DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1972/79

LAKE GEORGE, N.S.W. - NOTES FOR SEDIMENTOLOGISTS' EXCURSION, NOVEMBER, 1970

by

G.M. Burton

Record 1972/79

LAKE GEORGE, N.S.W. - NOTES FOR SEDIMENTOLOGISTS' EXCURSION, NOVEMBER, 1970

by

G.M. Burton

CONTENTS

TABLES

APPENDIX

FIGURES

FOREWORD

This Record was prepared by G.M. Burton for the Sedimentologists' Excursion to Lake George in November, 1970. It was issued after his death in November, 1972, without some of the amendments that he had intended to make.

SUMMARY

The study of Lake George has been in progress for over 150 years since its discovery in 1820, and the fluctuations in water levels that have transformed the lake into pastureland, and in turn inundated the area again to form a lake have captured the interest of scientist and layman alike. The earliest records of Lake George were compiled by H.C. Russell, Government Astronomer of New South Wales; following the reappearance of the lake after heavy rain in 1950, the Bureau of Mineral Resources (BMR) commenced regular observation of the lake, and subsequently initiated a continuing study into other aspects of scientific interest in the Lake George drainage basin.

Observations of water levels for over 20 years, and a study of the meteorological records in the area now permit a reasonably accurate water balance for the lake to be obtained in which the rainfall on the lake, plus run-off into the lake, less the water lost by evaporation can be equated with the change in water storage for any given period. Changes in level of the lake are therefore attributable to the natural processes of rainfall and evaporation, and there is no need to invoke mysterious and unaccountable phenomena in order to explain such changes.

Most claims that a sudden rise in the level of the lake has been observed, can be attributed to an optical deception; the contrast between the aspect presented by the lake when approached by road from the north at a height of 15 feet (5m) above lake bed, to that obtained on the approach from the south through Geary's Gap, 100 feet (31m) above the lake, suggests that there has been a change in the level of the lake, particularly if the two impressions were gained on different days. From the latter point the lake presents a vast expanse of water, whereas from the north, water is barely visible; the impressions are conflicting, and it seems reasonable to the observer to conclude, that a change has taken place in the water level since the lake was last seen. Others claim to have witnessed the water of the lake either advancing or receding. These reports are attributable to movement of the lake waters set up by the wind, causing the water to oscillate; recorded rises of 6 inches (0.15m) would account for advances of water over ½ mile (1km) across the almost flat lake margins. This is a common occurrence known as a seiche.

The salt concentration of the lake water increases as the lake level is reduced by evaporation. The water is dominantly a sodium chloride type, and analyses indicate that the ratio of the dominant ions is similar to that of sea water; in particular the bromide to chloride ratio is reasonably close to that of sea water. It is believed that the salt in the lake water is in fact salt brought inland with moist air from the Pacific Ocean by winds from

the east. and deposited with rain. The concentration of salt in the water increases during drought years and the water may become unfit for consumption by stock.

Sedimentation in and around the lake ranges from coarse scree slopes and alluvial fans, to beaches, bars, and spits of reworked material around the margin of the lake. Deposits of windblown sand are present along the eastern and southern shores, and stream beds entering the lake contain deposits of sand and gravel. High shrinkage clay and silty clay, and organic ooze occupy the bed of the lake.

Recent investigations including crustal studies have convinced the writer that formation of the lake followed disruption by faulting of the antecedent drainage in late Tertiary to Pliestocene times, and the formation of a number of fault blocks; the most prominent fault, lying immediately to the west of Lake George, is known as the Lake George Fault. Earlier opinions have been expressed that the Lake George Fault came into existence in Palaeozoic times, but that movement has also taken place along the fault in post-Palaeozoic times.

PREFACE

Lake George is the focus of drainage for an internal drainage basin of 360 square miles (932 sq km*) within the Great Dividing Range of southeastern New South Wales. The floor of the lake is 2208 feet (673 m) above sea level and only 65 miles (105 km) inland from the sea. The lake lies at latitude 35°05'S and longitude 149°25'E, 18 miles (30 km) northeast of the national capital, Canberra. It is a tectonic lake according to Hutchinson's (1957) classification.

The lake is of great interest to local residents, and also to the many tourists visiting Canberra. It is the natural centre of an area of the Southern Tablelands covering 3000 square miles (7770 sq. km) and embracing the cities of Canberra, Goulburn and Queanbeyan, the major towns of Yass and Braidwood, and the small towns of Bungendore, Tarago, Collector, and Gunning (Figure 2). The Federal Highway linking Canberra and Goulburn passes along the western shore of the lake and most of the towns are less than 25 miles (40 km) from the lake along the good network of roads that radiate from the lake.

The lake is a proclaimed Wildlife Refuge, and is a favoured recreational area. The wide expanse of water presents pleasant relief in the noticeably dry Southern Tablelands where the annual evaporation is about 50 inches (1270 mm) and rainfall only 25 inches (635 mm). Its use for recreation is expected to increase rapidly with the increasing population of Canberra and the nearby towns.

The lake shows marked seasonal fluctuations in depth and area, and similar fluctuations over longer irregular periods. It is a relatively shallow body of water compared to major lakes of the world (Lake Baikaal, U.S.S.R. depth 5710 feet (1741 m), and Lake Tahoe, U.S.A., 1643 feet (501 m)). Over the last 150 years (Figure 1) the depth of water in Lake George has rarely exceeded 20 feet (6.1 m) at its deepest point and, as far as is known, has not exceeded 25 feet (7.5 m). Commonly its maximum depth is between 5 and 15 feet (1.5 and 4.6 m) and its area between 50 and 60 square miles (130 and 155 km^2). When the area of the lake is 55 square miles (142 km^2), its length is about 12 miles

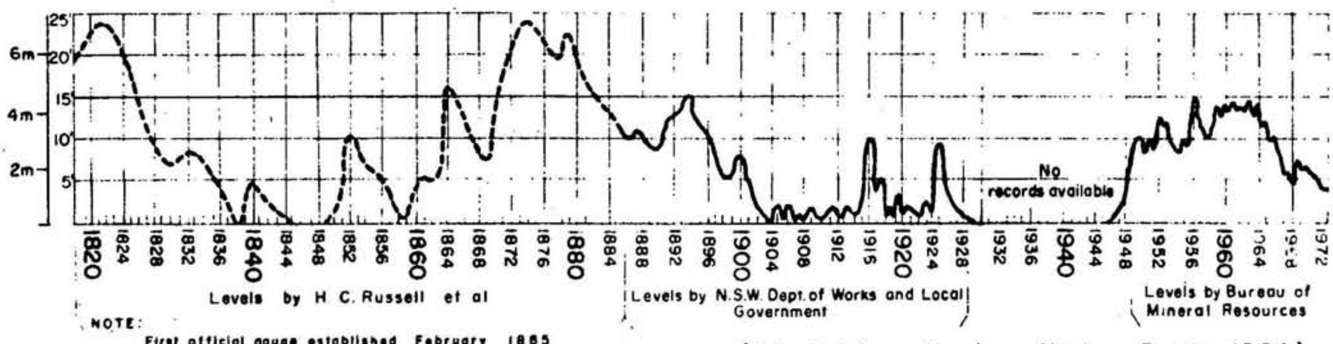
---

* BMR commenced conversion to metric units in 1970. Data for Lake George are being converted progressively and will be completed in 1973. British units are used herein, with equivalents where appropriate; conversion factors are given in Appendix 2.

