through three States, an independent authority has been established to control, conserve and develop the waters of the Murray River.

The River Murray Waters Act was passed in 1915 by the Commonwealth and the States of New South Wales, Victoria and South Australia. This Act provided for the establishment of the River Murray Commission whose function was to develop the river and its tributaries to enable an economical use of the water for irrigation, navigation and water supply to be maintained, and to arbitrate between the Commonwealth and the States on riparian rights. The Act also carefully defines the water resources on the apportionment between the States as follows:[9]

> "The flow of the River Murray at Albury including the natural or regulated flows of all tributaries of the River Murray above Albury as regulated by the Upper Murray Storage shall be shared equally by New South Wales and Victoria.
>
> New South Wales and Victoria shall each have the full use of all tributaries of the River Murray within its

territory below Albury and shall have the right to divert store and use the flows thereof and shall have the right below the affluence with the River Murray of any such tributary to divert store and use volumes equivalent to those arriving at the place of diversion as the result of contribution by any such tributary in addition to any other share of the waters at the place of diversion to which each of the said States is respectively entitled under this Agreement.

All rights under this Agreement shall be subject to provision by each of the said States of New South Wales and Victoria from the flow of its tributaries or from the flow of the River Murray at Albury or both of its contribution towards the share hereby allotted to South Australia."

South Australia's share was specified as 1.552 million Megalitres which is allowed to flow into the State in defined monthly amounts, unless the River Murray Commission declares restrictions on all States. During such a period of restriction, the Commission is bound by the Act to assess the total water resources for the period and to adjust this quantity by the anticipated losses (e.g. evaporation and seepage from rivers and storages, and other special losses). The remaining water resource referred to as "the available water" is then divided between the three States in the ratio of 5:5:3, with South Australia receiving the smallest quantity.

Since the inception of the Commission, the River Murray Waters Agreement has been amended to allow for the construction of several specific projects which have been built, maintained and operated by the most appropriate State in each case under the supervision (as required) of the Commission. Although the capital cost of such projects is borne equally by the Commonwealth and the three States, the cost of operation and maintenance is shared only by the three States themselves. This has enabled the water resources of the Murray system to be progressively utilised over the past years, and now, the reservoir storage capacity within the catchment area, both on the main stream and its tributaries, exceeds some 18.56 million Megalitres, of which storages totalling some 5 million Megalitres are controlled directly by the River Murray Commission.

In recent years it has become apparent that the continual increase in water demand from the river has led to an over-commitment of the available resource, and this has accentuated the need for further storage reservoirs. As a result, it was decided to build a new storage at Dartmouth in Victoria. This project was very important to South Australia for it enabled a re-negotiation of the River Murray Waters Agreement[10] such that:

(a) South Australia's annual entitlement be increased by 304,000 Megalitres from 1.552 million Megalitres to 1.856 million Megalitres; and

(b) during times of restriction, the available water will be shared equally between the three States, and not in the ratio of 5:5:3 as was previously the case.

These amendments to the Agreement now assure South Australia of sufficient water to satisfy the existing demand for irrigation and the anticipated water supply commitments for at least another 25 years. This second assurance is particularly important to South Australia since the River Murray provides by far the largest quantity of available water for water supply purposes.

2.4.4 Other Water Resources

2.4.4.1 General

In addition to the two major water resources for the State which were discussed in sections (a) and (b), there are three important sources of underground water. These sources are located on the Eyre Peninsula on the west coast of the State, in the South-East of the State, and on the Adelaide Plains. The location and extent of these resources is shown on Figure 9.

2.4.4.2 Eyre Peninsula Resources

The underground resources of the Eyre Peninsula are all located in the relative proximity of Port Lincoln, and constitute the most important source of supply for towns and farms in the vicinity. It has been estimated that the safe annual yield of the developed underground basins is about 9,200 Megalitres. This will provide the assurance of water required to enable normal development on the Peninsula to proceed in future years.

2.4.4.3 South-East Resources

2.4.4.3.1 General

The underground water resources in the South-East constitute virtually the only significant sources of water for the region and are used extensively not only for domestic purposes, but also for horticulture and viticulture. Despite this, very little is presently known of the hydrogeology of this important regional resource, with the result that these underground water resources are still largely undeveloped.

The South-East is not a single hydrogeological unit but consists of a large number of separate or only partially connected basins and aquifers. Therefore, the over-

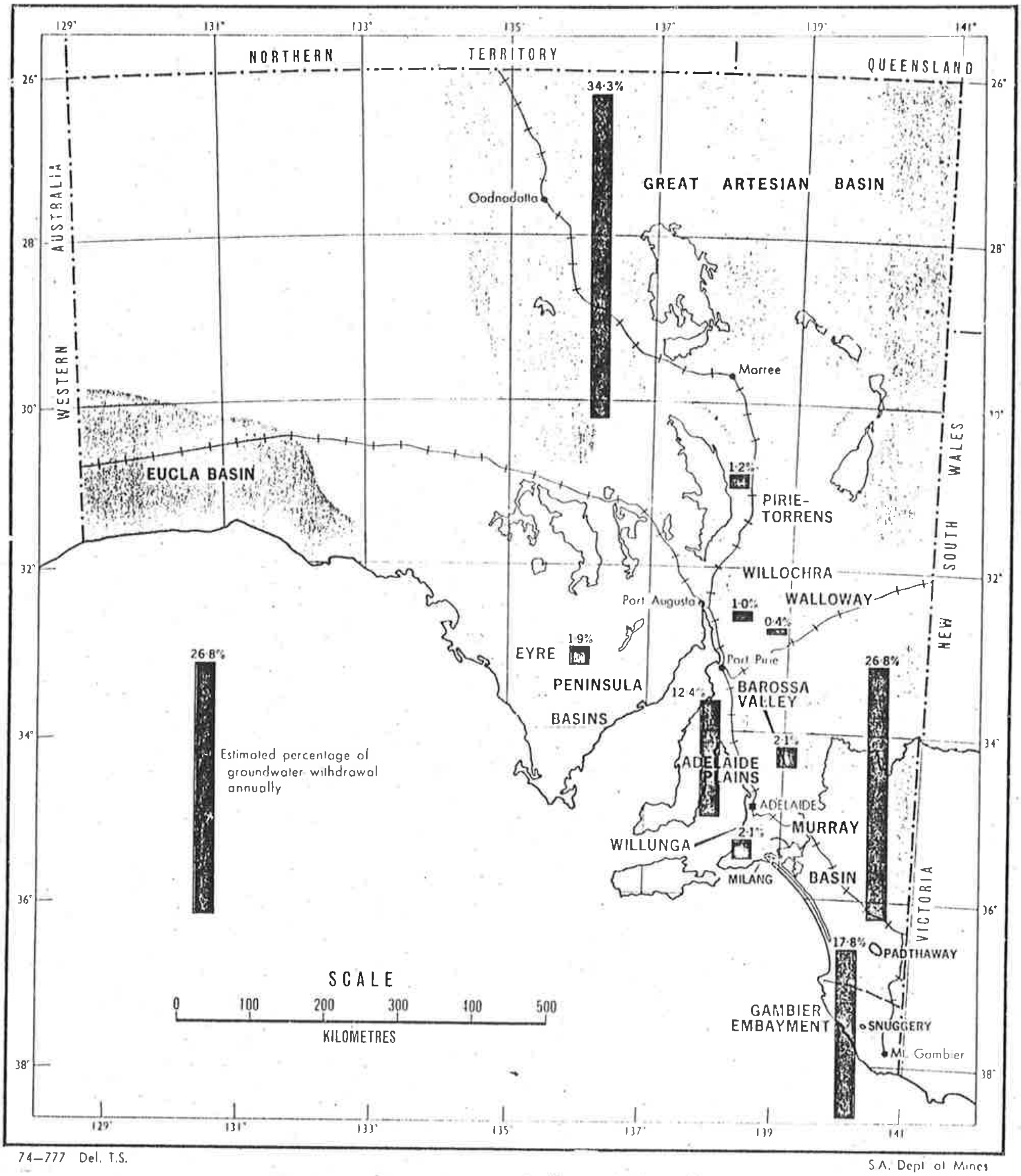


FIGURE 9

Groundwater Basins in South Australia
showing estimated percentages of water withdrawal

exploitation of any basin or aquifer could easily lead to a serious depletion of the local water table, a deterioration of water quality, and for the complete evacuation of the aquifer during a period of drought.

Of the various hydrogeological units in the region, only the Padthaway Basin has been investigated to the degree where it is possible to estimate the safe yield. However, studies have also recently been carried out to determine a rough order of the safe yield for the area of the Gambier Plain, and the Snuggery Area (see Figure 9).

2.4.4.3.2 Mount Gambier - Mount Schank

The water resources of the 1,430 square kilometre region of the Gambier Plain constitute the main source of supply for the city of Mount Gambier (which is the major regional centre in the South-East) and surrounding areas. The major town supply is from the Blue Lake which provides some 4,000 Megalitres annually for Mount Gambier. However, the lake is better known as a tourist attraction because of the unusual change of colour in the lake toward the end of November, when the colour changes from greyish blue-brown to aqua-blue in the space of a few days. The opposite change occurs more gradually from February onwards. In addition to this remarkable and, to date, unexplainable natural phenomenon, the water resource system of which the Blue Lake is only a small part is itself not as yet completely defined and understood.

A recent investigation of the water resources of the Gambier Plain has been carried out by Allison[11] using tritium techniques. This work has shown that between 160,000 and

202,000 Megalitres is discharged annually from this region to the sea. This gives an indication of the quantity of water which would be available for use, although it is expected that the actual safe yield will be much lower since it is probable that a significant flow to the sea must be maintained to prevent an accumulation of dissolved solids. Nevertheless, it is estimated that there would be sufficient water available to satisfy the expected domestic demand as well as to allow the irrigation of some 10,000 hectares of land which is considered to be suitable for vegetable production. However, both the extent and location of the horticultural development may be further limited by the possible contamination of the upper aquifer by fertilisers and insecticides.

Although there is still much work to be done to accurately determine the yield of this water resource, it is obvious that the resource is large enough to enable considerable development to take place on the Gambier Plain in coming years.

2.4.4.3.3 Northern Adelaide Plains

The final important underground water resource is located beneath the Adelaide Plains, and as such forms a valuable supplement to Adelaide's water supply. The Northern Adelaide Plains is underlain by a sequence of aquifers containing water of varying quality. The best of these aquifers contains a large quantity of good quality water which is used for the irrigation of most of the horticultural and viticultural crops on the Northern

Adelaide Plains. The demand on these aquifers by these land uses is 21,000 Megalitres per annum, which far exceeds the safe yield which is estimated to be only 7,000 Megalitres per annum. This has resulted in the serious depletion of groundwater reserves and a significant lowering of the water table. This in turn has allowed saline water from the overlying aquifers to flow downwards and contaminate the fresh water below. This is the cause of significant concern at this time for it is now apparent that if the present rate of withdrawal is continued, salinity problems will be apparent within 10 years and will be widespread and acute within 30 years.

Following hydrogeological investigations and subsequent consideration by the Underground Waters Advisory Committee, the use of water from this invaluable source was restricted, and these restrictions were subsequently tightened further. These measures have successfully held water usage down to the present level. However, more severe restrictions cannot be applied without causing hardship and social dislocation within the area. Many of the growers operate small family concerns, and the amount of water available to them is only just sufficient to maintain economic viability.

At the present time investigations are being carried out to examine ways of making additional supplies of water available for irrigation on the Northern Adelaide Plains. This would reflect in a lowering of the withdrawal rate from the aquifers. Preliminary investigations indicate that reclaimed water from the nearby Bolivar Sewage

Treatment Works could be used for this purpose as it is available in sufficient quantity and at a reasonable cost. It is therefore apparent that this proposal should be given further serious consideration. However, a number of technical and economic problems will need to be solved in the process.

In the immediate future there is therefore unlikely to be any further expansion of irrigated horticulture and viticulture in the area. Studies that are in progress will clarify technical alternatives and aid decision making processes in which the people of the area will be involved.

CHAPTER 3

WATER MANAGEMENT IN SOUTH AUSTRALIA

3.1 INTRODUCTION

> "South Australia is in a most fortunate position as regards its institutional arrangements for the public management of its water resources and its water supply and sewerage systems".[12]

In the other Australian States, and indeed in many overseas countries, including the United States of America, the responsibility for the provision and operation of water and sewerage services is split in an ad-hoc way between Federal, State and local government authorities and also private companies. This results in a complex and fragmented administration system which very often frustrates the efficient planning and development of water resources and causes unwarranted and costly delays in the provision of necessary services. Indeed, the 1962 report of the United States Advisory Committee on Intergovernmental Relations on "Intergovernmental Responsibilities for Water Supply and Sewerage in Metropolitan Areas" found that the aspect of split responsibilities was the overriding cause in the creation of almost insurmountable difficulties.

Fortunately therefore, South Australia is in the unusual position of having been endowed with a single public administration which is fully responsible for the provision of water and sewerage services throughout the State. The authority is the Engineering and Water Supply Department. There are only a few exceptions which are outside the Department's Statewide responsibility, namely:

(a) the irrigation areas along the River Murray where domestic water supplies are administered by the Department of Lands;

and

(b) the coal mining town of Leigh Creek where the water supply is the responsibility of the Electricity Trust of South Australia.

However, in both of these stated cases, the Engineering and Water Supply Department provides the services of specialized professional staff to undertake the design and construction of these water supply projects, and then to operate and maintain the services in the irrigation areas.

3.2 OPERATION AND ADMINISTRATION

3.2.1 General Organisation

The Engineering and Water Supply Department operates under the control of the Minister of Works, and is directed by the Director and Engineer in Chief, who is assisted by four Directors, viz.,

Director, Engineering Operations;

Director, Engineering Services;

Director, Administration and Finance;

Director, Management Services.

These five officers constitute "Executive Panel". Departmental policies and procedures are decided by panel and implemented by means of "directives".

Within the Department there are Branches, each dealing with a particular aspect of the Department's functions. These Branches are grouped under four major Divisions (as shown on Figure 10) as follows:-

Engineering Operations Division

This is comprised of those Branches which operate the services provided by the Department.

Engineering Services Division

This is comprised of those Branches which provide an engineering service to the Operations Division and to other outside Authorities.

FIGURE 10

THE ENGINEERING AND WATER SUPPLY DEPARTMENT

ORGANISATION CHART

DIRECTOR AND ENGINEER IN CHIEF

DIRECTOR
ENGINEERING OPERATIONS

BRANCHES

- Water Supply
- Sewerage
- Mains Extension
- Water & Sewage Treatment
- Operational Services

DIRECTOR
ENGINEERING SERVICES

BRANCHES

- Design
- Construction
- Survey
- Irrigation & Drainage
- Water Resources

DIRECTOR
ADMINISTRATION AND FINANCE

BRANCHES

- Administration
- Accounting
- Revenue
- Supply
- Property
- Plant
- A.D.P. Services

DIRECTOR
MANAGEMENT SERVICES

BRANCHES

- Organisation Services
- Safety
- Library
- Personnel & Staff Development
- Co-ordinating

Administration and Finance Division

This is the third major group in the Department, and is directly linked to the Engineering Divisions by the mutual need for budgetary control, regular costing and payment for engineering works whether by day labour or by contract.

Management Services Division

This Division was formed to provide specialized management support services to the other Divisions. These services cover several fields such as organisational methods, management science applications, personnel and staff development, and safety. The Division is also responsible for the Department's network scheduling system, which controls the various pre-construction activities to provide an integrated system which ties in with the financial budgeting programme.

3.2.2 Engineering Divisions

3.2.2.1 Engineering Operations Division

The Engineering Operations Division is made up of five Branches as follows:-

(i) Water Supply Branch

(ii) Mains Extension Branch

(iii) Sewerage Branch

(iv) Water and Sewage Treatment Branch

(v) Operational Services Branch

Water Supply Branch

This Branch is responsible for all water supply operations and maintenance throughout the State. The approximate capital value of its undertakings is $300 million, and there are some 21,000 kilometres of water mains in the metropolitan and country areas, 20 major storages or reservoirs, together with numerous pumping stations, serving a population of over 1 million people.

For the purposes of administration, the State has been divided into five regions, each under the control of a Regional Engineer. Headquarters have been established for each region at Port Lincoln, Crystal Brook, Mount Gambier, Kent Town and Elizabeth.

Head Office administration is carried out by the Engineer for Water Supply with two Assistants - one for Country and one for Metropolitan operations.

In addition, there is a Planning Section which is responsible for the planning of metropolitan and country water supply projects and the various distribution systems, and a Pumping Engineer who plans pumping programmes in an endeavour to achieve economy of operation for the distribution network of major pipelines, in particular the Mannum - Adelaide. He also runs frequent tests on pump efficiencies.

Until December, 1966, the Branch was responsible for the maintenance of a considerable mileage of roads outside those administered by the Highways and Local Councils. This was a legacy from the days prior to the foundation of the Highways and Local Government Department.

Mains Extension Branch

This Branch was formed in May, 1965, to deal directly with the public, the building industry and the land subdivision industry requiring extensions of water supply and sewerage systems and desiring to subdivide land.

It co-operates to a large degree with the Water Supply and Sewerage Branches.

Sewerage Branch

This Branch is responsible for sewer reticulation throughout the State. Until recent years, undertakings were in the metropolitan area, but an increasing volume of work is being carried out in country towns, e.g. Naracoorte, Gumeracha, Mount Gambier, Port Lincoln, Myponga and Angaston. The length of sewer mains laid in South Australia at present is in excess of 4,800 kilometres and serves a population of approximately 900,000. The approximate capital value of mains is $120 million.

The Branch is subdivided into Sections which deal with its own domestic engineering functions of Planning, Design, Construction and Operation, in addition to the work carried out for it by the Design Branch.

Water and Sewage Treatment Branch

This Branch was formed in August, 1943. Prior to that date, the work had been the subject of private consultants to the Department, and later of the Sewerage Branch.

The function of the Branch is to provide, utilising the services of the Design and Construction Branches, the complete investigation, planning, design, construction and operation of works necessary for the treatment of public water supplies, sewage and trade waste systems.

An example of a major project supervised by the Branch is the Bolivar Treatment Works (approximately $18 million), where a very modern laboratory provides constant information (by sample testing and analysis) concerning water quality, sewage toxicity, etc.

Operational Services Branch

This Branch was formed in 1975 with the responsibility to rationalize the activities of the various departmental workshops, and to undertake any future development of these and associated facilities. Prior to the formation of this Branch there were a number of workshops and depots throughout the metropolitan area which were separately controlled by several different operational Branches. This resulted in a high proportion of duplication of facilities, equipment and skilled staff, which led in turn to uneconomical workshop operations. However, under the direction of one Branch, these operations will be centralized where possible, and moulded into a much more economically viable unit.

3.2.2.2 Engineering Services Division

The Engineering Services Division is made up of five Branches as follows:-

(i) Design Branch

(ii) Construction Branch

(iii) Survey Branch

(iv) Irrigation and Drainage Branch

(v) Water Resources Branch

Design Branch

This is administered by the Engineer for Design and two Assistants, and is divided into Sections, viz.

(a) Services (Mechanical and Electrical, Hydraulics, Soils, Architectural, Specification and Estimating)

(b) Structural

(c) Headworks (Dams and Pipelines)

(d) Treatment (Sewage Treatment, South East Drainage)

In addition plans are stored, and tender drawings, specifications, etc. are issued, from the Plan and Tender Room.

There is also an official photographer who is a member of the Design Branch.

This Branch establishes the standard of Engineering Design in the Department and continually reviews that standard. Technical advice and assistance is provided for other Branches.

Construction Branch

This Branch is responsible for the construction of major civil engineering works by day labour, by contract or a combination of both for the Department or other Government Departments and Authorities.

Of necessity, the various work forces are spread throughout the State, moving as each project is completed and then commencing another.

The large volume of equipment and plant necessary to carry out the Branch functions is maintained at, and distributed from, the Department's major depot at Ottoway.

Survey Branch

The Survey Branch provides service for all Branches of the Department, and is staffed with qualified Surveyors and other skilled technical personnel. Accurate work and the intelligent evaluation of that work can represent considerable savings in the ultimate total expenditure of a project, particularly if evaluation occurs in the stage of planning and development.

Irrigation and Drainage Branch

This Branch originated as an Irrigation Department which functioned as a separate autonomy until 1923 when an Irrigation and Drainage Commission was formed. The Irrigation Act, 1930, abolished the Commission and placed the authority for administration of the Act under the Minister of Irrigation.

The work of both the former Irrigation Department and the Department of Lands and Survey was amalgamated under the Director of Lands and the staffs merged with the exception of the Engineering Section which was transferred to the Engineering and Water Supply Department, and engineering functions were and still are carried out by the Irrigation and Drainage Branch. Advisory work is provided for other Branches and Departments (e.g. Agriculture, Lands, Sheriffs and Gaols, Aborigines), also Renmark Irrigation Trust and others.

The Branch is responsible for the operation of the River Murray in South Australia, and for the maintenance of the Metropolitan Floodwaters Scheme involving portions of the River Torrens and the Sturt, Keswick and Brownhill Creeks. It also provides the engineering services for the South Eastern Drainage Scheme.

Water Resources Branch

This Branch was established in April 1975, and is administered by the Engineer for Water Resources and his Assistant, and is divided into four Sections, viz.

(a) Administrative

(b) Assessment

(c) Planning

(d) Data

The Branch is responsible for a continuing assessment of the State's water resources, forward planning for the most beneficial use of the resources and administration of water resources legislation.

The objective of the work carried out by this Branch will be to achieve total water resource management and planning within

South Australia, and it is the intention of the Government to pass appropriate water resources legislation to ensure this result. The concept of total water resources management and planning is considered an essential factor for the future development of the State due to the limited availability of resources, the estimated rates of urban, industrial and rural development and the ever increasing problems of maintaining and improving water quality. "Total water resource management and planning will be concerned not only with public water supplies and irrigation, but with water for industrial use, water for aesthetic and recreational enjoyment, and water for the preservation of fish, wild life and enhancement of the environment generally".[13]

3.3 LEGISLATION

3.3.1 General

The Engineering and Water Supply Department exercises control over the water resources of the State of South Australia under the legislative authority from the State Government. This authority is embodied in the Waterworks Act, 1932-1974, the Control of Waters Act, 1919-1925, the Water Conservation Act, 1936-1972 and the Underground Waters Preservation Act, 1959-1966. The Department is also responsible for the management of the River Murray in South Australia under the River Murray Waters Act. The following sections briefly outline the powers and responsibilities of the Engineering and Water Supply Department by virtue of the controlling legislation.

3.3.2 The Waterworks Act, 1932-1974

The Waterworks Act is the most comprehensive and most powerful piece of legislation which currently exists to enable the Department to control not only the surface water resources of the State, but also of all the various functions related to the provision, operation and administration of the water supply undertakings in the State. The Act firstly provides the Governor with the power to

> "... from time to time by proclamation declare any district, place, or town, to be a water district for the purposes of this Act, and may define the boundaries thereof. The Governor may in like manner add to or alter the boundaries of any water district."

This power is particularly important since it enables any area to be proclaimed by statute as being either a Township Water District or a Country Lands Water District as the case may be, for the purpose of administering water supplies, levying water rates and fixing annual charges for the water supplied. The powers of the Department, through the Minister, in respect to these factors are also defined in this Act.

Furthermore, the Act provides the Minister of Works, who is the government's representative as the ministerial head of the Engineering and Water Supply Department, with wide powers to

> "... from time to time divert and impound the water from any streams or springs as he may think fit, and alter the courses of the same, and also take the water of such streams or springs and also such waters as may be found in, under, or on any lands so to be taken for the purposes of this Act."

Also

> "... from time to time sink such wells or shafts, and make, maintain, alter, or discontinue such reservoirs, waterworks, cisterns, tanks, aqueducts, drains, cuts, sluices, pipes, culverts, engines, and other works, and

erect such buildings upon the lands, streams, and watercourses authorised to be taken by him as he thinks proper for supplying the inhabitants of any water district with water:"

These powers are most important since they enable the Department to exercise full and complete control over the development of the State's surface water resources which are used for water supply purposes and the water supply reticulation system, including all waterworks, structures and other appurtenances. It is these aspects of this Act and other legislation which have resulted in the Engineering and Water Supply Department being the only water supply authority in South Australia.

3.3.3 The Control of Waters Act, 1919-1925

The Control of Waters Act provides the Engineering and Water Supply Department with powers to control development, use and quality of the surface water resources in the State. The Act provides the Crown with the power to proclaim the waters of any watercourse, including the River Murray upstream from Mannum, as being protected under the Act. In this way, the Government through the agency of the Engineering and Water Supply Department can control the use to which the watercourse and its waters can be put. In particular, the Department is given the power to control the construction of levees and embankments for reclamation purposes, the obstruction, destruction or interference to the watercourse or its bed or banks, and the diversion of water from the watercourse except for domestic use or for animals.

In addition to these broad powers, the Act also offers the opportunity for the Department to exercise control of all activities which may affect the quality of the water. Section 12 of the Act states:-

"If any person -

(a) throws or conveys, or causes or permits to be thrown or conveyed, any rubbish, dirt, filth, or other noisome thing, into any watercourse to which this Act applies; or

(b) causes the water of any sink, sewer, or drain, or any other filthy water belonging to him or under his control, to run or be brought into any watercourse to which this Act applies; or

(c) conveys or discharges, or causes or permits to be conveyed or discharged, into any such watercourse any sludge, mud, earth, gravel, or other matter likely to obstruct such watercourse or any other watercourse to which this Act applies,

he shall be guilty of an offence against this Act."

In spite of these seemingly broad powers, it has so far proved impractical to extend the application of the Act beyond the River Murray.

Fortunately, however, specific legislation on this topic is also provided under Sections 56-58 of the Waterworks Act, and under other South Australian Acts which are administered by other Departments.

3.3.4 <u>The Water Conservation Act, 1936-1972</u>

The Water Conservation Act was drafted to consolidate certain Acts relating to the conservation of water. As a result, the Act is very similar to the Waterworks Act which was itself drafted to consolidate certain Acts relating to water supply.

Both Acts legislate for the proclamation of water districts within the State, for the control and development of surface water resources, for the construction, maintenance or improvement of any waterworks, or for improving the quality of the water to be supplied and for the matters dealing with assessments, rates and charges.

3.3.5 The Underground Waters Preservation Act, 1959-1966

The Underground Waters Preservation Act provides powers to exercise strict control of the State's underground water resources. This Act has only been administered by the Underground Waters Advisory Committee in this Department since the 30th June, 1974, when the responsibility for most of the Act was transferred to the Minister of Works. Prior to 30th June, 1974, this Act was administered by the Minister of Mines with the responsible Department being the Department of Mines. This rearrangement of responsibility was deemed necessary so that the Engineering and Water Supply Department would be able to control all the water resources in the State - be they surface waters or underground waters. This Act allows for the proclamation of defined areas within the State by the Governor with the advice and consent of Executive Council. In these areas, a permit must be obtained from the Department before any person can alter an existing well or bore, or before a new one can be sunk. This enables the Department to keep a comprehensive record of the details of all wells which are used to extract water from the underground water sources in the defined areas.

This Act also allows water usage to be regulated by the use of quotas, and also provides powers to prevent any actions which are likely:-

"(a) to cause contamination or deterioration of any underground water;

(b) to cause inequitable distribution of underground water;

(c) to cause undue loss or wastage of underground water;

or

(d) to deplete unduly the supply of underground water."

The areas defined by regulations under the Underground Waters Preservation Act are shown on Figure 11, and relevant conditions administered by the Department are as follows:-

(a) Area No. 1 - Northern Adelaide Plains

Permits are required to drill new wells, or to rehabilitate or deepen existing wells, and the extraction of water is restricted to approved quotas, as a result of the depletion of the aquifers due, in particular, to heavy demand for the irrigation of market gardens.

(b) Areas Nos. 2, 3, 4 and 5 - Kingston-Beachport, South-East Region

Permits are required for wells exceeding 5m in depth.

(c) Areas Nos. 6, 7, 9, 10 and 11 - Mount Gambier-Keith, South-East Region

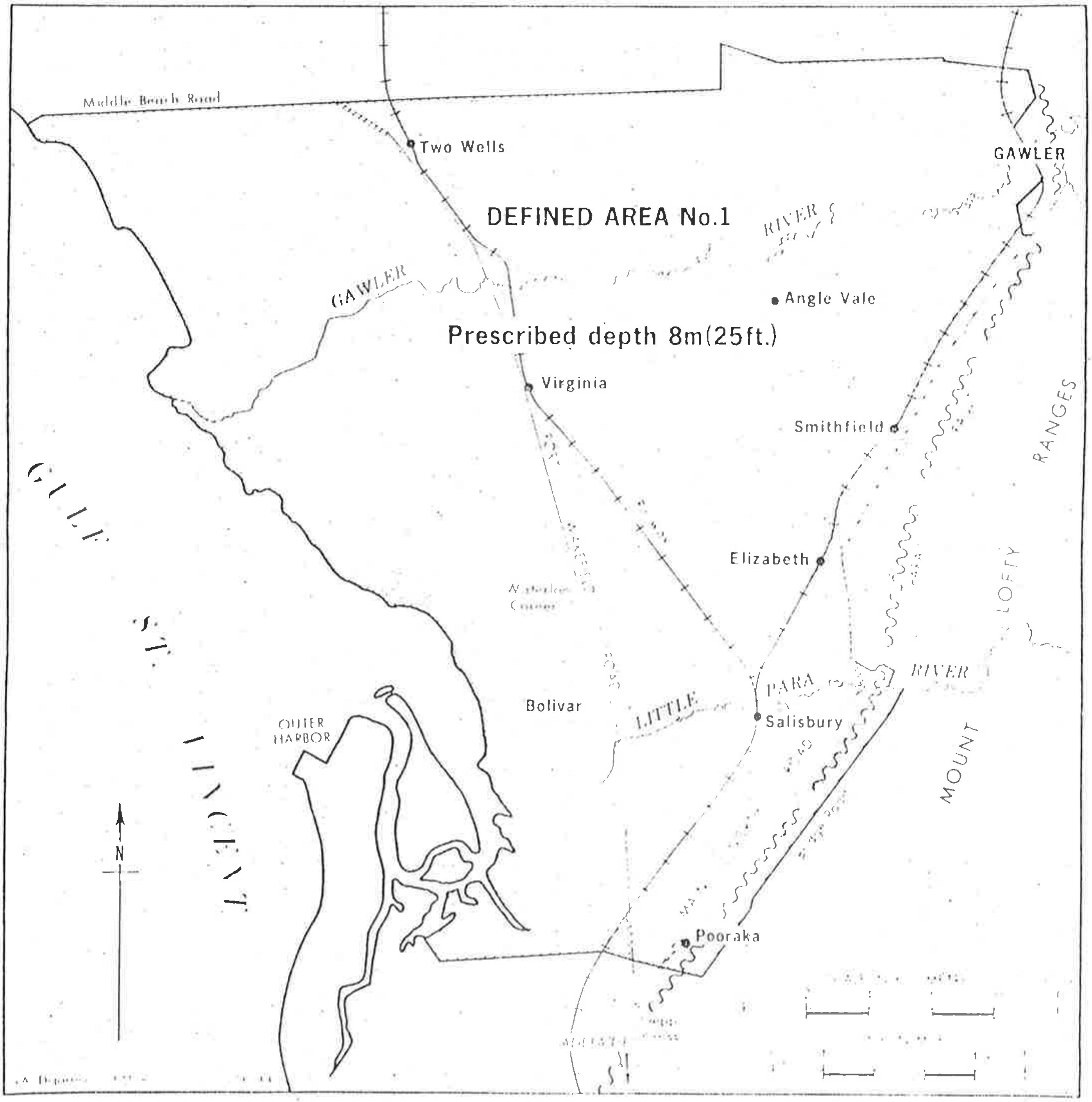
Permits are required for wells exceeding depths ranging from 2.5m to 25m. In October 1973, restrictions on the extraction of water for irrigation purposes were applied in part of Area No. 9. This is known locally as the Padthaway area and is extensively irrigated for pasture, vine and other crop production, with apparent signs of water depletion.