Fig. 1

LAKE GEORGE, N.S.W.
HYDROGRAPH - DEPTH

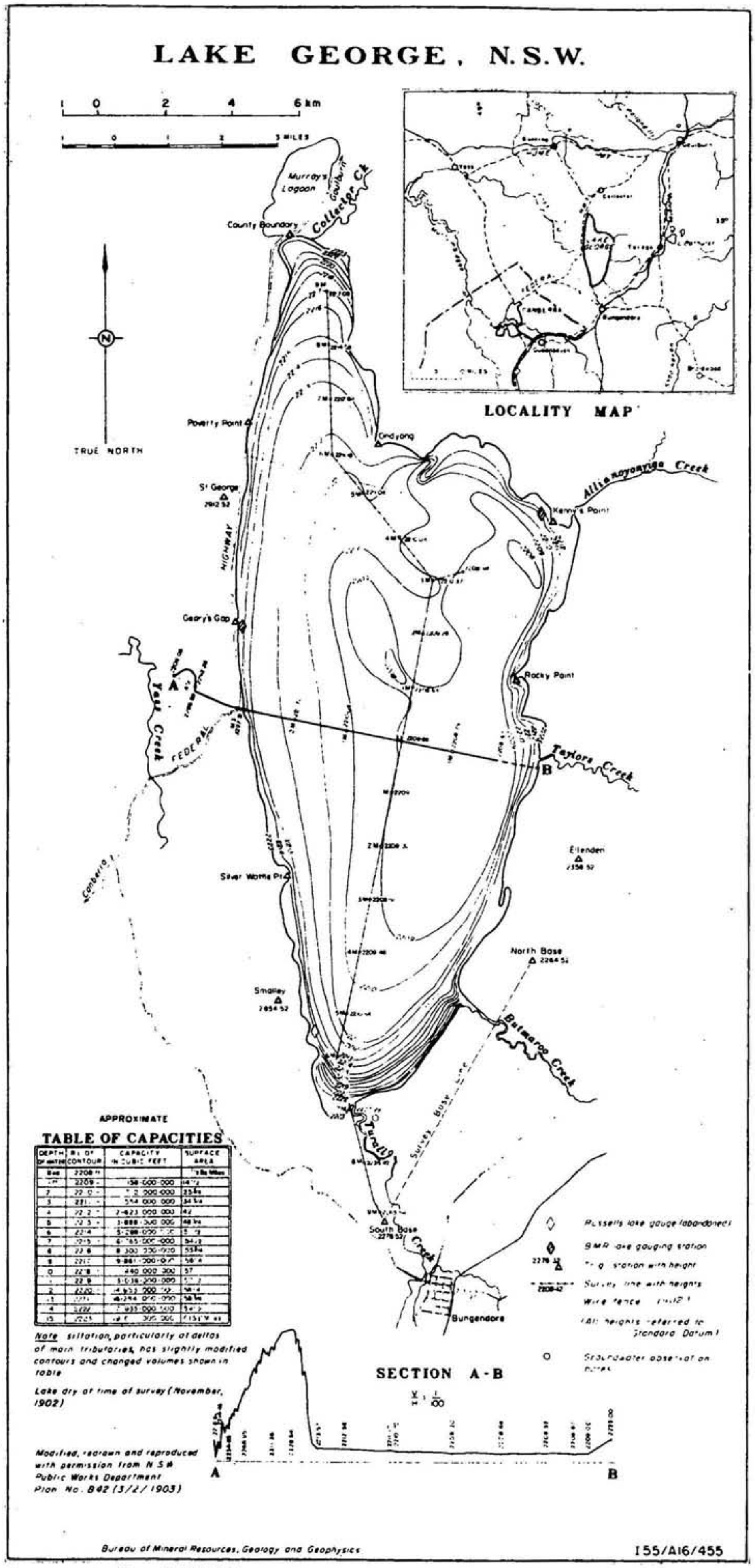
1819-1972



(Adapted from Jennings, Noakes, Burton 1964.)

(Updated to December, 1972)

Fig. 2



DEPTH OF WATER	R.L. OF CONTOUR	CAPACITY IN CUBIC FEET	SURFACE AREA
Bed	2208 ft		Sq Miles
1 ft	2209	[illegible]58 000 000	14[illegible]
2	[illegible]	[illegible] 2 000 000	25[illegible]
3	[illegible]	5[illegible]4 000 000	34[illegible]
4	[illegible]	2 423 000 000	42
5	[illegible]	3 888 [illegible]	48[illegible]
6	2214	5 2[illegible]	[illegible]
7	[illegible]	6 [illegible]65 000 000	54[illegible]
8	[illegible]	8 300 [illegible]	55[illegible]
9	[illegible]	9 [illegible]	56[illegible]
[illegible]0	[illegible]	[illegible]440 000 [illegible]	57
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]2	[illegible]	[illegible]	[illegible]
[illegible]3	[illegible]	[illegible]	[illegible]
[illegible]4	[illegible]	[illegible]	[illegible]
[illegible]5	[illegible]	[illegible]	[illegible]

To accompany Record 1972/79

(19 km) and width 5 miles (8 km): the ellipticity* is 0.6 and the shoreline is about 30 miles (48 km) in length. In Pleistocene times, the lake is believed to have attained a depth of about 115 feet (35 m), (E.G. Wilson, in Galloway, 1965).

The level of the lake falls rapidly during major droughts, and on several occasions it has been completely dry. The larger and more rapid fluctuations that have occurred from time to time have puzzled the casual observer and the lake has assumed an air of mystery for the layman. Nevertheless, studies of the lake undertaken by geologists and hydrologists have clearly demonstrated that the fluctuation in levels is a normal response to the wide range of climatic conditions encountered in the area.

The lake usually appears tranquil. However, the rapid onset of strong winds, and the long fetch across the lake quickly produce rough choppy seas, that necessitate great caution when boating. The surprisingly low temperature of the water for much of the year (Appendix 1) can cause cramps for overturned yachtsmen, and the heavy black mud on much of the floor can soon lead to fatigue for men attempting to wade to the shore.

Besides being an important recreational area, the lake is a regular source of interest to visiting scientists, particularly hydrologists, limnologists, geomorphologists, and geologists. These notes were prepared for an excursion for Australian Sedimentologists in November, 1970, the 150th anniversary of the discovery of the lake by Joseph Wild on 19 August, 1820. The notes complement an earlier and more detailed account of the lake (Jennings, Noakes, Burton, 1964). A short Appendix containing hydrological records of the lake from 1958 to 1972 has been added (Appendix 1).

It is appropriate on the occasion of this anniversary to draw attention to the work at Lake George in the 1880's of H.C. Russell, Government Astronomer of New South Wales. Russell's diligent investigations at the lake and in other areas of New South Wales, including the Great Artesian Basin, place him among the notable Australian pioneering hydrologists; his studies of seiches** at the lake are some of the earliest

---

$$\text{* ellipticity} = \frac{\text{length - width}}{\text{length}}$$

** Seiches (Figure 4) are oscillatory movements of the water in a lake, similar to water moving in a saucer when disturbed; they have been receiving increasing attention from hydrologists, including J.A.H. Brown (1961) at Lake Eucumbene. Seiches are commonly caused by meteorological phenomena such as when a persistent wind drives water to one side of a lake causing the 'set-up' from which the lake commences to oscillate. The generation of a seiche is shown in Figure 8. Hutchinson (1957) discusses seiches in detail.

published works on this phenomenon. The work begun by Russell lapsed during the 1930's and 40's, but the careful re-establishment of gauging of the lake by Noakes (1951), after the refilling of the lake during the flood rains of March 1950, enabled work on the water balance of the lake to be carried out over the last thirteen years. Noakes took particular care to link the new work with that of Russell, and the N.S.W. Department of Works and Local Government, who surveyed the bed of the lake in 1903 (Figure 2).

It is appropriate to recall part of Russell's (1885) address on Lake George to the Royal Society of New South Wales on 1 December, 1886. Therein is part of the reason of our debt to Russell and a reminder to continue his research: 'The history of floods in our rivers and lakes, if it could be accurately written, would form one of the most important chapters in the history of our climate, and probably throw much light upon the laws which control the changes in seasons that have such prominent effects upon a country like this, almost wholly devoted to pastoral pursuits'.

It is no longer true that the country is almost wholly devoted to pastoral pursuits, but the impact of the severe droughts of the second half of the 1960's embracing as they did, New South Wales, Queensland, Victoria, Tasmania, South Australia, and the Northern Territory, was severe over a wide range of Australian activities.

INTRODUCTION

As well as being the 150th anniversary of the discovery of Lake George by Wild in August, 1820, this year, 1970, also marks the completion of the first 150 years of one of the longest and most interesting hydrographic records in Australia, Lake George.

The Lake George basin probably contains the thickest section of Cainozoic sediments in the southern highlands. It is of major importance not only to sedimentologists, but also to geologists andgeomorphologists attempting to reconstruct the post-Palaeozoic geological history of the southeastern portion of N.S.W., a difficult task in the absence of widespread Mesozoic and Cainozoic sedimentation. The geological history is also important to engineering geologists in the A.C.T.* studying regional weathering, sand, and quarry products; however, studies over parts of the Lake George region have been impaired by the lack of suitable topographic maps and detailed geological maps. A notable exception is the excellent survey of the lake floor carried out by the N.S.W. Department of Public Works in 1902 (Figure 2). Some up-to-date topographic maps at 1:50 000 scale are now available, and the new maps will permit a sounder consideration of the theories proposed over the last 50 years for the formation of the lake.

RECENT SURVEYS BY BMR

The lake, during the last twenty years, has been an active area of investigation by officers of the Commonwealth Scientific and Industrial Research Organization (particularly Dr. R.W. Galloway), by staff of the Australian National University (J.N. Jennings, J.R. Cleary, R. Coventry and others) and by BMR geologists and geophysicists, starting with L.C. Noakes in 1950.

BMR surveys have been concerned with the hydrogeology of the basin, geological mapping of adjacent areas, e.g., Geary's Gap area (Hill, 1969), gravity surveys, the drilling of stratigraphic holes and groundwater observation bores, and the establishment of lake gauging stations.

---

* The Canberra 1:250 000 Geological Sheet (2nd Edition) published by the Bureau of Mineral Resources in 1964, and the Goulburn 1:250 000 Geological Sheet published by the New South Wales Geological Survey late in 1970 provide an excellent picture of the regional geological setting of the lake.

HYDROGRAPHY

The long hydrological record of Lake George is not only of regional importance, but is also important in establishing key national and international water balances. The study of lakes as world hydrological datum points has been increasing rapidly (e.g. Lamb, 1967; Tarasov, 1967; IASH, 1966) during the current world-wide studies under the International Hydrological Decade. The importance of even relatively minor climatic changes in a country such as Australia, which possess limited water resources, can be seen in the work of Lamb (1967) and Ambe (1967).

Hydrography not only measures the water resources of a basin but also helps to establish the environment of deposition of sediments. The United States Geological Survey (USGS) with a primary defined role as a hydrographic agency, has been able to contribute significantly to the sedimentology and geomorphology of alluvial and laucustrine deposits. BMR, although not possessing the same major hydrographic role, is gathering hydrographic data to a similar purpose. Gauging stations have been established for measuring depth, salinity and temperature (Figure 3). One offshore station (Figure 5) fitted with water-level and lake temperature recorders has been established. The seiches recorded by the station (Figure 4) are active agents in the formation and modification of sedimentary deposits in the lake. A small meteorological station is established at Kenny's Point to supply data on the generation of the seiches. Floats to define current movements have been used in preliminary studies, and temperature and salinity traverses have been run across the lake.

Reasonably accurate water balances for the lake have now been obtained. The water balance, which is illustrated in Figure 6, may be summarized as follows: (major components are underlined):

CHANGE IN STORAGE: = (Rainfall on lake + Run-off into lake + Groundwater seepage into lake) - (Evaporation from lake + Leakage to underground + Biological consumption + Loss to shore-line evaporation)

or $\Delta s = (R + RI + RU) - (Ev + LU + BC + LS)$

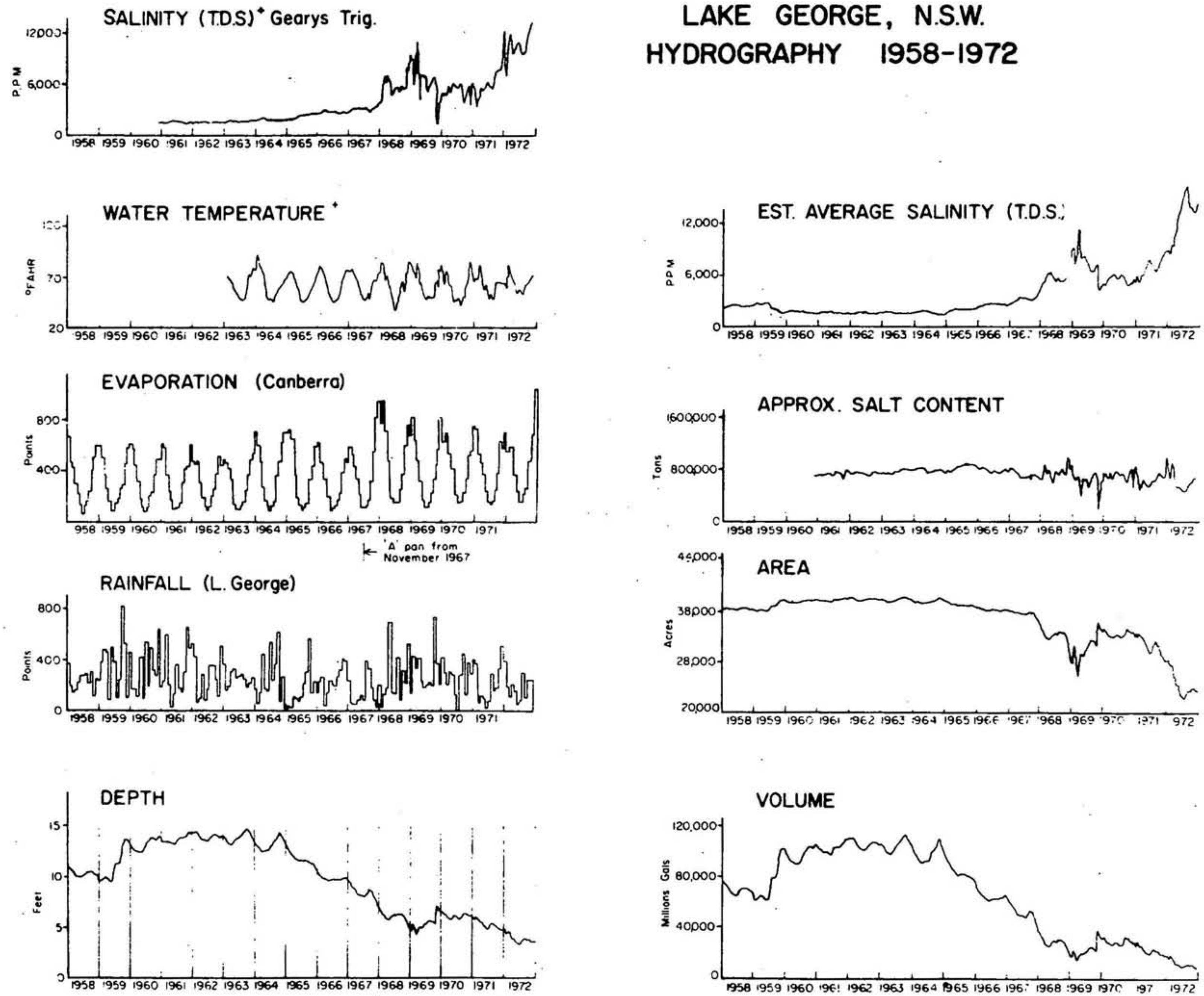


Fig. 3

+Readings at B.M.R. Gauging Station, Gearys Trig.