(d) Area No. 8 - Eyre Peninsula

Permits are required for wells exceeding 6m in depth.

3.3.6 Summary

Therefore, the Engineering and Water Supply Department currently



UNDERGROUND WATERS PRESERVATION ACT 1969-1970
NORTHERN ADELAIDE PLAINS DEFINED AREA

FIGURE 11 - PART I

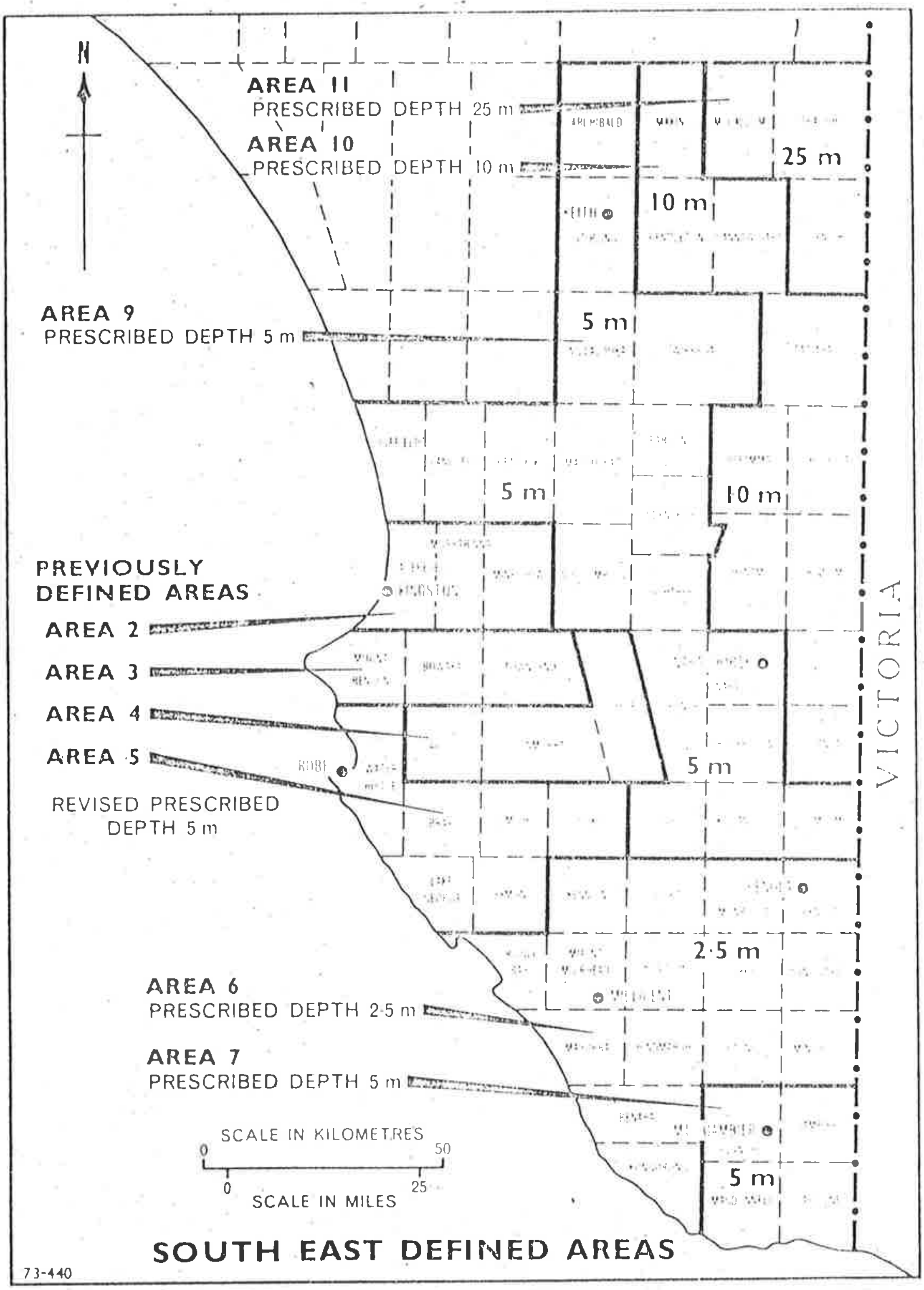


FIGURE 11 - PART II

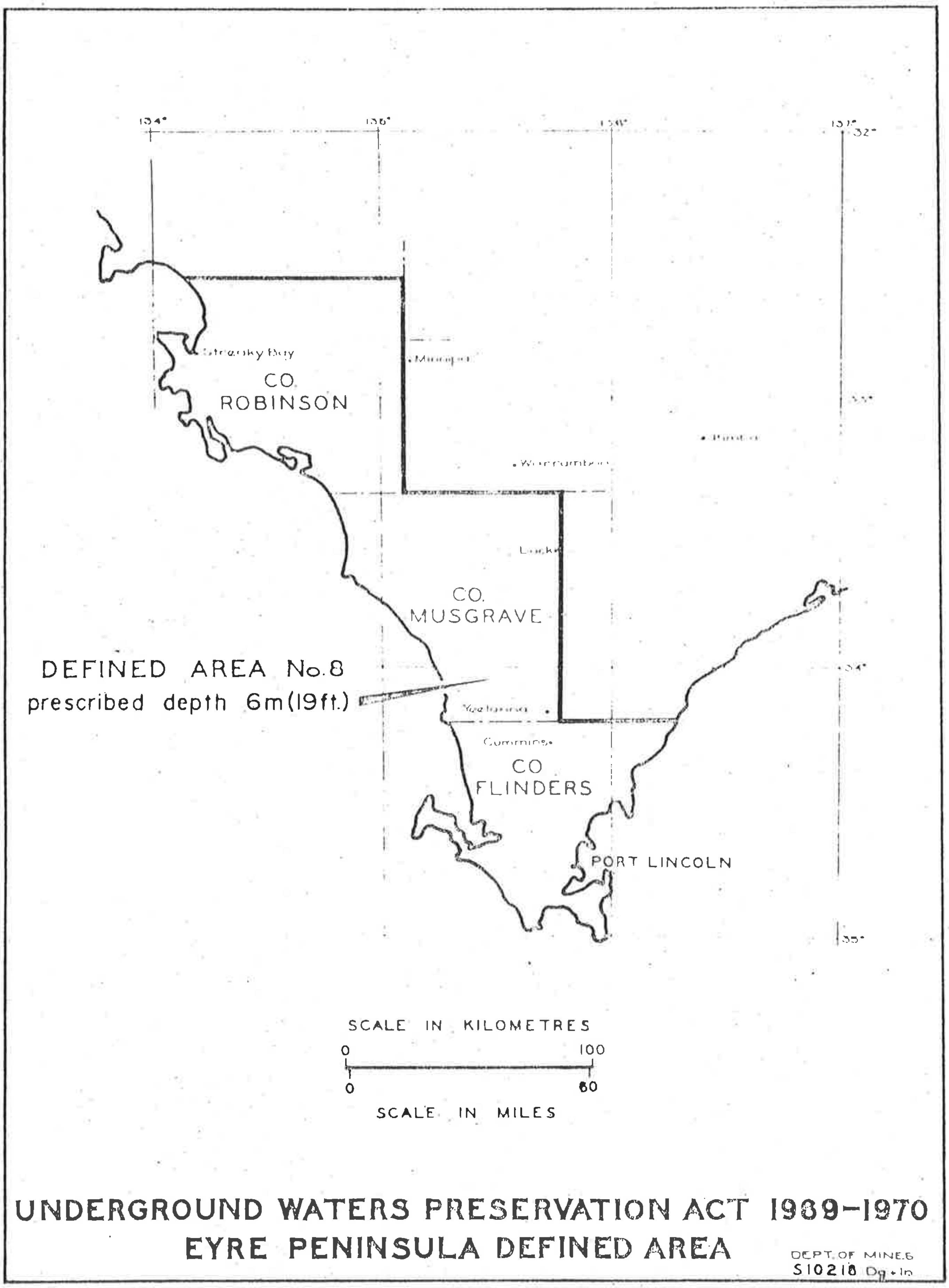


FIGURE 11 - PART III

has responsibility for management of all underground water resources in the areas prescribed under the Underground Waters Preservation Act, management of surface and underground resources developed for public water supplies under the Waterworks Act, and management of the River Murray in South Australia under the River Murray Waters Act and the Control of Waters Act.

3.4 FUTURE LEGISLATION

Although there may at first glance appear to be sufficient legislation to enable effective water resource management and water pollution control to be undertaken, a closer examination of the appropriate Acts has revealed that they require substantial upgrading and extension to ensure that adequate powers are available to the Minister of Works to enforce the Government's policies on water management in South Australia.

Therefore, in 1973 the Minister of Works announced that the Government would take steps to upgrade and consolidate the existing legislation into one Act, to be called the Water Resources Act. Prior to the drafting of this Act, comprehensive investigations were undertaken to determine the current situation as regards water resources planning, management, administrative and legislative techniques which existed not only in other Australian States, but also in many overseas countries. As a result of these investigations, the following objectives were outlined for the proposed Act:-

(a) The provision of adequate water supplies of appropriate quality to meet domestic urban and rural needs as well as those of viable primary and secondary industries;

(b) the conservation, development and management of water resources so that other purposes such as flood control, recreation and wildlife conservation are achieved in parallel with the purposes referred to above;

(c) the more intensive prevention of harmful pollution and the maintenance of high water quality standards;

(d) the development of effective wastewater treatment facilities in conjunction with water supply systems and the encouragement of recycling and re-use where appropriate;

(e) the adoption of water pricing policies which enable water needs to be met at a fair and reasonable price, but which provide an incentive to all water users to avoid wasteful or environmentally harmful practices and which encourage the efficient allocation of resources;

(f) the maintenance of adequate undisturbed aquatic environments as reference areas and the preservation of appropriate wetlands for the benefit of native wildlife;

(g) the implementation of a programme of public education aimed at ensuring a proper understanding of the factors affecting the development and use of water resources and a sense of responsibility in these matters;

(h) the involvement of the public in the planning of water enterprises.

These objectives have now been incorporated in the Water Resources Act, which is currently being examined by the South Australian Parliament. The Act as presented, contains the following seven parts:-

PART I - PRELIMINARY

PART II - ADMINISTRATION

Division I - The Council

Division II - The Advisory Committees

Division III - The Tribunal

PART III - SURFACE WATERS

PART IV - UNDERGROUND WATERS

Division I - Proclaimed Region

Division II - Wells

PART V - WATER QUALITY

PART VI - APPEALS

PART VII - MISCELLANEOUS

SCHEDULE

The adoption of this comprehensive Act will promote greater opportunities for water resources planning to be incorporated within the framework of a comprehensive policy, incorporating economic, environmental and social factors which can be uniformly related to local, regional and State programmes. The Act will also enable better water resources planning and management to be undertaken in conformity with the best up-to-date technical and legal concepts which recognise the interrelationships which exist between surface and underground waters, qualitative aspects and quantitative requirements. The Act will also provide the means whereby the planning and management efforts, which have already been expanded to tackle many unique problems encountered in this State, can actually take the initiative rather than to be used to attempt a remedy after the damage has been done. It is only in this way that the valuable water resources of the State can be effectively protected from further deterioration. Indeed, it should also be possible to enhance the water resources, particularly in respect to water quality considerations.

CHAPTER 4

METROPOLITAN ADELAIDE WATER SUPPLY SYSTEM

4.1 GENERAL

The water supply systems which are controlled by the Engineering and Water Supply Department are administered and operated on a Regional basis. The boundaries of the Metropolitan, Central, Northern, Western and Southern Regions are delineated on the map showing the Principal Water Supply Undertakings (see Figure 12), and respective Regional Headquarters are located at Kent Town (Adelaide), Elizabeth, Crystal Brook, Port Lincoln and Mount Gambier.

The water sources from which the supplies for Metropolitan Adelaide are obtained may be grouped into three categories as follows:

(a) Watersheds in the Mount Lofty Ranges

(b) The River Murray

(c) Sub-Artesian Bores on the Adelaide Plains

Figure 13 indicates the location of the surface water sources which serve Adelaide. Figure 14 illustrates the spread of the watersheds for the existing and proposed reservoirs in the Mount Lofty Ranges.

4.2 MOUNT LOFTY RANGES

The water supplies for Metropolitan Adelaide are primarily drawn from storage reservoirs which are located in the Mount Lofty Ranges. Table 4 lists the reservoirs which supply Metropolitan Adelaide, along with details on capacity, etc. These reservoirs are fed by the flow from four major rivers which originate in the ranges. The rivers are the South Para, the Torrens, the Onkaparinga and the Myponga.

TABLE 4 - Principal Metropolitan Reservoirs

Source of Supply	Catchment Area Sq. Kilo-metres	Name of Reservoir	Dam Con-struction	Capacity Mega-litres	Date Compltd.
River Torrens	350	Thorndon Park	Earth	640	1860
		Hope Valley	Earth	3,470	1871
		Millbrook	Earth	16,500	1918
		Kangaroo Creek	Rockfill	24,400	1969/70
Onkaparinga River	450	Happy Valley	Earth	12,700	1896
		Mount Bold	Concrete Gravity-Arch	30,200	1938
South Para River	230	Barossa	Concrete Arch	4,510	1902
		South Para	Earth and Rockfill	44,900	1958
Myponga River	120	Myponga	Concrete Arch	26,800	1962

The historical development of these rivers as water supply sources for Metropolitan Adelaide is briefly discussed below.

4.2.1 River Torrens

When South Australia was established as a colony in 1836, the selection of the site of its capital city, Adelaide, on the plains between the Mount Lofty Ranges and the sea was largely influenced by the water supply afforded by the River Torrens, a relatively small stream meandering across the plains. In the early years of development of the city, water was carted or pumped from the river or its tributaries or from other small streams crossing the plains.

The first initiative to provide a reticulated supply for the city was taken in 1856 with the establishment of the Adelaide Waterworks and Drainage Commission. This Commission later became the Waterworks Department, which was the predecessor of the present Engineering and Water Supply Department. In 1860 the first section of a reticulated water supply for the city of Adelaide was completed. This involved the construction of a weir near the entrance to the

Torrens Gorge from where water was diverted through a conduit into the Thorndon Park Reservoir, from whence it was piped into the city. This scheme was completed in 1862.

As the city grew, it became necessary to further utilise the waters of the River Torrens. This was done by way of the construction of a second off-stream storage at Hope Valley in 1872. This reservoir also receives its water by diversion through an aqueduct and tunnel from the weir on the river. For many years the two reservoirs were used as the principal sources of water for the Adelaide Water District.