Bureau of Mineral Resources, Geology and Geophysics

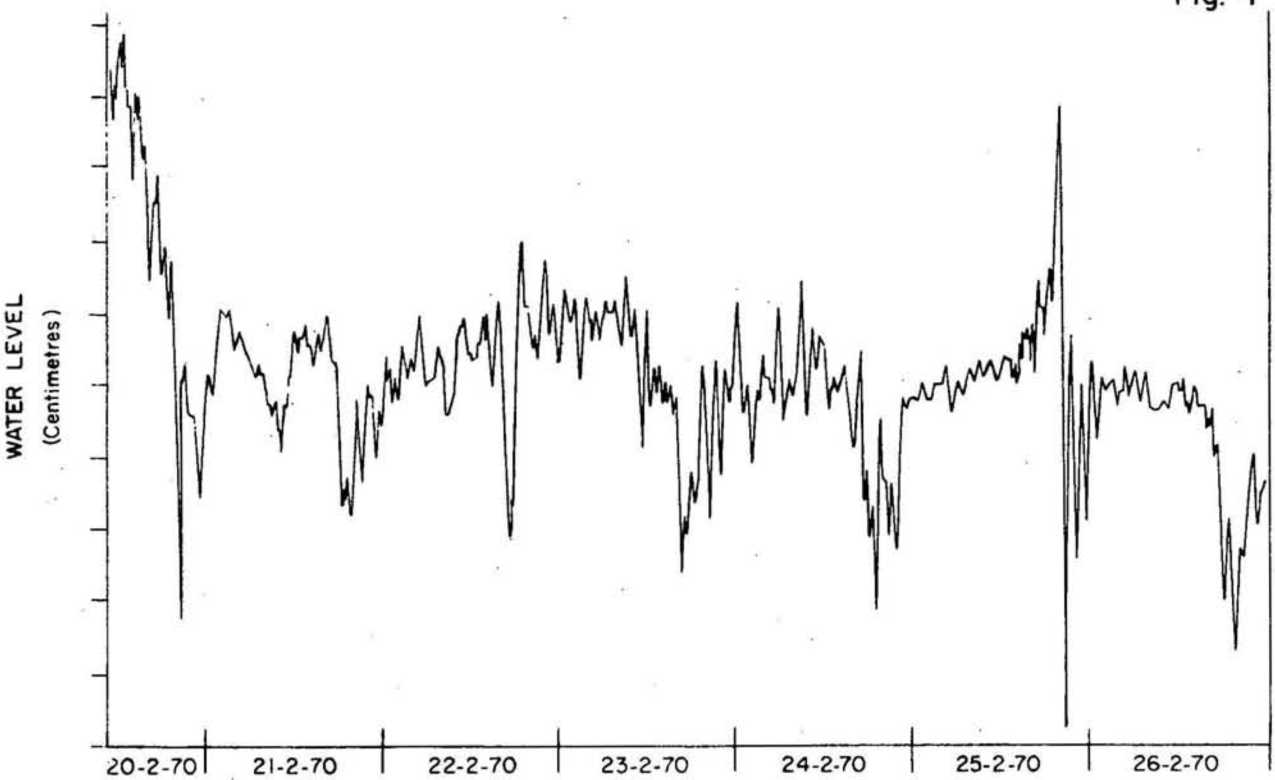
To Accompany Record 1972/79

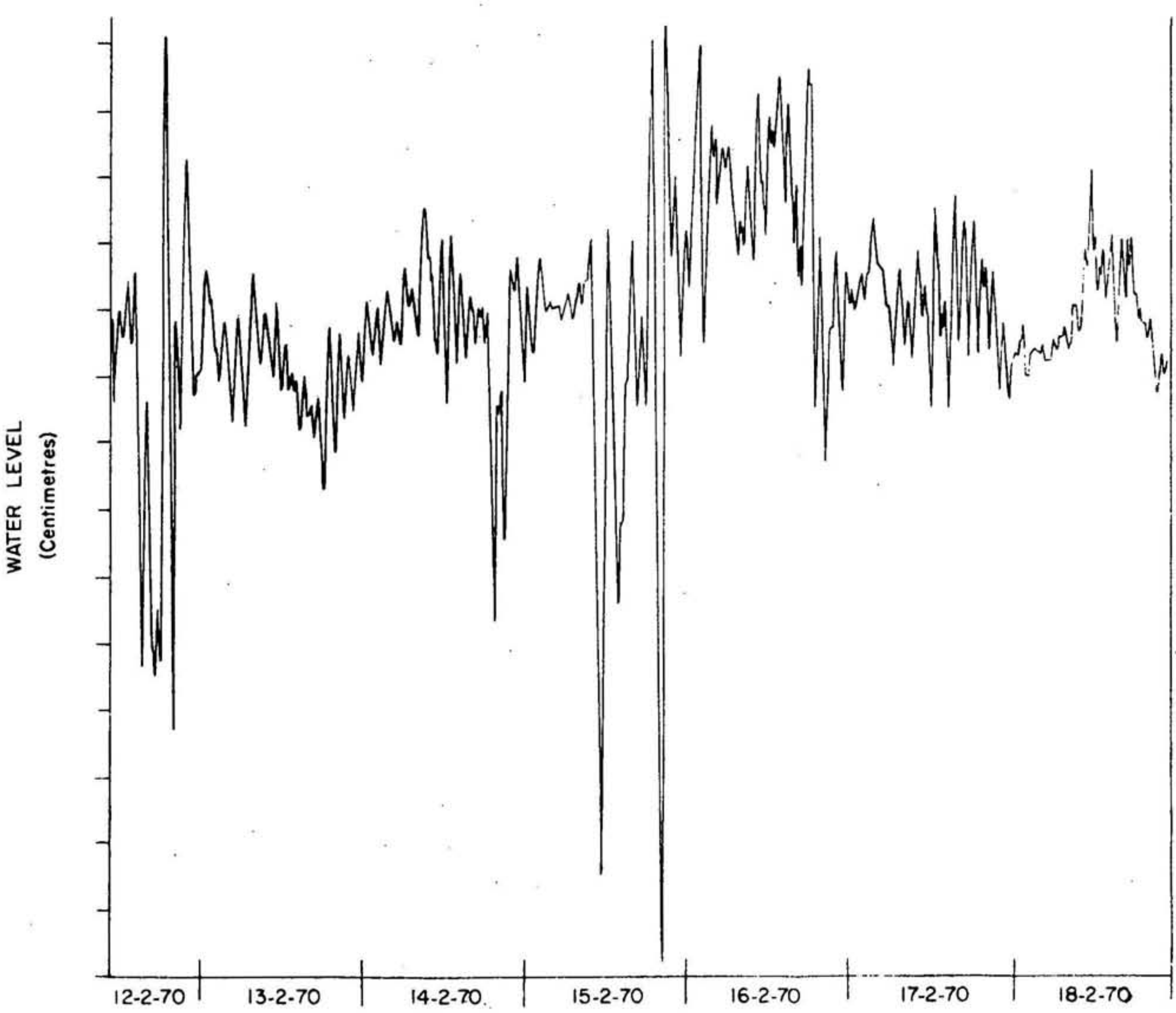
M(G)150

LAKE GEORGE, N.S.W. HYDROGRAPHS SHOWING SEICHES

BMR GAUGE - KENNY'S POINT

Fig. 4





BMR negative GA/3973

A. Kennys Point Off-shore Gauging Platform.

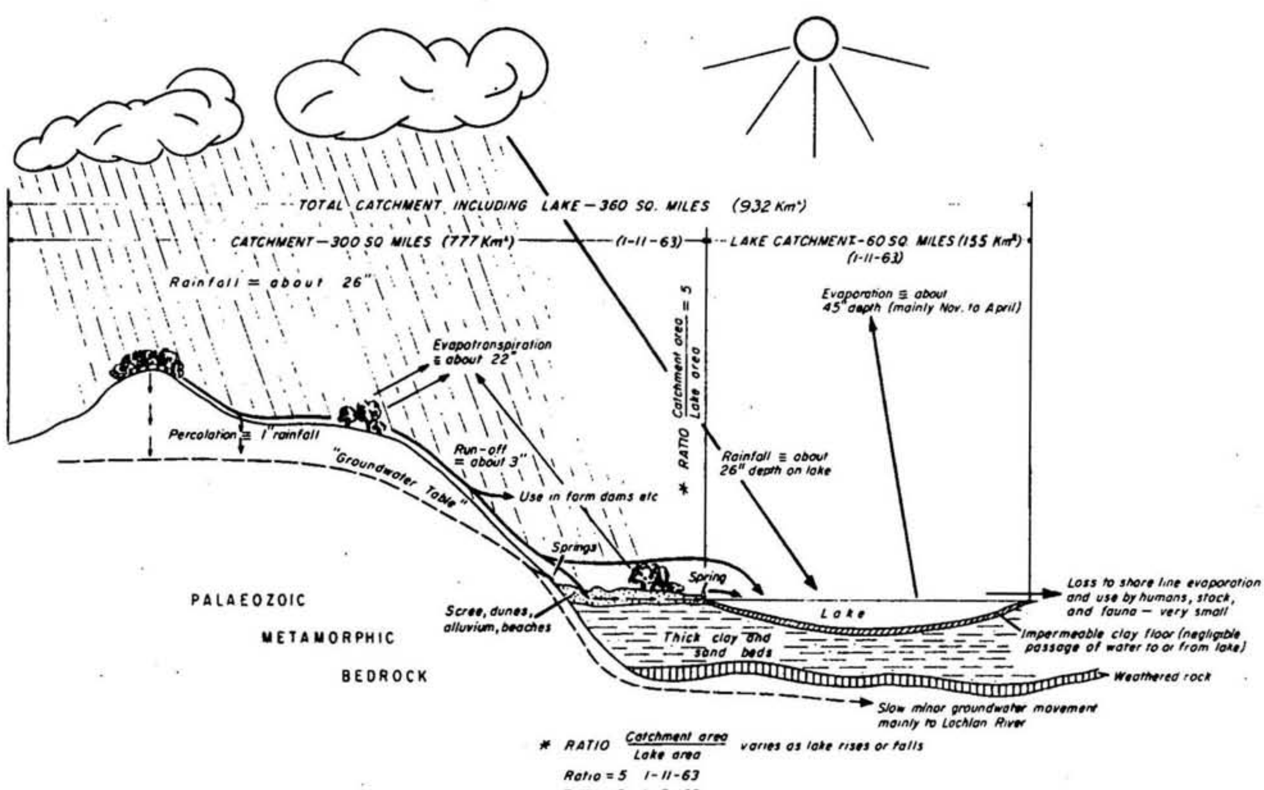
BMR. negative GA/3976

B. Detail of Water-Temperature and Lake-level Recorders.

LAKE GEORGE, N.S.W

Fig. 6

ANNUAL APPROXIMATE WATER BALANCE



To accompany Record 1972/79

I55/A16/585

Changes due to thermal expansion and contraction are not included. They are difficult to measure (Reeves, 1968) and the writer believes they are not relevant to the present studies, although they may explain minor but rare anomalous readings of lake level, e.g. where a severe cold snap reduces markedly the temperature of a thin upper layer in the lake during calm conditions.

The response of the lake to the normal seasonal changes (Figure 7) are summarized in Table 1, Estimated Annual Water Balance for Lake George from 1958 to 1970 (13 years). The 13 values for a particular month were averaged, and they illustrate how the monthly variation between rainfall and evaporation imparts a seasonal influence on the additions to, and losses from the water in the lake.

During the drought of 1965 a water balance based on rainfall at Bungendore and evaporation at Canberra (Australian pan) was prepared for four months, February to June. The pan evaporation was corrected for salinity and altitude. The gauges and pan indicated a likely fall in the lake of 17.32 inches (44 cm): an actual decline of 17.64 inches (44.8 cm) was recorded at the lake. The relationship between lake and pan evaporation is complicated (AWRC, 1970; Reeves, 1968; Webb, 1966) and BMR is preparing more detailed studies, particularly use of the Bulk Aerodynamic Method, in keeping with the Australian Water Resources Council's draft recommendations.

The hydromechanics of a lake are particularly complicated (Hutchinson, 1957) but are of great interest to the sedimentologist, as well as to the hydrogeologist seeking suitable aquifers in the area of a former lake. Wind direction, fetch, depth of water, present and previous shapes of the basin and its shore profiles, each play their part in the generation and modification of waves, set-ups, seiches, and the breaking of waves. The relationship between temperatures and salinity stratification further complicates the environment of sedimentation.

DECEPTIVE OBSERVATIONS

Frequent statements by responsible laymen that they have witnessed the lake draining, filling or behaving in an unusual manner call for comment. It is important to note that optical illusions at lakes are common; Hutchinson (1957) in a chapter on the optical properties of lakes covers a number of these, including mirages. There are two other forms of deception, however, that are believed to have led to errors at Lake George in the past; they are based on reliable and

TABLE 1: ESTIMATED ANNUAL WATER BALANCE

LAKE GEORGE, N.S.W. (1958-1970)

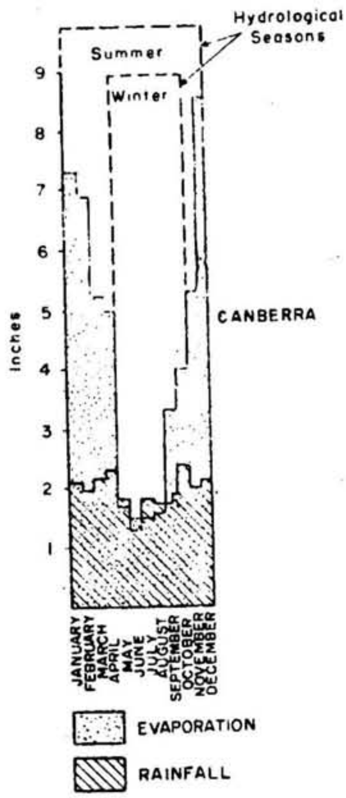
Hydrological seasons and month	Precip-itation points	Change in Lake Level Ft.	Change in Lake Volume Ac.-Ft.	Precip-itation on lake Ac.-Ft.	Evaporation from lake (v. approx.) Vol. Ac.-Ft.	Evaporation from lake (v. approx.) Depth Ft.	Inflow to lake (v. approx.) Ac.-Ft.
'Winter'							
May	222	0.00	-85	6489	7078	0.20	504
June	167	0.13	4613	4938	2380	0.07	2055
July	239	0.24	9035	7277	2352	0.07	4110
Aug.	246	0.18	6480	7272	2195	0.06	1403
Sept.	271	0.15	5545	8173	4690	0.13	2062
Oct.	376	0.17	6095	11288	8468	0.24	3275
Total	1521	0.87	31683	45437	27163	0.77	13409
'Summer'							
Nov.	260	-0.07	-2559	7821	10494	0.29	114
Dec.	310	-0.33	-11510	9249	20759	0.59	0
Jan.	253	-0.27	-9959	7634	17593	0.49	0
Feb.	194	-0.26	-9394	5663	15057	0.42	0
Mar.	201	-0.23	-8340	5764	14104	0.40	0
Apr.	209	-0.11	-4105	6069	10174	0.28	0
Total	1427	-1.27	-45867	42200	88181	2.47	114
Annual Total:	2948	-0.40	-14184	87637	115344	3.24	13523

Note: The period covers the severe drought of 1965-1968.

Method used slightly underestimates evaporation, particularly in 'winter', and slightly underestimates run-off particularly in 'summer'.

Climatological Data
Canberra - Queanbeyan Area

MEAN RAINFALL AND EVAPORATION



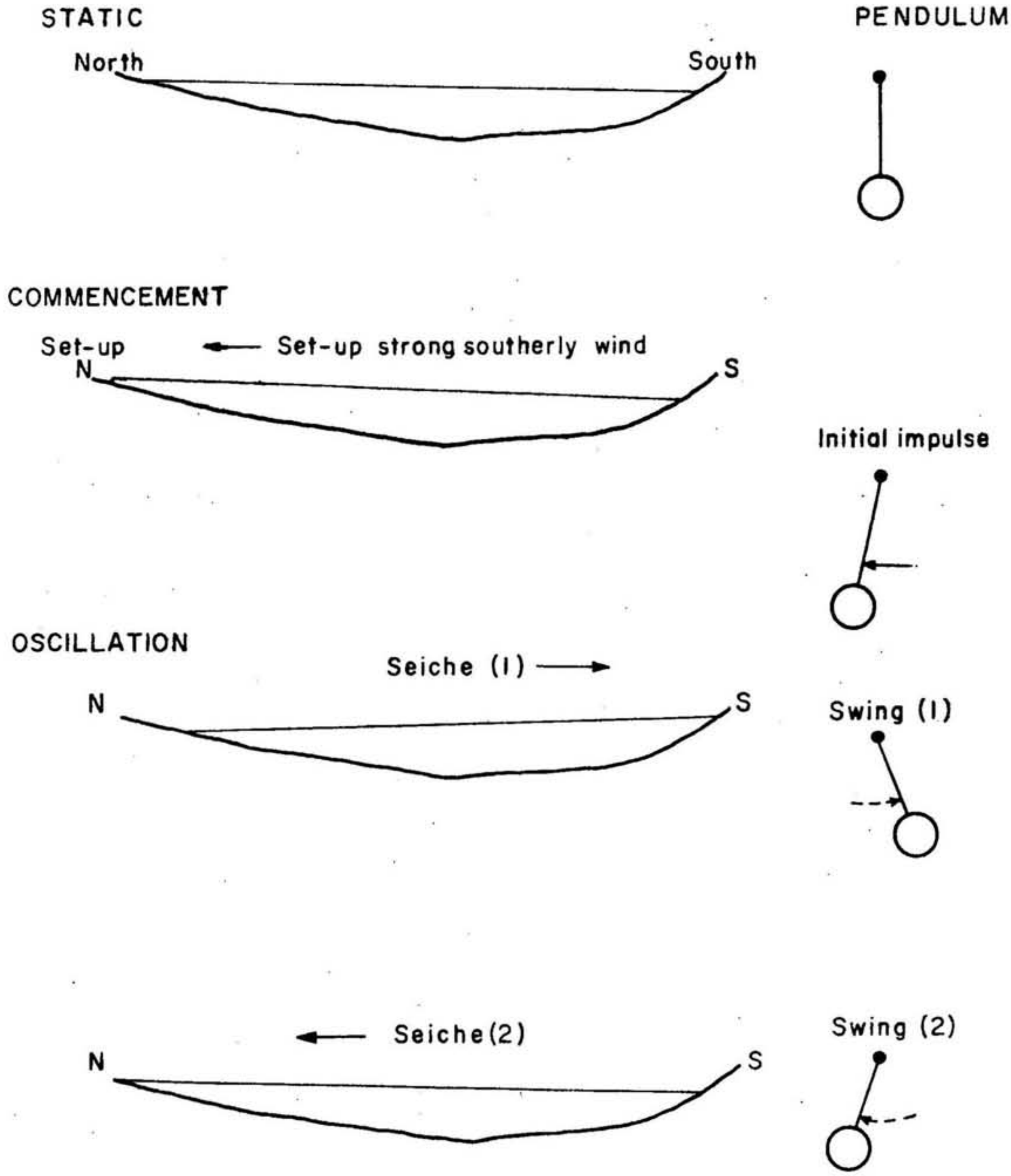
Bureau of Mineral Resources, Geology and Geophysics.