However, as the city developed more and more water was required along the foothills of the Mount Lofty Ranges. Moreover, it was not possible to satisfy this demand from the Thorndon Park or Hope Valley Reservoirs, even by pumping up to the higher levels. This problem was overcome in 1920 with the completion of a new reservoir at Millbrook, which enabled water to be supplied to the foothills areas by a gravity system. This storage was constructed on the Chain-of-Ponds Creek which is a tributary of the River Torrens. However, the major inflow to the storage comes from the main river via a 1.5 kilometre diversion tunnel with the offtake located at Gumeracha.

No further development of water storages on the Torrens watershed occurred until 1969 when the Kangaroo Creek Reservoir was completed. This is the only storage which has been built across the River Torrens itself. The water from this reservoir is distributed to the Adelaide metropolitan area via the Kangaroo Creek trunk main - formerly called the Millbrook trunk main.

4.2.2 Onkaparinga River

The utilization of the Onkaparinga watershed as a water source for the city of Adelaide was initiated in 1897 with the completion of the Happy Valley Reservoir, which was filled from the Onkaparinga

River via a diversion weir at Clarendon and a 5 kilometre tunnel to the storage. The reservoir had a capacity which was more than three times the combined capacity of both Thorndon Park and Hope Valley. This scheme allowed water to be supplied to the southern part of the metropolitan area, and mains were eventually extended northwards to serve the coastal districts to Outer Harbor.

Although the Onkaparinga River was recognised as providing more scope for development than the Torrens, it was more than forty years until a second storage was constructed on this watershed. 1937 saw the completion of the Mount Bold Reservoir, and the adaption of a philosophy of reservoir construction which had previously been used only in country watersheds. Up until this time all metropolitan storages had been constructed away from the main stream and received water via tunnels or other conduits. However, the Mount Bold Reservoir was built directly across the river, and floods were to flow over the crest of the dam and cascade down the sloping concrete face into the river bed below. This then heralded the practice of using on-stream storages for metropolitan water supply purposes. Another unusual feature of this dam was that it had no outlet main leading to the reticulation system. Instead, the dam provided a storage from which water was released to run downstream to the Clarendon weir where it was diverted to replenish the Happy Valley Reservoir.

In 1962 the Mount Bold Reservoir was effectively raised by the installation of control gates on the spillway crest. The gates are opened to allow floodwaters to pass and are so operated that, on closing, water can be retained to the level of the gate tops. This has allowed the capacity of the storage to be increased by 57%.

4.2.3 South Para River

The resources of the South Para watershed were first utilized by the construction of an off-stream storage which was filled from the South Para River via a diversion weir and tunnel. The Barossa Reservoir, as it is known, provided a reticulated water supply to the northern extremities of the metropolitan area, including Gawler and the surrounding country lands. This dam, completed in 1902, was one of the first thin wall arch type dams constructed. Furthermore, the curvature of the wall endows the dam with unusual acoustic properties, which accounts for the dam being known as the "Whispering Wall".

In 1958 the South Para Reservoir was constructed directly on the South Para River just upstream from the diversion weir which supplies the Barossa Reservoir. This storage has the largest capacity of any in South Australia (see Table 4). Water in this storage is released to the river in sufficient quantity to maintain the level in the Barossa Reservoir. In 1960, the capacity of the South Para Reservoir was increased by about 14% by the installation of gates on the spillway crest.

A third reservoir, the Warren, was constructed on the South Para River in 1916. However, this storage supplies water to the country lands to the north-east of Adelaide, and therefore is not considered as a metropolitan water storage.

4.2.4 Myponga River

This water resource was first exploited as recently as 1962 when the Myponga Dam was commissioned. The reservoir is primarily intended to augment the water supply to the southern areas of metropolitan Adelaide, although it also serves as the supply for the surrounding townships of Myponga, Yankalilla and Normanville. Since the construction of this storage, the southern areas of metropolitan Adelaide have undergone rapid domestic and industrial development, and the water consumption for the area has risen sharply. As a result, little of the water from the Myponga Reservoir is now distributed as far north as the Happy Valley Reservoir, with which the Myponga system is connected.

4.3 RIVER MURRAY

The exploitation of the River Murray as a water supply resource for Adelaide (and elsewhere) became possible following the closing of the mouth of the river by the construction of barrages at Goolwa in 1940. These structures effectively dam the river, thereby maintaining the level of freshwater in the river, and thus preventing the intrusion of salt water up the river at times of low flow.

It was not until 1950 that work commenced on the construction of a pipeline from Mannum to Adelaide. This was the largest water supply project to have been undertaken in the State, and careful planning was required to ensure that sufficient capacity was provided to satisfy the needs of Adelaide for a reasonable period of time without incurring unwarranted expenditure by over-sizing the pipeline. The pipeline was commission in 1954 when water was discharged into the Torrens and Onkaparinga Rivers to augment natural intakes. However, it was not until 1961 that the 60 kilometre pipeline to Terminal Storage at Modbury (some 15 kilometres north-east of the city) was finally completed. The pumping capacity of the original system was 3,550 litres per second (l/s), although this has since been boosted to 4,250 l/s. Distribution mains carry the water from Terminal Storage to the metropolitan area, and provision has also been made to discharge into Millbrook, Mount Bold and Hope Valley Reservoirs. Finally, special branch mains also enable water to be easily distributed to wide areas of the Mount Lofty Ranges.

A second large pipeline from the River Murray has recently been commissioned to augment the Adelaide water supply system. This pipeline extracts water from the river at a point just upstream of Murray Bridge and discharges it into a small balancing reservoir (Summit Storage) on the Onkaparinga River near Hahndorf. From this point the water flows downstream to supplement the natural intake to the water storages on that stream. The initial capacity of this pipeline is 5,900 l/s, although provision has been made to boost this capacity to 7,100 l/s at a later date.

At the present time between one-third and one-half of all the water requirements for the Adelaide metropolitan area is extracted from the River Murray, and an increasing proportion of the water demand for the city will need to be met from this vital resource in future years.

4.4 UNDERGROUND WATER

The Engineering and Water Supply Department maintain 40 bores which can be used during periods of water shortages to supplement the supplies from the reservoirs and the River Murray. This enables up to 35 to 45 Megalitres per day to be drawn off from the Vincent Basin, which underlies the western and northern suburbs of metropolitan Adelaide. Bore water was first used to augment the reticulated water supply during the severe drought in 1914, and has since been used during the summers of 1950-51, 1959-60 and 1967-68 to help overcome water shortages.

However, these waters are characterised by their high hardness (300 to 500 milligrams per litre (mg/l) as calcium carbonate), and it is therefore desirable that they only be used in an emergency. Nevertheless, when used in this way they become an extremely valuable resource, as illustrated by the fact that during the drought periods mentioned above, about 10% of the total annual metropolitan water consumption was extracted from this reserve.

4.5 THE DISTRIBUTION SYSTEM

The reticulation of water throughout the metropolitan area is accomplished by a complicated system of more than 7,000 kilometres of pipe, which vary in size from 75 millimetres to 2,100 millimetres in diameter. The pipes form an interconnected system which allows great flexibility in the method of operation, and which ensures that adequate quantities of water at suitable pressures are readily available for domestic and industrial consumers and for fire-fighting purposes.

Since the topography of metropolitan Adelaide is such that the natural surface level varies from E.L.10 at the coast up to E.L.250 at Wattle Park in the foothills, it has been found necessary to establish a number of pressure zones, each of which is supplied with water from a specified level. In this way the supply to the consumer can be held within prescribed pressure limits, which can be maintained to allow reasonably constant pressures to be available anywhere in the metropolitan area from the low-lying seaside areas through to the high-level foothills suburbs. Furthermore, the pressure limits have been selected with a lower limit of 30 metres head and an upper limit of 100 metres head. This allows economical installations of departmental and private water supply systems. Figure 15 shows the major water distribution zones which are designated by the static water level of the supply source. There are 18 different zone levels throughout the metropolitan area at the present time. Each zone has been arranged to be independent of any other zone, except for the trunk mains and feeder mains which are the only pipes to cross zone boundaries.

The maintenance of these pressure zones is achieved by the use of approximately 100 storage tanks of various capacities which are scattered throughout the metropolitan area. There are also some zones which are maintained directly under the pressure head of Terminal Storage and the

Thorndon Park, Hope Valley, Happy Valley and Myponga Reservoirs. An additional function of these storages is to retain sufficient capacity to allow the supply of peak demands of water which can in fact be many times greater than the average demand. They also act as break-pressure devices and allow supply to be maintained during breakdown or maintenance of trunk mains. Generally, these storages are 5 or 10 Megalitre concrete surface tanks which are sited at suitable levels. However, several elevated concrete tanks of 1 or 2 Megalitre capacity have also been constructed - particularly on the flatter western plains.

In addition to the trunk mains and storage tanks which are primarily used to disperse water into the local distribution systems, the Engineering and Water Supply Department also maintains more than 50 minor pumping stations which are used intermittently to transfer water from lower to higher levels. This provides an additional degree of flexibility which enables the Department to maintain supply under almost all foreseeable circumstances.

CHAPTER 5

WATER QUALITY

5.1 INTRODUCTION

The quality of water supplied to the public for municipal uses is a subject of significant social importance throughout the world. Indeed, the maintenance of a suitable quality water supply is imperative for the sustenance of life. As a result, the considerations of water quality management exert an ever increasing influence on the management of water resources.

The relative importance of the criteria which are used to describe water quality depend largely on the uses to which the water will be put. Water is historically used for drinking, cooking and bathing. As such it is essential that the water used in this way is clean, odourless and palatable. It must also be free of pathogenic organisms and dangerous concentrations of toxic substances, any of which may cause ill-health, genetic disturbances or death. It is not surprising then that man is instinctively attracted to sparkling clear water, and naturally selects the best water available for domestic use. It is this aesthetic consideration which exercises the most powerful influence on the mind of the user, and which can mean the difference between the enjoyable use of the water or the revulsion which is induced by dirty or smelly water.

In our modern societies, however, water is used for many other domestic and industrial purposes. These uses quite often place most emphasis on the physical and chemical properties of the water. For example, the properties of turbidity, colour, hardness, dissolved solids and gases, and pH are most important for the control of corrosion and scale formation and other similar problems.

5.2 MEASUREMENT OF WATER QUALITY

There are basically two classifications which can be used to describe the quality characteristics of water. However, within each classification there are a number of individual criteria, each of which describe a specific aspect of water quality. The two classifications are discussed in the following sections.

5.2.1 Physical and Chemical Characteristics

This classification includes such criteria as colour, turbidity, taste and odour, temperature, and the concentrations of individual elements and compounds which are dissolved in the water. A description of these and other characteristics is presented in Appendix I.[14]

Physical and chemical characteristics of water provide an accurate indication of the suitability of the water for various domestic and industrial uses. Firstly, they indicate the degree of clarity of the water and enable the nature and level of organic impurities and metallic salts to be analysed. This is most important, since it is these factors which often determine the potability of the water and its suitability for general municipal use. These characteristics also provide evidence of chemical impurities in the water which may be harmful or undesirable in many industrial (and other) applications. For example, the presence of calcium and magnesium salts (commonly referred to as "hardness") cause an accumulation of a scale in boilers and elsewhere.

5.2.2 Biological Characteristics

This classification involves the identification of the types and numbers of living organisms - such as plankton, bacteria and viruses. The biological characteristics of water are related to the environmental conditions of the location from which the supply is derived.

For example, the excessive proliferation of aquatic flora and fauna due to a high concentration of plant nutrients (such as phosphorous and nitrogen compounds) may impair the quality of the water - particularly by causing a deterioration of the physical characteristics of colour, turbidity, and taste and odour. In general, however, the excessive development of macro-flora and fauna is much less significant in its effect on water quality than the micro-flora and fauna which exists in the form of plankton, bacteria and viruses. Indeed, in the consideration of the public health aspects of water quality and the provisions of a safe drinking water supply to a city, it is the biological characteristics of the water which demand the utmost attention.

These characteristics are discussed in more detail in Appendix II.[14]

5.3 WATER QUALITY STANDARDS

Water quality standards have been adopted by many countries throughout the world as a means of defining what are considered to be desirable or minimum permissible criteria for the water quality characteristics. The establishment of such standards for municipal supplies must take into consideration many factors including:

(a) the maintenance and promotion of health,

(b) minimal problems in industrial, domestic and agricultural undertakings,

(c) aesthetic values.

It is, however, not desirable to establish rigid limits on all factors because of the wide variability of water supply conditions. The first two factors mentioned above must be considered in the light of past experience, with a large safety margin being allowed in considerations related to health aspects. But the aesthetic values are purely subjective by nature since they are determined solely by public opinion.

Desirable criteria for water supplies in Australian Capital cities have been under consideration by the Biennial Conference of the Water and Sewerage Authorities for several years. The Fourteenth Conference (in 1969) adopted the final report of the Water Quality Committee containing limits for the different quality parameters as a uniform objective for all States. These objectives or limits were upgraded in part by the 1973 conference. Table 5 sets out these criteria, together with the World Health Organisation "International Standards for Drinking Water" (1971), and the United States Public Health Service "Drinking Water Standards" (1972).[15]

5.4 THE PROBLEM OF WATER POLLUTION

5.4.1 The causes of Water Pollution

Water pollution may be defined as any alteration of the physical, chemical and/or biological properties of any water which impairs or is likely to impair the suitability of such water for its most beneficial use. In this context, the beneficial use of water may be for domestic or industrial supply, for irrigation, for recreation, or just for aesthetic purposes.

It is therefore not difficult to realise that the pollution of water is invariably associated with the actions of man in his environment. Although man has been polluting water throughout his history, it has not been until recently that pollution of water sources has become widespread and serious. The reasons for this are threefold.

(a) Firstly, the trend to large scale urbanisation was a development of the nineteenth century. Since that time, man has congregated in densely populated urban areas of ever increasing size. Indeed, it is safe to say that in

TABLE 5

WATER QUALITY CRITERIA

Characteristic	World Health Organisation International Standards (1971) Max acceptable concentration	World Health Organisation International Standards (1971) Max allowable concentration	U.S. Public Health Service Drinking Water Standards (1972) Max acceptable concentration	U.S. Public Health Service Drinking Water Standards (1972) Max allowable concentration	Australian Capital Cities Criteria and Objectives (1973) Max allowable concentration	Australian Capital Cities Criteria and Objectives (1973) Max allowable concentration
Physical and Chemical					TREATED SUPPLIES	OTHER SUPPLIES
Colour (Hazen units)	5	50	15	-	5	50
Turbidity (Jackson units)	5	25	1	-	5	25
Taste	Unobjectionable	-	Unobjectionable	-	Unobjectionable	Unobjectionable
Odour	Unobjectionable	-	Unobjectionable Threshold No. 3	-	Unobjectionable	Unobjectionable
Total Dissolved Solids (ppm)	500	1500	-	-	500	1500
Total Iron (ppm)	0.1	1.0	0.3	-	0.3	1.0
Zinc (ppm)	5.0	15	5.0	-	5.0	5.0
Copper (ppm)	0.05	1.5	1.0	-	0.3	1.0
Detergent (ABS) (ppm)	0.2	1.0	0.5	-	0.5	0.5
pH range (units)	7.0-8.5	6.5-9.2	-	-	7.0-8.5	6.5-9.2
Fluoride (ppm)	*0.8	1.7	*0.8	1.7	1.5	1.5
Nitrate (ppm)	-	45	45	-	45	45
Manganese (ppm)	0.05	0.5	0.05	-		
Toxicological					ALL SUPPLIES	
Chromium (hexavalent) (ppm)	-	0.05	-	0.05	0.05	
Arsenic (ppm)	-	0.05	-	0.1	0.05	
Lead (ppm)	-	0.1	-	0.05	0.05	
Selenium (ppm)	-	0.01	-	0.01	0.01	
Barium (ppm)	-	-	-	1.0	1.0	
Cadmium (ppm)	-	0.01	-	0.01	0.01	
Cyanide (ppm)	-	0.05	-	0.2	0.01	
Silver (ppm)	-	-	-	0.05	0.05	
Carbon Chloroform Extract (ppm)	-	-	-	0.7	0.20	

*Average dose of 0.8 ppm for average daily maximum temperature of 72.4°F (Adelaide).

TABLE 5 (CONT'D)

WATER QUALITY CRITERIA

Characteristic	World Health Organisation International Standards (1971)		U.S. Public Health Service Drinking Water Standards (1972)		Australian Capital Cities Criteria and Objectives (1973)	
	Max acceptable concentration	Max allowable concentration	Max acceptable concentration	Max allowable concentration	Max allowable concentration	Max allowable concentration
Radiological						
Strontium 90 (μμc/l)	-	-	5	-	30	
Radium - 226 (μμc/l)	-	-	0.5	-	10	
Gross Beta Concentration (in absence of Strontium 90 and alpha emitters) (μμc/l)	-	30	-	-	1000	
Microbiological						
Total Coliforms	(a) none in 95% of samples in year (b) no two consecutive samples with coliforms		1/100ml (membrane filter) arithmetic monthly mean		(a) none in 95% of samples in year (b) no sample greater than 10/100ml (c) no two consecutive samples with coliforms	
Faecal Coliforms	0/100ml				0/100ml	

every country whose economy is largely based on secondary industry, the majority of the population live in cities. Australia is one of the most highly urbanised countries in the world with more than 60% of the total population living in towns and cities of 100,000 people or more.[16]

(b) Secondly, pollution of water supplies has long been associated with the advancement of technology. During the last 50 years in particular, the rate and sophistication of technological advancement has been breathtaking and without parallel at any prior time in the history of the world. However, these developments not only improve the standard of living of the industrialised nations, but exploit the earth's natural resources, and pollute the environment by the discharge of the waste products to the land, air and water.

(c) Thirdly, the advancement of agriculture has itself been responsible for the deterioration in the quality of valuable water resources. The contribution from this source stems from the modern practice of intensive agriculture and the associated widespread and frequent use of a multitude of chemicals which invariably accumulate in the water and the soil.

Although each of these three factors separately contribute towards the deterioration of water quality to a greater or lesser degree, it is obvious that the water resources which are threatened by all three factors simultaneously are likely to deteriorate rapidly unless effective action is taken to reverse the trend. Unfrotunately, it is often the case that the origins of pollution develop concurrently, due to the fact that concentrated urban developments require high industrial activity for employment. Furthermore, it is desirable that intensive agriculture and animal husbandry be also carried out in close proximity to the city for the provision of primary produce. In addition to this, most towns and cities are established near good water resources which are valuable not only for domestic and industrial use, but are becoming even more valuable for their recreational and aesthetic properties. It thus becomes obvious that the sources of potable water for a city are also those most likely to be endangered by the pollution from the city itself.

5.4.2 The Nature and Mechanics of Water Pollution

5.4.2.1 General

The principal types of water pollution which cause concern are:-

(a) Pollution by bacteria, viruses and other organisms in sewage, sewage effluents and other human and animal wastes.

(b) Pollution by plant nutrients such as nitrogen, phosphorus, potassium etc., which are derived from decomposing organic matter, farm animal wastes, fertilizers, domestic sewage, detergents and industrial wastes.

(c) Other recognised forms of pollution are pollution by inorganic salts (salinity), pollution by oily materials, pollution by toxic agents (metal salts, pesticides, weedicides, radio-active substances etc.) and thermal pollution.

5.4.2.2 Water Pollution by bacteria, viruses, etc.

Water pollution by bacteria and viruses and other parasitic organisms (worms, fungi and protozoa) are vitally important from a public health viewpoint. Although bacteria and viruses are present in soil, water and even the air we breathe, the group of bacteria which may at times be present in human and animal waste and which can be transmitted to both surface and underground water sources are the most potentially dangerous. It is this group of bacteria which include many of the disease producing organisms such as those causing dysentery, gastroenteritis, poliomyelitis and infective hepatitis. In addition, bacteria which are responsible for the classical waterborne diseases of typhoid and cholera may also be present. Today, however, bacterial contamination of drinking water no longer represents a serious problem to water supply authorities due, in the main, to the recognition of the problem and the means which are available for the protection of the water supplies.

The almost universally accepted method of protection is the disinfection of the water prior to distribution to the consumer. This is generally done by the addition of chlorine to the water in a concentration sufficiently high to ensure that any harmful bacteria or viruses will be killed. A more recent innovation has been the addition of ozone, or the use of ultra-violet radiation - both of which have the same fatal effect on the organisms. However, in all cases, disinfection is used as the final line of defence in the provision of a safe water supply.

Despite the fact that disinfection is used effectively for the virtual elimination of bacterial infection, it would be most unwise to neglect the sources of pollution. To this end, every reasonable effort should be made to improve the quality of the raw water by instituting various controls to protect the source or to reduce the concentration of pollutants prior to disinfection.

5.4.2.3 Water Pollution by plant nutrients

Pollution by plant nutrients causes more concern in this day and age. This is particularly the case in South Australia where the metropolitan reservoirs are all located in areas which are valuable to Adelaide for intensive agriculture and animal husbandry. Pollution of this type causes excessive biological growth (mainly algae) in the rivers and storages which are used for water supplies. In these surface waters algae exist as greenish microscopic, free-floating organisms, and in fertile waters these plants quickly spread, giving rise to uncontrollable problems of odour, taste, turbidity and colour, not to mention a deterioration of the aesthetics of the water body. Moreover, when the plants die and eventually decay, the biological processes contribute to oxygen depletion. This type of pollution may eventually seriously limit the use of the water not only for municipal use and irrigation, but even for recreation purposes.

The nutrients which are responsible for the support of algal growth originate in the watershed and are washed into the rivers with the run-off. The nutrients may be derived from the natural fertility of the soil, as well as from the artificial chemical fertilizers which are applied to the land to promote crop growth. Nitrogen and phosphorus are the elements which are most important in the promotion of abundant algal growth. Moreover, the absence of these elements tend to impair the production of algae and other potentially offensive material.

Unfortunately, while sewage treatment of human wastes may solve the public health problem, it is not generally the complete answer to the water pollution problem. For although the final effluent may be acceptable insofar as health, aesthetic and even most re-use applications are concerned, the removal of plant nutrients - particularly nitrogen and phosphorus - is minimal unless special measures are adopted for this purpose. It is not surprising therefore that rivers and storages which accept the disposal of sewage effluents within the watersheds are much more subject to abundant plant growth than those which are just naturally fertile.

The process whereby lakes and reservoirs undergo a natural ageing process by the accumulation of sediments and nutrients and become shallow, more fertile and productive is referred to as "eutrophication". This process is recognisable by the excessive blooms of algae which accompany it. Normally, this natural ageing process is extremely slow and is not measurable in the human life span, but significant pollution can drastically accelerate the process. Indeed, over the past 50 years there has been much documentation of cases where the normal enrichment processes have led to the eventual extinction of lakes and reservoirs. One example of this can be found in the South-East of South Australia where the volcanic Leg-of-Mutton Lake has become overgrown by reeds and other plants.

5.5 WATER POLLUTION CONTROL

5.5.1 General

Water pollution control aims to at least preserve the balance of nature whereby polluting material, washed into streams and storages during times of heavy run-off, is settled out or diluted sufficiently to be harmless or is broken down by oxidising organisms into simpler, less troublesome compounds. Wherever possible, water pollution control techniques can also be successfully used to aid the natural processes or to reduce the pollutional loads which may upset the normal ecology of the water body.

In practice there are four main areas of water pollution control which are used in all modern societies - namely:-[17]

1. Continual field surveillance of water resources and laboratory testing of samples of water at all stages from its appearance as run-off on catchments to its final drainage to the sea. This, of course, is essential in the implementation of all other aspects of water pollution control.

2. The effective management of water catchments, coastal areas and underground basins to prevent or control activities which may lead to pollution. It would be most desirable if all catchments, stream banks and so on could be reserved entirely from human occupation, but this is obviously impractical in areas where established communities owe their original existence to an adjacent water source or harbour facility. In such areas water storages must be protected by adequate unoccupied buffer zones, certain activities must be entirely prohibited and others only permitted subject to strictly enforced requirements as regards location, sanitary arrangements and disposal of household, trade and industrial wastes.

3. The treatment of water stored or delivered to ensure that a consistent standard of quality is maintained for the purpose intended. This may involve retention of the water in storage for a period sufficient for natural purification processes to be effective, or sterilization by chlorination or some other method, and possibly treatment to improve the appearance and physical quality of water if this is required.

4. The collection of sewage and waste waters and their treatment to render them suitable for disposal by means of natural drainage or for re-use as the case may be. This involves establishing such systems and policing them to ensure that only material which can be effectively removed by treatment or natural processes is admitted. Requirements may demand the pre-treatment of various types of wastes or disposal by some other approved safe method.

5.5.2 Water Pollution Control in South Australia

South Australia is in a very enviable position in regard to water pollution control, since the development of the State has taken place during an era of constantly improving living standards which has been coupled with an enlightened approach to public health matters. This has allowed our predecessors to develop and maintain a very satisfactory standard of water quality and an excellent record in the field of sewage treatment. Despite the fact that we do not need to face the monumental water pollution problems which exist in many parts of Europe, Asia and America, there are some areas in the State where rapid domestic and industrial growth, together with agricultural development, provide the potential for rapid water quality deterioration.

The major responsibility for water pollution control throughout South Australia lies with the Engineering and Water Supply Department. It is indeed fortunate that this department not only operates the water collection and distribution system, but that it exercises control over the sewerage systems throughout the State. This is obviously an advantage in the process of water pollution control. Nevertheless, the co-operation of the Department of Public Health and

Local Government authorities is also an essential factor in the implementation and monitoring of pollution control policies.

Within the departmental organisation, the Water and Sewage Treatment Branch has the delegated responsibility of controlling all water pollution control activities in South Australia. An important contribution in this endeavour is provided by the Bolivar Laboratories. These laboratories provide facilities for sampling and analysing many parameters associated with water supply, waste water and pollution control. The laboratories are a modern, well-equipped complex which is staffed by experts in many fields, including chemistry, bacteriology, virology, etc.

5.6 WATER POLLUTION IN THE METROPOLITAN WATERSHEDS

Figure 14 indicates the locations of the existing and proposed watersheds in the Mount Lofty Ranges. All of the watersheds shown on this figure, with the exception of the Hindmarsh River and Angas River watersheds, provide water to Adelaide and its surrounding metropolitan area.

These watersheds provide a substantial proportion of the water for Adelaide (as much as 50%). Furthermore, water supplied from these sources is provided at the least cost to the Department, in comparison to water supplied from the River Murray and elsewhere. Finally, these reservoirs are also used to store River Murray water prior to distribution to the consumer. It therefore becomes immediately obvious that the reservoirs in these watersheds are the most important asset to the city of Adelaide, and as such, they must be maintained free from significant pollution.

Unfortunately, the catchments represent some of the best watered arable land in the State, and it would be virtually impossible to reserve them completely from occupation and agricultural use. Nevertheless, the Department maintains reservoir reserves around each of the major reservoirs which are excluded from general public use, except along defined roadways and at approved lookout areas. In addition to this, access to the water for any purpose whatsoever is prohibited. The extent of these reserves varies from place to place depending upon the vulnerability of the water storage to pollution and on the departmental policy which existed at the time of construction of the reservoir. The planning for modern reservoirs allows for the acquisition of all land within about three-quarters of a kilometre of the full supply level in the reservoir.

In the remaining areas of the watersheds, the potential for water pollution is high. Until recently the only population in the Adelaide Hills was rural, except for a few small townships scattered through the area. Thus, it was a relatively easy matter to control pollution from these sources, and sewage treatment facilities were provided in Lobethal and Gumeracha where heavily polluted waste waters were discharged from local woollen mills, cheese factories, abattoirs and fruit processing works. However, apart from being aesthetically desirable, fertile and productive, this land is also very close to the metropolitan area, and access from the city is excellent. As a result of these and other attractions, it is not at all surprising that the Adelaide Hills have become a favourite place for commuter living. This recent trend to hills urbanisation has contributed to the Department's concern for the safety of the metropolitan water storages.

In addition to urbanisation, the demand for primary products by an ever increasing metropolitan population has markedly increased over recent years. This has stimulated the development of intensive animal husbandry (including pig and poultry raising, dairying and sheep and cattle grazing) and horticultural activities such as market gardening and orcharding. Furthermore, more and more virgin land has been cleared of vegetation to accommodate this development. All of these land uses contribute further to the problem of water pollution in the metropolitan watersheds, and it is not known at this stage whether the metropolitan reservoirs can satisfactorily assimilate further excessive pollutional loads without the water becoming undesirably enriched with plant nutrients.

The answer to this predicament will be governed by many complex and inter-related factors such as the degree of nutrients leaching from the fertile soils, the existing and possible future pattern of fertilizer usage, the type of future rural development, population trends and distribution; waste disposal practice from existing and future sub-divisional and industrial development and climatic conditions. However, there exist certain symptoms of eutrophication which have become evident in the rivers and reservoirs in the metropolitan watersheds. Unlike water authorities in the United States and Europe which ignored these symptoms some 15 to 20 years ago, the Engineering and Water Supply Department has recognised the problem and has taken various steps to control it.

The Department is satisfied that the problem of water pollution must be tackled at the source - that is by controlling wherever possible the activities on the metropolitan watersheds. To this end, several amendments to the Waterworks Act have been passed, and these incorporate the Department's detailed policy on the metropolitan watersheds. This policy, as summarised in Appendix III,[18] attempts to provide appropriate controls on future watershed activity without unnecessarily interfering with existing activities. However, it will be some time before the success or otherwise of these measures can be analytically recorded.

5.7 WATER POLLUTION IN THE RIVER MURRAY SYSTEM

In comparison with many major rivers in Europe and the United States, the level of water pollution in the River Murray, apart from salinity, is slight. This is very fortunate since about one half of the water requirements for Adelaide are supplied from this source. The Engineering and Water Supply Department is very conscious of this fact and closely monitors the water quality at many points along the length of the watercourse.

There are four major origins of pollution on the River Murray:-[19]

(a) Domestic wastes from river towns, both in South Australia and in Victoria and New South Wales.

(b) Saline or nutrient rich drainage waters from the irrigation and pastoral areas which exist along much of the length of the river.

(c) Industrial wastes associated with irrigation and pastoral activities. These wastes originate from a number of large industries such as wineries, distilleries, fruit processing works and dairy produce factories.

(d) Wastes from holiday shacks and recreational activities.

Although water pollution in the river is not rife, the Engineering and Water Supply Department has adopted a water pollution control policy for the progressive clean-up of the River Murray. The summary of this policy is presented in Appendix IV.[20]

5.8 WATER TREATMENT REQUIREMENTS

5.8.1 Existing Techniques

Despite the measures which have been adopted to control water pollution on the metropolitan watersheds or in the River Murray, certain water treatment measures are required so that the quality of Adelaide's water supply can be maintained at a suitable standard.

There are three techniques which are currently used to maintain the quality of Adelaide's water.

(a) Copper Sulphate Dosing of reservoirs

This action is taken to control the excessive growth of algae in the reservoir storages, thereby reducing the possibility of introducing unpleasant tastes and odours to the water. This method of maintaining a desirable water quality was first used in 1924 at the Hope Valley reservoir. Since that time, the dosing of copper sulphate in the metropolitan reservoirs has become commonplace. This indicates that pollution by plant nutrients has accelerated the eutrophication process in the metropolitan watersheds. By contrast, no such trend has been noticeable in country reservoirs.

(b) Selective withdrawal from reservoirs

In an attempt to provide the best quality water for Adelaide, the metropolitan reservoirs have been constructed with the facility for selective withdrawal. This facility, which is actually built into the reservoir outlet works structure, enables water to be drawn from any one of several levels within the storage. In this way it is possible to select the level from which the best quality water is available for supply purposes.