To accompany Record 1972/79

155/A16

SET-UPS AND SEICHES

LAKE GEORGE, NEW SOUTH WALES



PERIOD OF LAKE

$$T_n = \frac{1}{n} \quad \frac{2L}{\sqrt{gd}}$$ (Simplified equation)

n = *number of nodes*
L = *mean length of basin*
d = *mean depth*
g = *acceleration of gravity*

PERIOD OF PENDULUM

$$T = 2\pi\sqrt{\frac{l}{g}}$$

l = *length of pendulum*
g = *acceleration of gravity*

accurate observations, but the conclusions arrived at have been due to mistaken interpretation of hydrological phenomena.

An example of the first, 'observer deception', is the report of visitors to Canberra who return to Sydney and believe that the lake rose suddenly between their journey to Canberra and the return journey. The reason for the apparent rise would appear to be as follows: The approach from Sydney to the lake traverses low ground about 15 feet (4.5 m) above water level, and in the low western light of afternoon an observer sees a long dry foreground of grass and little water with the road sign 'Lake George', 1½ to 2 miles (2.5 - 3 km) from the present shore. On the return journey the motorist rounds a bend at Geary's Gap, and from a height of about a hundred feet (30 m) suddenly sees a vast stretch of water spread out in front of him, and at the same time he sees the southern road sign 'Lake George'. The two visual impressions appear incompatible to the observer and he must therefore conclude that a rise in lake level has taken place since he proceeded southbound.

The other type of deception is that associated with the observation of a seiche. The sudden onset of a wind, or a change in the wind can cause water in a lake to oscillate like a pendulum, like water set in motion in a saucer (Figure 8). Measurements by BMR indicate that seiches in Lake George have periods of 1½ to 2 hours, and can cause temporary changes in level of more than 6 inches (0.15 m) (Figure 4); in some bays, these changes could be considerably more, and cause the strand line to advance and retreat across the almost flat lake margins by from ½ to 1 mile (1 to 2 km) in an hour. An observer, unfamiliar with the effect of a seiche, would gain the impression that a rapid emptying or filling of the lake was in progress.

CHEMISTRY

The chemistry of the lake water has been an essential area of BMR study since 1959. The principal cations and anions categorize the water as distinctly different from the range of water types found in local rivers, or in local groundwater. The lake water is dominantly a sodium chloride type and several analyses of the main ions in the early 1960's indicated similar ratios of the main ions to that of sea water. A.D. Haldane (pers. comm.) has commented on the unusual content of bromine for a local surface water. The bromine to chloride ratio is reasonably close to that of seawater. The writer, after examining analyses of some similar eastern

Australian water storages, believes that most of the salt in Lake George is cyclic salt brought in from the Tasman Sea and Pacific Ocean by eastern coastal rainfall. Evaporation continually concentrates the salts, and calcium and magnesium bicarbonates introduced by surface run-off are probably lost from solution by deposition as carbonates.

Figure 3 shows that the salinity of the lake varies considerably with the stage of the lake, and warnings have been issued to graziers from time to time concerning the unsuitability of the lake water for consumption by stock.

Bue (1963) quotes the USGS classification of lakes as follows:

Slightly saline	1000 to 3000	parts per million (ppm)
Moderately saline	3000 to 10000	" " "
Very saline	10000 to 35000	" " "
Brine greater than	35000	" " "

The water in Lake George has ranged from slightly saline to very saline over the last twelve years* and may well pass at some future stage to brine. The total salt content of the water in the lake is estimated by the writer at 735000 tons.

During the 1965-68 drought the lake lost salt from solution as thin evaporite deposits along the shore-line; these were dispersed by wind (mainly the 'willy-willies' that sweep the shore in summer) to higher areas of the catchment or to other catchments. Recent observations suggest that much of this salt has returned to the lake in solution as run-off over the last two years.

Table 2 gives two analyses of water from Lake George and one from Lake Bathurst. The samples were collected on 30 January 1969 and indicate that the total dissolved solids is now many times greater than in the samples collected on 14 November 1960 (Jennings et al., 1964), which contained total dissolved solids of 1286 and 714 ppm respectively for Lake George and Lake Bathurst.

---

* Since 1970 salinities ranging to 29 000 ppm (December, 1972) have been recorded in the lake waters.

TABLE 2.

WATER ANALYSES - LAKES GEORGE AND BATHURST

		LAKE GEORGE				LAKE BATHURST	
Sampling Point -		Near Gearys Trig.		Off Kennys Point		Southern end	
Date of Sampling		30/1/69		30/1/69		30/1/69	
Sample Number		69270001		69270002		69270003	
		ppm	meg/L	ppm	meg/L	ppm	meg/L
pH		8.9		8.9		8.3	
T.D.S.		9893		7163		2935	
Calcium	Ca	18	0.9	22	1.1	18	0.9
Magnesium	Mg	205	16.9	152	12.5	90	7.4
Sodium	Na	3506	152.5	2504	108.9	990	43.1
Potassium	K	17	0.4	13	0.3	15	0.4
Total Iron	Fe Total						
Manganese	Mn	0.02	0.001	0.03	0.001	0.01	< 0.001
Boron	B						
Fluoride	F	1.88	0.10	1.54	0.08	0.49	0.026
Chloride	Cl	4995	140.9	3535	99.7	1420	40.0
Sulphate	SO_4	470	9.8	325	6.8	10	0.2
Bicarbonate	HCO_3	1085	17.8	930	15.2	700	11.5
Carbonate	CO_3	66	2.2	33	1.1	Nil	-

Sampling Point - Date of Sampling		LAKE GEORGE Near Gearys Trig. 30/1/69		Off Kennys Point 30/1/69		LAKE BATHURST Southern end 30/1/69	
Sample Number		69270001		69270002		69270003	
		ppm	meg/L	ppm	meg/L	ppm	meg/L
Phosphate	PO_4	0.94	0.03	1.01	0.032	<0.01	<0.001
Silica	SiO_2	4.56	0.15	3.14	0.11	18.1	0.60
Nitrate	NO_3	0.16	0.003	0.10	0.002	0.77	0.012
Conductivity at 25°C		16250		11900		4575	
Bromine	Br	23	0.29	16	0.20	<2	<0.02
Nitrate	NO_2	ND <0.05		ND <0.05		ND <0.05	
Aluminium	Al_2O_3						
Copper	Cu	0.02		0.02		0.02	
Zinc	Zn	0.04		0.01		0.01	
Strontium	Sr	0.75	0.017	0.72	0.016	0.70	0.016

Note: Analyses carried out for BMR by Australian Mineral Development Laboratories. (AN4064/69). The maximum depth of Lake George on 30/1/69 was 4.55 feet; the lake was continuing to recede after the 1965-68 drought and reached its lowest stage, 4.08 feet on 11/3/69. The proportions of the main ions differ significantly from the analysis of the sample of 13/11/60, when the depth of the lake was 13.49 feet and the total dissolved solids (T.D.S.) was 1286 ppm (see Jennings et al., 1964).

SEDIMENTATION

Few comments will be made on the sedimentation taking place in and around the lake other than to indicate the range of sediments to be observed. Fans and scree sediments are common along the steep western shore; these have been reworked by waves, seiches and current action into beaches, bars, and spits. The finer lacustrine sediments such as silt, clay, and organic ooze occupy the bed of the lake in the deeper water. Streams entering the lake form deltas and can be readily identified on aerial photographs, and aeolian deposits can be recognized along the eastern and southern shores. (Note the wind-roses of Fig. 9 for Canberra). The stream channels that form the bed of Turallo Creek bear sand and gravel alluvial deposits.

The complex pattern of sedimentation during the different stages of the lake is evident in the sediments encountered in drilling water bores. Correlation between holes is difficult as the distribution of shore lines, lake bed, aeolian banks and stream channels has changed continually with the progressive infilling of the lake bed (Fig. 10).

FORMATION OF THE LAKE

The Lake George basin is a minor basin of internal drainage within the Great Dividing Range (Fig. 2). East of Lake George the Shoalhaven and Wollondilly River systems drain to the east coast, and to the west the Yass and Lachlan River systems drain inland and westwards to the Australian Bight. Data are still inadequate to permit a reconstruction of the stages of the formation of the lake. The three main theories for the formation of the lake basin proposed in turn by T. Griffith-Taylor in 1907, by M.D. Garretty in 1936 and by Noakes and Jennings in 1954 are outlined in Jennings et al., (1964); all three theories postulate the disruption and blockage of a pre-existing drainage system by crustal movement and consequent formation of the lake at the lowest point.

The writer believes that Cleary (1967), working on more recent seismological evidence, defines more clearly the nature of the crustal movements and adds considerably to Noakes' and Jennings' theory.

From geomorphological observations and observations on weathering in the field, from oblique aerial photographs specially taken of the scarp, and from Hill's (1969) mapping, the writer believes that the Lake George Fault along the western shore of Lake George is not a simple meridional fault dividing the area into the Cullarin Horst and the Lake George Graben; but rather, that the area is divided into a series of differentially tilted blocks with the Lake George Fault being the dominant fault. The differential tilting and movement between blocks has disrupted the old established drainage system, and set the conditions for the formation of the new drainage system.

Most of the tilting and faulting probably occurred late in the Tertiary and early in the Pleistocene. Consequently the lowest areas of the tilt blocks contain the thickest sections of post-Miocene sediments, and beneath the sediments, the thick weathered profile of the Miocene land surface. The provenance of the post-Miocene sediments is the deeply weathered Miocene(?) and Pliocene(?) land surface and its superficial sedimentary deposits.

The presence of copious quartz-rich gravels in the region has frequently been commented on. H.F. Doutch drew the writer's attention some years ago to a partly weathered section of rock containing an angular quartz fragment shedding a sharp corner in situ. The plucking of quartz by colloidal clay is well known; hence if one accepts this, and Jennings' and Noakes' view that the Lake George Fault is partly Palaeozoic, one may easily reconstruct the formation of quartz-rich gravel banks and rounded quartz scree deposits (Figure 11). Many of the major Palaeozoic faults, such as the Lake George fault, contain numerous quartz 'blows'. During the Mesozoic-Tertiary peneplanation deep pockets of weathering would have penetrated the fault lines; the pockets would contain deeply weathered rock fragments, clay, and rounded quartz. Reactivation of the faults would have led to active erosion of these same pockets and the deposition nearby of apparently mature quartz gravels, and scree banks containing clay, weathered rock, and rounded quartz. The distance of transport in such circumstances would often be quite short.

CONCLUSION

Many problems concerning Lake George remain to be answered, and additional work is under way. Cores from the lake bed will provide some of the answers as well as pose some additional problems. The possibility of the lake drying up could provide an opportunity to survey the bed of the lake.

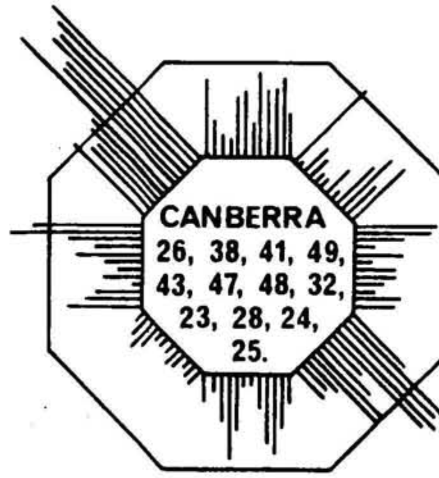
The formation of the lake and its subsequent history will continue to exercise the minds of those engaged in one or other aspects of the study of Lake George, for years to come.

Fig. 9

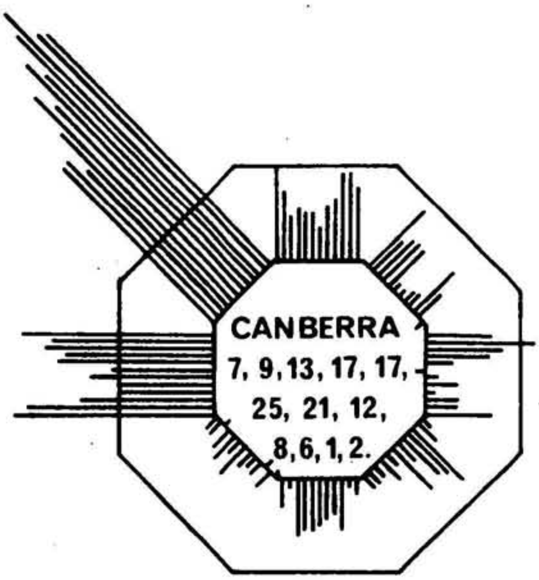
WIND ROSES
CANBERRA

Compiled by the BUREAU OF METEOROLOGY

9 a.m.
Showing monthly percentage frequency distribution of wind directions to eight points of the compass



3 p.m.
Showing monthly percentage frequency distribution of wind directions to eight points of the compass



SCALE OF FREQUENCIES PER. CENT.