(c) Chlorination

All of Adelaide's water is disinfected by chlorination prior to distribution to the consumer as a means of ensuring good bacteriological quality, and thereby protecting the health of the public. The practice of chlorinating Adelaide's water supplies was commenced in May 1953.

The theory of disinfection using chlorine is to add a suitable quantity of chlorine to the water to ensure that a residual of about 0.5 milligrams per litre (mg/l) is obtained. This theoretically guarantees the destruction of harmful bacteria without the introduction of an unpleasant odour. In practice, however, this procedure only works effectively if the water being treated is relatively clean. In the event of the presence of organic matter (such as dirt or colour) in the water, two problems may arise. Firstly, some of the chlorine will be utilised in the oxidation of the organic matter, thereby reducing the actual amount of chlorine which is available to destroy the bacteria. Secondly, if any bacteria are concealed in the organic particles, they may be effectively shielded from the action of the chlorine. Under these conditions, therefore, larger doses of chlorine will be required to provide sufficient disinfection and to prevent recontamination in the distribution system. However, the resultant deterioration in taste and odour is often rather undesirable.

5.8.2 Future Water Treatment techniques

5.8.2.1 General

For many years, the water treatment techniques enumerated in section 5.8.1 have provided Adelaide with a water supply which was bacteriologically safe and generally acceptable in other ways. However, the quality of Adelaide's water is no longer acceptable for a modern city.

Recent investigations, including examination of water quality records, have shown that although the chemical and radiological characteristics are satisfactory, and the hardness levels in the water are tolerable, the physical characteristics (colour, turbidity and taste and odour) are well below the acceptable international standards (see section 5.3).

Furthermore, although the bacteriological quality of the water may be judged to be satisfactory, it no longer satisfies the current international standards.

As a result of these findings, the South Australian Government adopted the proposals put forward by the Engineering and Water Supply Department in 1971 to construct seven works capable of providing fully treated water for metropolitan Adelaide. The benefits of such a programme are outlined in Appendix V.[14]

5.8.2.2 The water treatment process

The process which has been selected to fulfil the requirements of the water treatment programme was based on extensive laboratory and pilot-plant studies, and a survey of the best international engineering practice. The process includes:-

(a) Chemical dosing with alum and other chemicals.

(b) Rapid mixing for up to 30 seconds to completely blend the chemicals into the flow.

(c) Flocculation for about 20 to 30 minutes in baffled tanks using paddle flocculators. This is a gentle stirring process which encourages the formation of large settleable flocs to which the turbidity and colour become attached.

(d) Sedimentation for about 2 hours in quiescent conditions to allow the major proportion of floc to settle. The settled floc is withdrawn as a sludge from the floor of these units and disposed of to the sewerage system.

(e) Filtration in open rapid gravity filters containing 12 inches of sand underlying 18 inches of anthracite (coal). This step polishes the settled water by removing the remaining floc.

(f) pH control is a measure of the acidity of alkalinity of a water and this characteristic may require adjustment by the addition of an alkali.

(g) Chlorination and Fluoridation.

The final product of this process will be a completely safe, crystal clear water, free of any taste or odour which will conform to the most rigid international standards.

CHAPTER 6

WATER MANAGEMENT PLANNING FOR METROPOLITAN ADELAIDE

6.1 GENERAL

The responsibility of water management planning for metropolitan Adelaide (and elsewhere in South Australia), rests with the newly formed Water Resources Branch in conjunction with the Water and Sewage Treatment Branch and the Water Supply Branch, which are separately responsible for matters related to water quality and water distribution respectively.

In short, the task of the Water Resources Branch in the context of water management planning for metropolitan Adelaide, is to estimate the future demand for water in the city, to investigate the water resources available to meet this demand, and to examine methods of increasing the available resources if required. Over the years, several investigations have been undertaken by various Branches within the Engineering and Water Supply Department for this purpose, the latest being in June 1973[21] just prior to the establishment of the Water Resources Branch.

However, water resource planning is largely influenced by certain predictions (namely, population estimates and distributions and water consumption), and many other factors (e.g. pumping costs, interest rates, etc.). As a result, the planning process must be a continuing programme, and periodic revisions are required to ensure that satisfactory results are achieved. Therefore, it is not surprising to note that a new distribution and headworks study is now being undertaken by the Water Resources Branch to compensate for the dramatic reduction in population and water consumption predictions since the 1973 investigation.

6.2 FUTURE WATER DEMAND

6.2.1 Historical Demand

The water demand of metropolitan Adelaide has steadily increased since the turn of the century, as indicated by the typical figures on Table 6. As can be seen, the rising demand is reflected not only by the increasing population base of the city, but also by an expanding water use as illustrated by the general increase in the average daily per capita consumption.

TABLE 6

Year	Population	Annual Consumption (Megalitres)	Average Daily per Capita Consumption (litres/cap.)
1900	160,000	11,800	200
1910	190,000	15,000	215
1920	240,000	20,000	230
1930	290,000	27,300	260
1940	340,000	36,400	290
1950	420,000	47,700	310
1960	590,000	104,500	510
1970	810,000	146,000	490
1975	900,000	170,000	520

Although the typical figures indicate a trend towards increasing water consumption, the trend has been briefly interrupted on occasions due to unusual circumstances. In particular, during 1967/68, the annual per capita consumption dropped to 410 litres/cap./day which was significantly lower than the expected consumption of 510 litres/cap./day. This was brought about by voluntary restrictions which were imposed by the Engineering and Water Supply Department as a result of shortages in the supply situation. Similar reductions in consumption are also evident in years with unusually high rainfall during the summer months.

Since the use of water for industrial purposes would not be expected to alter significantly with climatic conditions, it becomes obvious that any appreciable change in the total water consumption under these circumstances must be due in the main to a change in the pattern of domestic water use. This observation is reinforced by the break-down of water usage figures for metropolitan Adelaide[22] which indicate that as much as 70% of the metropolitan demand is used for domestic purposes, 15% is used for industrial purposes and the remaining 15% is used by commerce, local governments (for the irrigation of parks and gardens, etc.) and for other small organisations.

Nevertheless, the pattern of demand may gradually change in future years if the current trend toward flat dwelling continues and other forms of medium density housing emerge. Moreover, there are several other factors (to be mentioned later) which may also affect the pattern of demand in metropolitan Adelaide.

6.2.2 Future Demand

6.2.2.1 Introduction

The reliable estimation of future water demand in a metropolitan area is made very difficult by many physical and socio-economic factors which exert considerable influence on the pattern and degree of water usage. Insofar as residential water consumption is concerned, factors such as climate, income, type of housing, population density, pricing policy and changes in the technology of use, all have been shown to have a significant effect.

Although much recent work has been carried out in an attempt to establish forecasting models[23] which consider these and other factors, the conventional methods of forecasting the future demand for municipal water supply are still widely employed. Generally speaking therefore, the future water consumption within a city is estimated by multiplying the projected population by a suitable per capita consumption figure (estimated from historical rates of use). These variables will be considered in the following sections.

6.2.2.2 Population Projections

Of the two determining factors mentioned, it is the population factor which will normally be the most significant determinant of water demand. As such, the growth trends of any area under consideration require careful evaluation to enable suitable population projections to be made. In an area where stable social norms and effective development planning exists, the prediction of future populations can be carried out with some degree of confidence.

In normal circumstances, the projections of total population and its distribution are prepared by the State Planning Authority and the Premier's Department. At the time of writing, the last projections for South Australia and metropolitan Adelaide were those issued in June 1975 by the Premier's Department - see Table 7. These estimates have been adopted by the Government as the basis for all planning by the various Government Departments and Statutory Authorities, and it is intended that they will be reviewed annually.

These population estimates have been prepared using the 1971 census data and the distribution projections for the various local government areas as presented in a State Planning Authority report of December 1974.[24] A more recent investigation[25] of projected populations by water district has been carried out by a consultant to the Engineering and Water Supply Department, with due consideration being given to the effect on the population of metropolitan Adelaide by the establishment of a new city at

Monarto. A series of projections is given for different growth rates for the new city. However, in all cases, the total projected population for metropolitan Adelaide and Monarto combined correspond to the projections on Table 7.

These three studies will form the nucleus of population data for water management planning for metropolitan Adelaide. However, the uncertainty which presently exists in respect to the rate and staging of development of the proposed city of Monarto will create some difficulty in carrying out separate water management studies for the Adelaide metropolitan area.

TABLE 7 - The Adelaide Statistical Division (including Monarto) and Country S.A.

At 30th June	ADELAIDE STATISTICAL DIVISION INCLUDING MONARTO		COUNTRY S.A.	SOUTH AUSTRALIAN
	Population Estimate (persons)	Increase In Year To June 30th	Population Estimate (persons)	Population Estimate (persons)
1975	903,200		337,700	1,241,000
1976	913,500	10,300	338,800	1,252,000
1977	923,800	10,300		1,264,000
1978	934,100	10,300		1,275,000
1979	944,400	10,300		1,287,000
1980	954,700	10,300		1,298,000
1981	965,000	10,300	344,500	1,310,000
1985	1,005,900			1,355,000
1986	1,015,900	10,000	350,200	1,366,000
1990	1,053,400			1,408,000
1991	1,062,000	8,600	355,300	1,417,000
1995	1,092,900			1,452,000
1996	1,099,700	6,800	359,500	1,459,000
2000	1,123,600			1,486,000
2001	1,128,800	5,200	362,700	1,492,000

6.2.2.3 Consumption Projections

The annual per capita consumption has shown an increasing trend in the past (see section 6.2.1), and it is almost certain that this trend will continue. In addition to moving with the general trend of the period, the per capita consumption also varied widely from year to year, and indeed from season to season. These variations are governed largely by general weather conditions and restrictions in supply. Therefore the projections for per capita consumption must be carefully selected to suit the purpose for which the figures are required.

The generally accepted per capita consumption estimates are shown on Table 8 below.

TABLE 8 - Average Daily Demand
(per Capita in Litres)

Year	1976	1981	1986	1991	1996	2001
Demand	520	530	540	550	560	570

By comparison, it has been estimated[26] that the consumption for the larger Australian cities (Sydney and Melbourne) by the year 2000 will be between 570 and 720 litres/cap./day. These figures compare favourably with the estimate of 640 litres/cap./day for United States cities.[27]

6.2.2.4 Conclusion

In accordance with the current population projections and consumption projections for metropolitan Adelaide, the annual water demand in the year 2001 can be computed to be 235,000 Megalitres, which is an increase of about 38% on the 1975 consumption.

6.3 FUTURE WATER RESOURCES

6.3.1 Surface Water Resources

Table 9 indicates the estimated safe annual yield of the existing surface water resources and facilities which are currently used for metropolitan Adelaide supply. By way of explanation it should be

TABLE 9

YIELDS OF CATCHMENTS AND RESERVOIRS

Stream	Average Catchment Yield (Megalitres)	Reservoirs	Safe Solo Annual Yield* (Megalitres)
South Para	29,500	Barossa) Warren) South Para)	10,800
Torrens	50,100	Hope Valley) Millbrook) Kangaroo Creek)	15,700
Onkaparinga	83,200	Happy Valley) Mount Bold)	32,000
Myponga	18,400	Myponga	11,400
Little Para**	7,500	Little Para**	3,500
River Murray			282,000
		TOTAL	355,400

*Safe Solo Annual Yield means the demand which a reservoir or group of reservoirs can just meet on the basis of historical stream flow inputs only.

**This reservoir is now being constructed.

stated that the figure for the safe solo annual yield for the River Murray of 282,000 Megalitres is in fact the "maximum practical capacity" of the Mannum - Adelaide Pipeline and the Murray Bridge - Onkaparinga Pipeline combined, where the term "maximum practical capacity" is used to define[21] the quantity of water that could be delivered in 10½ months, pumping at full capacity. In actual fact, the total amount of water estimated to be available from the River Murray post-Dartmouth entitlement, for the metropolitan Adelaide water supply system is 340,000 Megalitres. This is after allowing 550,000 Megalitres for irrigation diversion, 845,000 Megalitres for evaporation and seepage losses and 110,000 Megalitres for town and district supplies other than for metropolitan Adelaide. However, the full utilization of the available water would only be possible by the construction of a new pipeline. Despite the fact that such large quantities of water are reliably available from the River Murray, it must be remembered that this is an expensive source of water for metropolitan Adelaide, and as such, will only be used when the occasion demands. Finally, it should be stated that under conditions of conjunctive use of all the existing surface water resources the actual safe yield will be somewhat less than the total which appears on Table 9 due to the method of operation of the system, and the completion for storage.

Nevertheless, it is apparent that the existing surface water storages will be sufficient to meet the estimated demands of metropolitan Adelaide well into the twenty first century.

In addition to the existing surface water resources, there are still several undeveloped reservoir sites in the Mount Lofty Ranges. Possible sites include Pinkerton Gully and Millbrook on the River Torrens, Clarendon and Baker Gully on the Onkaparinga River, and on the Finnis River, Currency Creek, Hindmarsh River, Holland Creek and the North Para River. However, much more investigation work would be required to determine the economic feasibility of these sources of supply.

6.3.2 Reclaimed Water

As the economic cost of developing new surface water resources for metropolitan Adelaide increases, so will the use of reclaimed water become more important. Indeed, the use of reclaimed water in Adelaide is already carried out wherever practicable. This has arisen due to two factors, namely:-

(a) more than 80% of the population in metropolitan Adelaide are connected to the sewerage system which collects both domestic and certain industrial wastewaters and transmits them to one of four major treatment works - Port Adelaide, Christies Beach, Glenelg and Bolivar. The drainage areas[28] for these works is shown on Figure 16.

(b) that the wastewaters are given both primary and secondary treatment, thus providing water which is suitable for most irrigation uses.

The high quality chlorinated effluent from the Glenelg Treatment Works was used as early as 1933 for lawn and shrub beautification around the plant. Today, the summer effluent yield from 250,000 persons (average 45 Megalitres/day (Ml/day)) is fully committed for irrigation of recreation and beautification areas, thereby ensuring considerable saving of valuable fresh water. The water is used for irrigation of 4 golf courses, 8 ovals, other sporting facilities, public lawns and extensive areas of Adelaide Airport. During the 40 years of effluent use, due consideration has always been given to the high salinity of the effluent and the various public health aspects related to its use, thereby ensuring an excellent record of

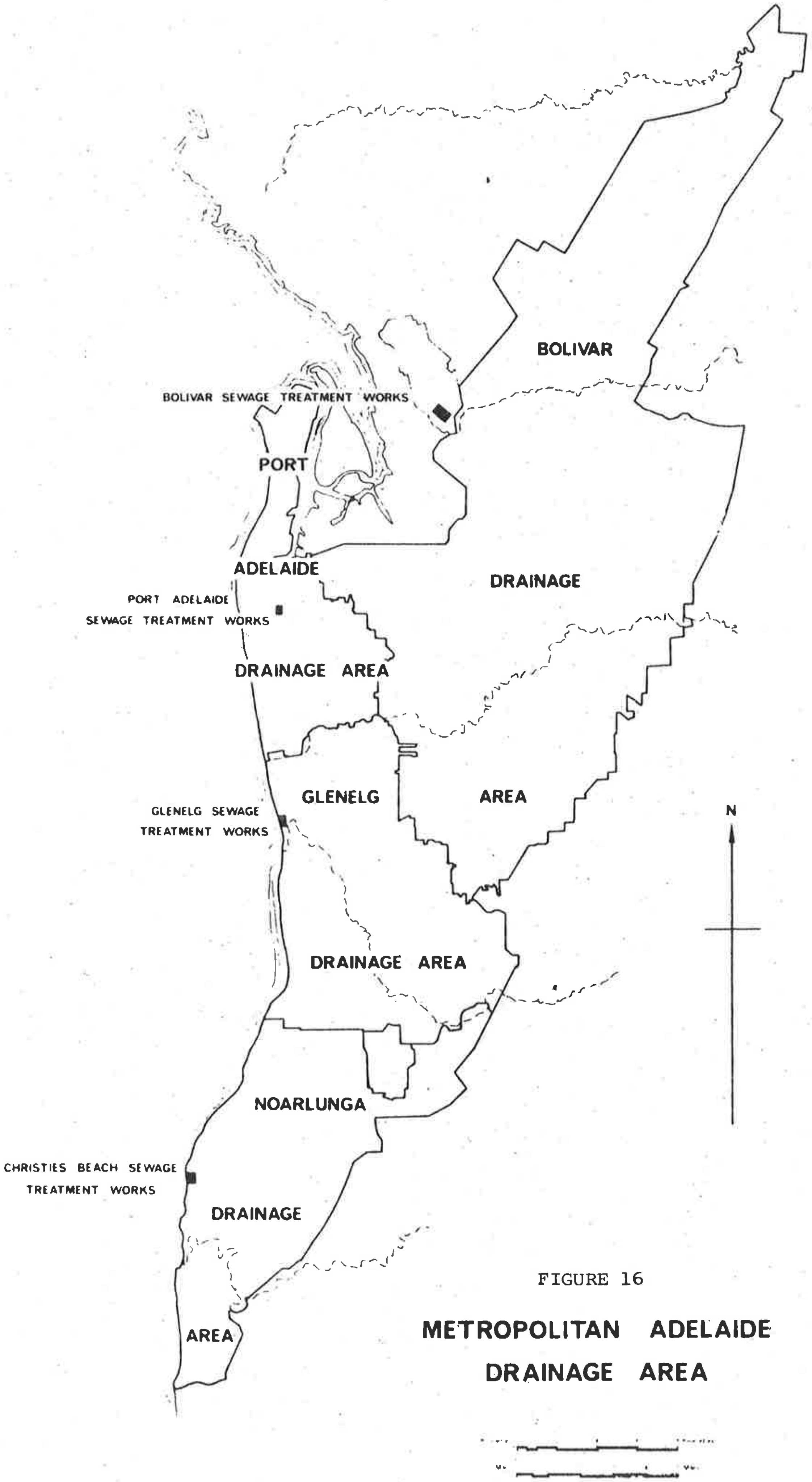


FIGURE 16

METROPOLITAN ADELAIDE DRAINAGE AREA

use.

The re-use of effluent from the Bolivar Treatment Works has been a prime consideration ever since the plant was originally proposed. The works now treats an average of 100 Ml/d from about 500,000 persons and it will eventually treat some 164 Ml/d. Moreover, the demand for this water has become much publicised in recent years due to the proximity of the works to the productive market gardening and fodder production areas on the Northern Adelaide Plains which are currently faced with restrictions on the use of underground waters in the region. However, because the effluent is required for multiple purposes, the Government has been understandably cautious in releasing the water for public and private use, until the results of several investigations and experimental work have been completed. This work includes consideration of transmission of tapeworms, safety of vegetables and fruit eaten raw, as well as the effect of salinity on the soils in the Bolivar-Virginia area.[29] When these studies are all completed, the State Government will then be in a position to design and seek finance for a complete effluent irrigation scheme.

In the meantime, effluent has been made available on a limited basis to private persons in accordance with the conditions and restrictions outlined in a written agreement. These restrictions are required since the effluent which is discharged from the works is not chlorinated. The most important restrictions in the current agreement are included in clause 12 which states:-

"(12) To ensure that:-

(a) No reclaimed water is used for the irrigation of vegetables or other produce that may be used uncooked for human consumption except in the case of tomatoes that are furrow or flood irrigated.

(b) No reclaimed water is used for the irrigation of pasture or fodder crops for the feeding of beef cattle or dairy cattle without the prior written consent of the Minister of Agriculture.

(c) No reclaimed water is used for the irrigation of pasture or fodder crops for the feeding of pigs without the prior written consent of the Minister of Agriculture.

NOTE: Stock Diseases Regulation (c) No. 45 Gazetted 29/7/71

(13) If required by the Director and Engineer-in-Chief, to provide satisfactory drainage of the owner's land to protect the owner's land or land adjacent from salinity or other problems."

Effluent re-use from the Port Adelaide Treatment Works (which treats an average flow of 29 Ml/d from an estimated 150,000 persons) is severely limited by the high salinity of the effluent. The average salinity for 1973 was 3,730 mg/l. In all other aspects, the effluent is of high quality. The high salinity is attributed to the infiltration of extremely saline groundwater into the sewerage system in the old low lying coastal areas of Port Adelaide. Despite the unsuitability of the water for general irrigation, it has been used with some success in a mixture of equal proportions with mains water for the irrigation of lawns around the plant. However, the quantity of effluent used in this way is only about 0.5 Ml/d during summer.

The Christies Beach Treatment Works was commissioned in 1971, and presently treats an average flow of 2.7 Ml/d from an estimated contributing population of 15,000. The ultimate capacity of Stage I is 9.1 Ml/d from 50,000 persons. The effluent from this plant is of an excellent quality in all respects, and it is anticipated that the reclaimed water will be much sought after for local irrigation in years to come. However, at the present time, the chlorinated reclaimed water is only used for works beautification and for the irrigation of a neighbouring sports and recreation centre.

The re-use of reclaimed water is therefore an important water resource available to metropolitan Adelaide, and as such, must receive high priority consideration in future years.

6.3.3 Desalination

Although the desalination of sea-water and other brackish or reclaimed waters is a practical solution to many water resources problems throughout the world, it is a very expensive process by comparison with the conventional water sources. Moreover, the capital and operating costs of these processes are escalating very rapidly. As a result, this method of water supply is generally used only when all other economical resources are fully utilized.

This is the situation which currently exists in Adelaide. From sections 6.3.1 and 6.3.2 it is apparent that the water supply needs of metropolitan Adelaide can be met by the existing water resources and by future development of other surface water resources, well into the twenty first century. Nevertheless, it is inevitable that the desalination of sea-water for metropolitan Adelaide supply will need to be given serious consideration at some time in the future. In order that the up-to-date information will be available for this purpose, the Engineering and Water Supply Department established a Desalination Advisory Committee to undertake a continuing review of water desalination processes. This Department has since sponsored Amdel to carry out additional research[30] to supplement information gathered by the Committee.[31]

6.4 CONCLUSION

In concluding this thesis, it is useful to consider the objectives of the European Water Charter:[32]

EUROPEAN WATER CHARTER

"Water knows no frontiers

Water is a human problem."

1. There is no life without water. It is a treasure indispensable to all human activity.
2. Fresh water resources are not inexhaustible. It is essential to conserve, control and wherever possible, to increase them.
3. To pollute water is to harm man and other living creatures which are dependent on water.
4. The quality of water must be maintained at levels suitable for the use to be made of it and, in particular, must meet appropriate public health standards.
5. When used water is returned to a common source it must not impair further uses, both public and private, to which the common source will be put.
6. The maintenance of an adequate vegetation cover, preferably forest land, is imperative for the conservation of water resources.
7. Water resources must be assessed.
8. The wise husbandry of water resources must be planned by the appropriate authorities.
9. Conservation of water calls for intensified scientific research, training of specialists, and public information services.
10. Water is a common heritage, the values of which must be recognized by all. Everyone has the duty to use water

carefully and economically.

11. The management of water resources should be based on their natural basins rather than on political and administrative boundaries.

12. Water knows no frontiers; as a common resource it demands international co-operation.

If water management planning in South Australia can effectively aim to achieve these objectives, the continued development of a prosperous community in South Australia, and Adelaide in particular, is assured.

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APPENDIX I

MEASUREMENT OF WATER QUALITY - PHYSICAL AND CHEMICAL CHARACTERISTICS

Chemical Properties

These are measured by uniform analytical procedures as set out in Appendix 3 of the Water Quality Committee Report to the 14th Biennial Conference of Authorities controlling Australian water supplies. Ionic concentrations are expressed in milligrams per litre (mg/l) which in potable waters is equivalent to parts per million by weight (ppm).

Total Dissolved Solids

(TDS) are measured by summing the concentrations of anions and cations present or by evaporation, in which case care must be taken to allow for the loss of carbon dioxide. Approximate dissolved solids (ADS) can be estimated from the electrical conductivity of the solution, provided the relationship has been previously checked by the more rigorous method.

Hardness

Hardness, or the resistance to soap lather formation is due to the presence of calcium and magnesium salts. The bicarbonate salts give rise to what is known as 'carbonate' or 'temporary' hardness, which is removed if the water is boiled. The sulphate and chloride salts give rise to "permanent" hardness which is not eliminated by boiling.

To permit easy comparison of hardness levels in different waters the concentrations of the various calcium and magnesium salts are expressed as the equivalent concentrations of calcium carbonate ($CaCO_3$).

Colour

Colour is usually due to dissolved or colloidal substances of vegetable origin. The presence of iron and manganese may also contribute to colour. Colour measurements are expressed in Hazen units which are based on direct colour comparisons with standards of chloroplatinates. The presence of turbidity can affect the readings, in which case the results are expressed as units of 'apparent colour'.

Turbidity

Turbidity is due to the presence of finely divided matter in suspension, such as clays, silt, organic matter and even micro-organisms. It is expressed in Jackson Turbidity Units (JTU) and is a measure of the optical property of a sample of water which causes light to be scattered and absorbed rather than transmitted in straight lines. Measurements are usually carried out in a turbidimeter where a beam of light is passed through the sample and scattered light, measured photoelectrically, is indicated on a scale calibrated directly in JTU.

Taste and Odour

These parameters are the least precise of all because the substances causing taste and odour are usually present in minute quantities that defy analysis and recourse must be made to one or more observers. There are only four true taste sensations: sour, sweet, salty, and bitter. All other sensations commonly ascribed to the sense of taste are actually odours. Odours have been classified as aromatic, balsamic, chemical, disagreeable, earthy, grassy, musty and vegetable, with further subdivision within these classes. By diluting the sample with odour free water to the threshold of smell, the number of dilutions can be recorded as an indication of its intensity. Odours can be recorded with both hot and cold samples.

pH indicates whether a solution is acidic or basic. The practical pH scale extends from 0, very acidic, to 14, very alkaline, with the middle value (pH 7) corresponding to exact neutrality at $25^{o}C$. In municipal supplies pH should be slightly basic in order to control corrosion in the distribution system. Measurements are usually made electrometrically using a glass electrode immersed in the solution and connected to a pH meter.

APPENDIX II

MEASUREMENT OF WATER QUALITY - BIOLOGICAL CHARACTERISTICS

The biological characteristics of surface waters depend upon environmental conditions. Where there is an abundant supply of nutrients excessive development of aquatic flora and fauna may occur which can impair water quality in various ways. Normally however the larger submersible, semi-emergent and marginal flora and other macro-biota such as fish do not have as significant an effect on water quality as the micro-flora and fauna, the planktonic algae and protozoa, and bacteria and viruses.

Plankton

This heading includes mainly algae and protozoa; organisms which may be identified and counted under a microscope. These are always present in rivers and reservoirs but usually in numbers small enough to have no harmful effects. Occasionally conditions develop for a 'bloom' of one particular species, usually contributing an unpleasant taste or odour to the water as well as affecting colour and turbidity. The death and decay of these organisms in the reticulation system exerts an oxygen demand on the water causing a deterioration in quality. Measurements of plankton characteristics are usually limited to identifying the dominant organisms and estimating the number of cells present.

Bacteria and Viruses

The bacteriological and virological quality of water is of the utmost significance chiefly because of health implications. However nuisance and slime forming bacteria, as well as large numbers of harmless saprophytic bacteria which encourage the growth of often undesirable predators, can impair water quality in other ways. Fortunately only few organisms are harmful to man, and if it could be guaranteed that these are not present in a reservoir or river then the presence of others would be of little consequence. In these days when inhabited catchments are becoming more and more common such guarantees cannot be given and resort must be made to laboratory examination of samples. However, because of the relatively small number of pathogens required for an infective dose, examination for the pathogens themselves would be like looking for the proverbial 'needle in a haystack'. Techniques have therefore been developed to discover whether or not indicator organisms, usually the coliform group of bacteria, are present. Coliforms are the normal inhabitant of the intestinal tract of warm blooded mammals and, though most are harmless, they provide a warning that contamination has taken place and that pathogens may be present.

By innoculation of a suitable medium with a small quantity of the sample and incubation for a minimum time at a fixed temperature, the presence or absence of coliforms can be demonstrated. The use of serial dilutions and statistical tables enables an estimate to be made of the most probable number (MPN) present in the sample. The precise examination techniques can vary between authorities, those used in Adelaide being based on the British Ministry of Health Bulletin No. 71 "The Bacteriological Examination of Water Supplies".

APPENDIX III

ADELAIDE METROPOLITAN WATERSHEDS - WATER POLLUTION CONTROL

SUMMARY OF CURRENT POLICY (refer to map as required)

1. Reservoir Reserves

The public will continue to be excluded from reservoir reserves except at defined lookout points.

Reserves around new reservoirs will provide for buffer zones at least 0.8 km wide to high water level. In certain situations some additional land will be purchased at existing reservoirs to provide adequate protection.

2. Agricultural Activities

The Department has no plans for any restriction on agricultural activities (market gardening, orchards, field crops, etc.) on the watersheds.

Some concern has been expressed that the increasing use of nitrogenous fertilizers may warrant some restriction on agricultural activities if used to excess. Whilst this aspect will be kept under surveillance, the Department does not anticipate a significant problem from this source.

3. Animal Husbandry

(a) Intensive Animal Husbandry

The Department is opposed to the establishment of new piggeries or other intensive animal husbandry projects (e.g. confined feeding) on the watersheds. This is in line with accepted practices elsewhere which prohibit piggeries from any water supply catchment.

It is hoped that the few existing piggeries in Watershed Zone I will eventually be phased out. However, the Department is not opposed to the existing piggeries in Watershed Zone II provided that the pigs are held in approved sties (i.e. not free ranging); provided that the piggeries are not modified, extended or relocated; and provided that approved waste disposal facilities are installed and properly maintained.

(b) Dairies

The Department is not opposed to the continuation of existing dairies with free-ranging stock on any part of the watersheds provided that milking sheds and holding yards are located well away from watercourses and that the associated concentrations of wastes are disposed of in an approved manner to minimize entry to watercourses.

The Department is opposed to the establishment of new dairies in Watershed Zone I but is not opposed to new dairies with free-ranging stock in Watershed Zone II provided that milking sheds and holding yards are constructed in approved locations well away from watercourses and provided that the associated concentrations of wastes are disposed of in an approved manner to minimize entry to watercourses.

(c) Poultry Farms

The Department is not opposed to the continuation of the existing poultry farms on the watersheds provided that they are located well away from watercourses and provided that all wastes are collected and disposed of in an approved manner to prevent entry to watercourses.

The Department is opposed to the establishment of new poultry farms in Watershed Zone I but it is not opposed to poultry farms in Watershed Zone II provided that the poultry sheds are constructed in approved locations well away from watercourses and that the associated wastes are collected and disposed of in an approved manner to prevent entry to watercourses.

(d) Grazing

The Department is not opposed to normal stock grazing on the watersheds.

(e) Dog Kennels

The Engineering and Water Supply Department is opposed to the establishment of new dog kennels within Watershed Zone I. The Department is not opposed to the continuance of existing dog kennels in Zone I provided that they are not materially extended or relocated; and provided that approved waste disposal facilities are installed and properly maintained.

The Department is not opposed to the establishment of dog kennels in Watershed Zone II provided that the dog kennels are constructed in approved locations well away from watercourses and that the associated wastes are collected, treated and disposed of in an approved manner.

NOTE - For the purpose of this policy, a "dog kennel" is defined as a structure used for the confinement and/or feeding of three or more dogs.

4. Industry

The Department is opposed to the establishment of new industries having strong organic or other wastes which are difficult (if not impossible) to treat to the required standards for discharge. Such industries include fruit and vegetable processing, wineries and distilleries, dairy products, wool processing, abattoirs, etc. Treatment on the watersheds would prove economically unattractive to such industry and treatment would not remove the nutrients discharged with the effluent.

Quarrying and mining enterprises are not opposed by the Department provided that associated operations do not pollute, or are not likely to pollute, watercourses on the watersheds.

5. Recreational Activities

The Department foresees no need to place special restrictions on current recreational activities on the watersheds. There will, of course, be continued surveillance of such activities and, as in the past, the Department will need to take action as necessary, e.g. where sewage disposal facilities are overloaded during peak usage.

6. Subdivisional Activity

The Government has authorized the following Departmental policy regarding subdivision and resubdivision on the Metropolitan watersheds:-

(a) The Department will not oppose the creation of urban or other type allotments within well built-up watershed townships.

NOTE - The Department is currently examining watershed township areas and, following consultation with the Director of Planning, State Planning Authority, will shortly define the exact limits within which no objection will be raised to urban or other type subdivision and resubdivision.

(b) Outside well built-up watershed township areas, the Department will strongly oppose all subdivision and resubdivision proposals which would create an allotment of less than 8 hectares except that:-

(i) Owners of parcels of land of not less than 8 hectares covered by a single current title which existed at 1st April, 1970, will be permitted to create one (1) only additional allotment of not less than 0.4 hectares in area provided that such allotment shall be created prior to any further subdivision or resubdivision of the land.

(ii) Owners of any allotment on which there were two or more dwelling houses existing or under construction at 1st April, 1970, will be permitted to create allotments of not less than 0.4 hectares in area provided that each allotment so created contains at least one such dwelling house. An allotment means a parcel of land for which only one title could be issued.

This means that any allotment containing, say, three dwelling houses at 1st April, 1970, will be permitted to be divided into a maximum of three allotments provided that each allotment contains at least one of the houses and exceeds 0.4 hectares in area.

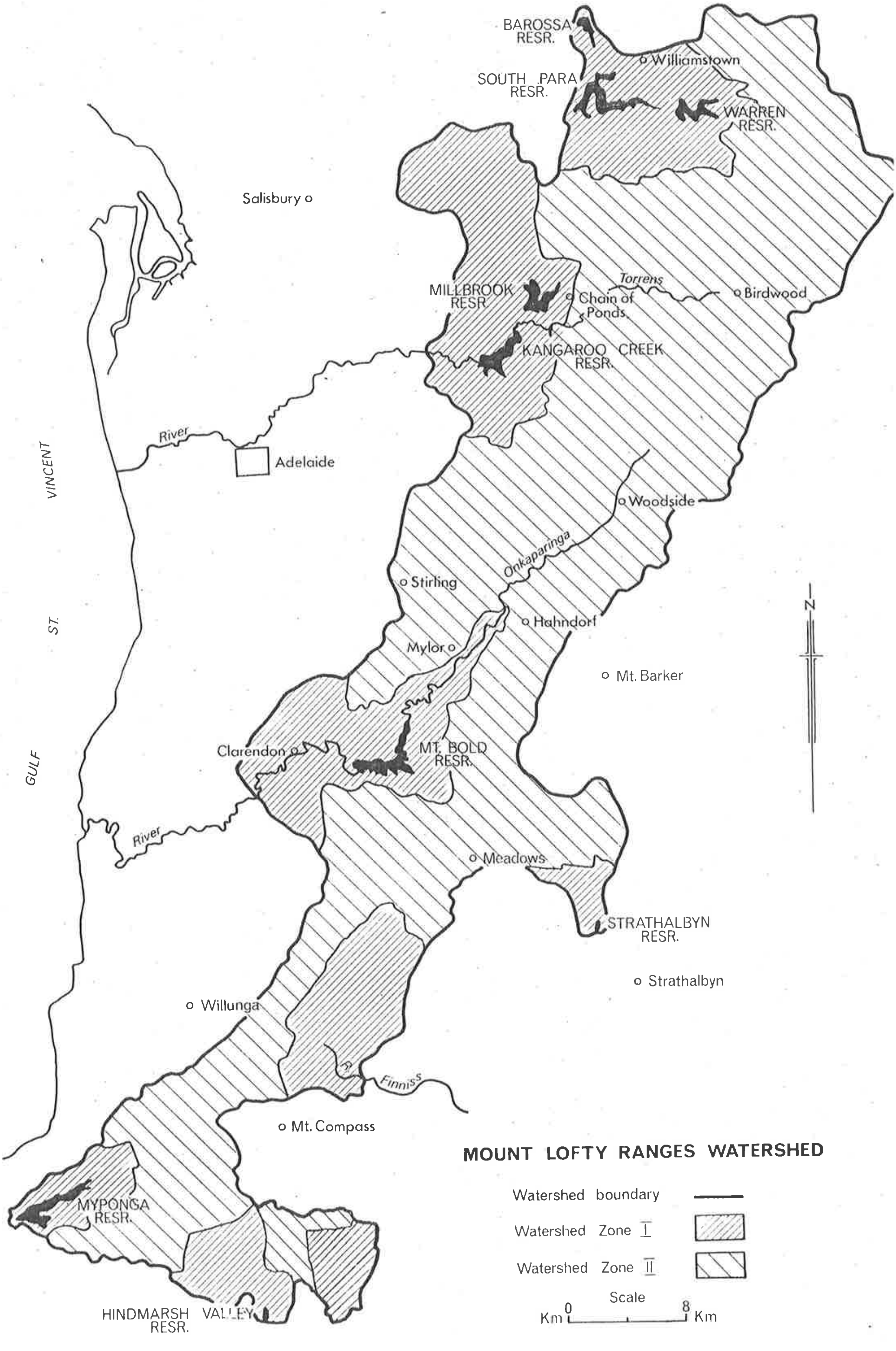
Following Departmental recommendation, the Planning and Development Act, 1966-1967 has been amended to give the Director of Planning specific power to refuse applications to subdivide or resubdivide land on the grounds that approval of the proposal would be likely to give rise to pollution of a public water supply resource.

7. Water Supply Policy

Except within those township areas where the Department will raise no objection to subdivision and resubdivision, the Department's policy is not to extend water mains or grant indirect services.

8. Sewerage Policy

The policy of the Department continues to aim at treatment of all watershed township waste waters. Priorities are being investigated by the Drainage Co-ordinating Committee and depending on the requirements of the situation, Departmental sewerage schemes or Council financed septic tank effluent drainage schemes will be recommended.


BAROSSA RESR.
Williamstown
SOUTH PARA RESR.
WARREN RESR.
Salisbury
MILLBROOK RESR.
Chain of Ponds
Torrens
Birdwood
KANGAROO CREEK RESR.
River
Adelaide
GULF ST. VINCENT
Woodside
Onkaparinga
Stirling
Hahndorf
N
Mylor
Mt. Barker
Clarendon
MT. BOLD RESR.
River
Meadows
STRATHALBYN RESR.
Strathalbyn
Willunga
Finniss
Mt. Compass
MOUNT LOFTY RANGES WATERSHED
Watershed boundary
Watershed Zone I
Watershed Zone II
Scale
Km 0 8 Km
MYPONGA RESR.
HINDMARSH VALLEY RESR.

APPENDIX IV

RIVER MURRAY - WATER POLLUTION CONTROL

SUMMARY OF POLICY

The Department's water pollution control policy for the River Murray in South Australia is aimed at minimum interference with existing activities.

Note: For the purpose of this statement "River Murray" shall be as defined under the Control of Waters Act, 1919-1925, and as extended by proclamation in the Government Gazette dated 19th October, 1967. It includes the River Murray itself and any anabranch, channel, river, creek, stream, watercourse, spring, lake, lagoon, swamp or marsh connected with the River Murray in South Australia.

1. Agricultural Activities

There is no intention to attempt to restrict agricultural activities (market gardening, orchard, field crops, etc.) on account of water pollution.

No evidence exists to date that pollution from fertilizers or pesticides used in such operations is significant, but the situation will be kept under continued surveillance.

2. Animal Husbandry

(a) Intensive animal husbandry

No new piggeries or other intensive animal husbandry projects (e.g. confined feedlots, zoos, etc.) should be established within ¼ mile of the River Murray. In any case wastes from intensive animal husbandry operations shall be treated in approved waste disposal facilities before being permitted to discharge, drain or be washed into the River Murray.

Existing piggeries and other intensive animal husbandry projects within ¼ mile of the River Murray shall be fenced back at least 300 feet from the water's edge and provision made to ensure that wastes from such piggeries are fully treated in approved waste disposal facilities or are excluded from the River Murray. All such animal husbandry projects shall then have a grace period of three years to comply with the specified requirements for new piggeries.

(b) Dairies

The establishment of new dairies and the continuation of existing dairies with free ranging stock is not opposed along the River Murray provided that:-

(i) dairy cattle are prevented from entering the River

Murray;

(ii) milking sheds and holding yards are located in approved locations well away from the River Murray;

(iii) that the associated concentrations of wastes are disposed of in an approved manner to prevent entry to the River Murray.

(c) Poultry Farms

The establishment of new poultry farms and the continuation of existing poultry farms is not opposed along the River Murray provided that:-

(i) poultry are prevented from entering the River Murray;

(ii) that poultry farms and yards are located well away from the River Murray; and

(iii) that the associated concentrations of manure wastes are disposed of in an approved manner to prevent entry to the River Murray.

(d) Grazing

Normal stock grazing (sheep, horses, beef cattle, etc.) is not opposed along the River Murray.

3. Industry

The establishment of industries is not opposed along the River Murray provided that polluted wastes are not to be discharged to the River Murray and that approved treatment and disposal facilities for such wastes are located well removed from the River Murray on land above the 1956 flood level.

Quarrying and mining enterprises are not opposed provided that associated operations do not pollute, or are not likely to pollute, the River Murray.

The disposal of any hard rubbish or sanitary land fill of soft rubbish is opposed in any area below the 1956 flood level or in any location where seepage and natural drainage from such material can gain entry to the River.

4. Subdivision

In general the subdivision or resubdivision of land within 300 feet of the River Murray and of any land below the 1956 flood level is opposed. However, all riverfront subdivisions or resubdivisions proposals will be examined to determine any specific circumstances that may exist.

5. Riverfront Development

(a) Houses, Shacks and Other Buildings

Riverfront development on existing allotments is not opposed provided that all new houses, shacks, motels and other buildings are located as far away from the water's edge as practicable; and provided that every effort is taken to limit pollution of the River Murray from both polluted waste waters and solid wastes.

All existing and new houses, shacks and other buildings for human occupation shall be connected to a sewerage system or septic tank effluent drainage scheme or provided with an all purpose septic tank system to the approval of the Department of Public Health.

To ensure that local pollution does not get access to water supply systems proposals for new riverfront development within a ¼ mile upstream and downstream of a public water supply pumping station should be discussed with the Engineering and Water Supply Department.

(b) Caravan Parks, Camping Sites, Recreation Reserves, Commercial Tourist Resorts, etc.

New sites for caravans, tents, etc., shall be kept back 300 feet from the water's edge while all permanent or semi-permanent structures including associated lavatories, ablution blocks, etc., shall be located at least 300 feet from the normal water's edge. Existing sites and associated amenities as opportunity presents, shall also be relocated as far away from the water's edge as practicable.

All wastewaters shall be connected to a sewerage scheme or septic tank effluent drainage system or provided with an all purpose septic tank system to the approval of the Department of Public Health.

To ensure that local pollution does not get access to water supply systems, it is recommended that proposed caravan parks, camping sites, recreation reserves and commercial tourist resorts within ¼ mile upstream or downstream of a public water supply pumping station, should be discussed with the Engineering and Water Supply Department.

6. Recreational Activities

(a) Fishing, Water Ski-ing, Swimming, Boating, etc.

There are no proposals to restrict recreational activities of this type. However, depending on future trends, it cannot be overlooked that some restrictions may become necessary in the vicinity of public water supply pumping stations.

(b) Houseboats

It is proposed that the owners and lessees of commercial and private houseboats and other specified water craft will be prohibited from discharging water closet wastes to the River Murray.

Minimum standards and requirements for waste disposal from such craft are being formulated in association with other authorities and will form the basis of regulations under the Control of Waters Act.

All new houseboats and other specified craft will be required to comply with the regulations while all such existing craft will be given a reasonable grace period in which to make the necessary modifications.

SEWERAGE POLICY

The policy of the Department is to aim at treatment of domestic wastewaters from all River Murray centres.

Existing sewerage schemes will be extended as necessary to meet development at Mannum and Murray Bridge. Elsewhere, River Councils are encouraged to extend existing septic tank effluent schemes as necessary or install new schemes where none exist at present.

The Government has indicated recently that it will subsidise new schemes to limit the cost per house connection to $30.

Septic tank effluents shall be disposed of in a manner which will not contravene Section 12 of the Control of Waters Act.

Oxidation ponds used for larger schemes shall be suitably constructed with satisfactory erosion protection materials on the banks when sited on river flats subject to inundation by floods.

APPENDIX V

THE BENEFITS OF WATER TREATMENT

Adelaide's water supply is unsatisfactory from the viewpoint of the physical characteristics of colour, turbidity, taste and odour and also in regard to bacteriological quality. Water treatment, therefore, must have the correction of these physical and microbiological factors as its goal, and the term will be used in that sense.

The benefits of water treatment are as follows:

1. The aesthetically pleasing effects of clear, sparkling, well aerated water

The Board of Directors of the American Water Works Association adopted the following policy statement on January 28th, 1968.

> "Todays consumer expects a sparkling clear water. The goal of less than 0.1 unit of turbidity ensures satisfaction in this respect. There is evidence that freedom from disease organisms is associated with freedom from turbidity and that complete freedom from taste and odour requires no less than such clarity. Improved technology in the modern treatment process makes this a completely practical goal".

This situation applies equally well in Australia.

2. The elimination of tastes and odours

The advantages of this require no elaboration.

3. Improved safety of the Supply

As indicated by the statement of the American Water Works Association quoted in (1) above, water treatment will greatly assist in the removal of biological organisms including pathogenic bacteria and viruses making disinfection by chlorination even more effective. Chlorine resistant organisms such as the cysts of Entamoeba hystolytica (causative agent for amoebic dysentery) are removed by filtration. The result will be an uncluttered background against which potential contamination will be quickly recognised and corrected.

4. The elimination of stain and dirt and complaints arising therefrom

Today an unknown amount of money is being expended in trying to combat the effects of stain and dirt in the domestic and industrial fields. Clothes, washing machines, hot water services and industrial machinery including pumps, pipes and valves - all have a shorter life in the present situation. A staff of 9 Inspectors is maintained in the Metropolitan Region, about 10% of their time being taken up dealing with complaints that arise from dirty water. Water treatment will change all this and prevent the frustrations of both supplier and consumer and the resultant poor public relations.

5. Reduction in Maintenance Costs of System

At the present time approximately $20,000 per annum is spent in flushing and cleaning mains and tanks containing sediment, an expense that will be almost eliminated with water treatment. In addition, maintenance costs (about $190,000 per annum) of the 250,000 meters installed on individual services at Government expense will be reduced.

6. Improved consumer prestige and visitor attitudes

Treated water will make a favourable impression on interstate and overseas visitors with the tourist industry benefitting to some extent.

7. Attraction of New Industries

Water treatment will be a factor favouring location of new industries in Adelaide.

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