0 10 20 40 60 80 100

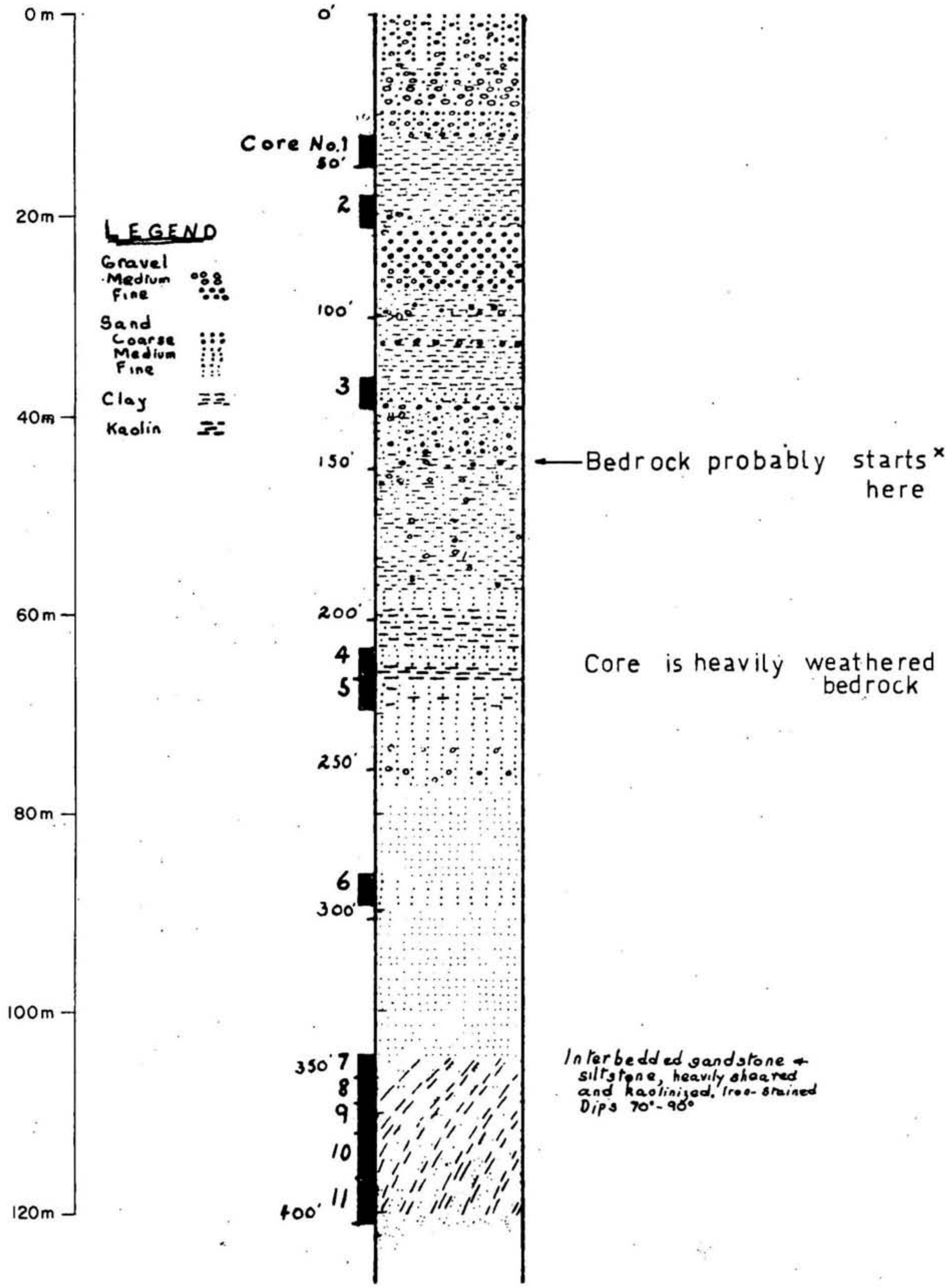
The sides of the octagons face towards the cardinal and semi-cardinal points. Projecting from each side are twelve columns representing the twelve months of the year, and the lengths of the columns are proportional to the percentage frequencies of the winds from the given direction in the successive months, working round clockwise from January to December. The scale is shown above, and the outer octagons have been drawn, separated from the inner octagons by a distance representing 12½%. The tops of the columns would all be on these outer octagons if winds from the eight directions were equally frequent and there were no calms. The percentage frequency of calms in the 12 months is shown by figures within the octagons. Small dashes within the inner octagons indicate months when the percentage of winds from that direction is practically zero.

To accompany Record 1972/79 I 55/A16/1002

B.M.R.1 SCOUT HOLE CANBERRA

(Southern end of Lake George)

Fig. 10



General log by M.A.Randal

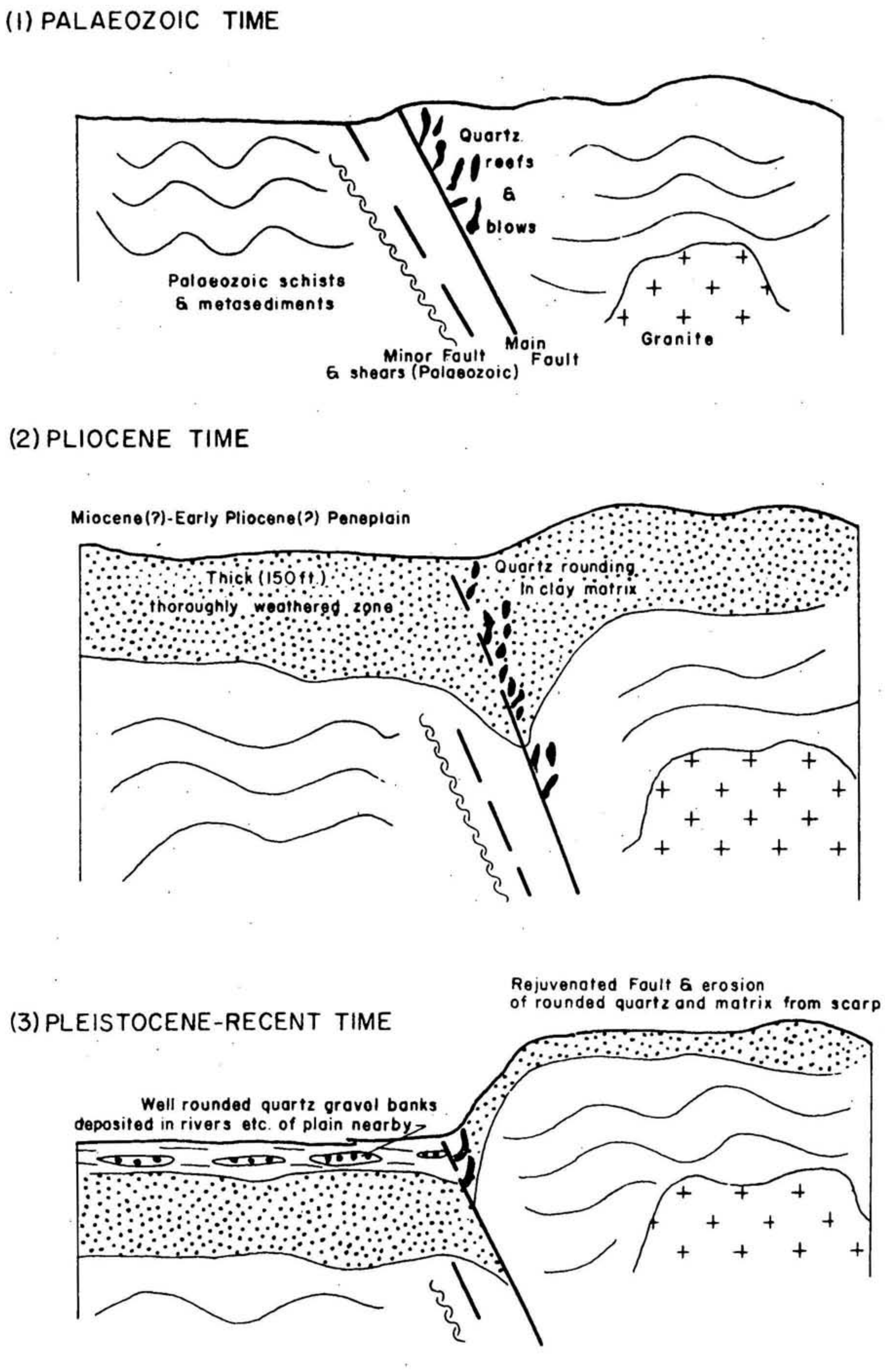
× Comment by G.M.Burton

Bureau of Mineral Resources

To accompany Record 1972/79

155/A16/730

FORMATION OF APPARENTLY MATURE QUARTZ GRAVELS NEAR FAULT



ACKNOWLEDGEMENTS

The study of a lake embraces many disciplines and the many helpful discussions in the field at Lake George with Messrs J.N. Jennings and R. Coventry of the Australian National University, Dr R. Galloway of CSIRO and of Mr J.A.H. Brown of the Snowy Mountains Engineering Corporation, were greatly appreciated. Mr A.D. Haldane and fellow officers of the Bureau's chemical laboratory have assisted with many analyses and discussion.

It is not usual to acknowledge the routine assistance of fellow Bureau officers but it would be inappropriate not to mention the assistance of former geologists of the field party, particulary E.G. Wilson, H.F. Doutch, M.A. Randal, Miss R.G. Warren and Mrs R. Thieme, and the continued excellent field hydrography and instrumentation of A.W. Schuett assisted by F.F. Simonis over the last few years, and previously by Mr R.B. Grey and other assistants.

BIBLIOGRAPHY

AMBE, Y., 1967 - Secular variation of aridity in the World. Jap. J. Geol. & Geophys., 38, 1, 43-77.

AWRC, 1970 - Evaporation from water storages. Aust. Wat. Resour. Counc., Hydrological Series, 4.

BROECKER, W.S., & WALTON, A.F., 1959 - Re-evaluation of the salt chronology of several Great Basin Lakes. Bull. geol. Soc. Amer., 70, 601-18.

BROWN, J.A.H., 1961 - Oscillations of water level on Lake Eucumbene. Snowy Mts. Hydro-Electric Authority Rep. (unpubl.).

BUE, C.D., 1963 - Principal lakes of the United States. U.S. Geol. Surv. Circ., 476.

CLEARY, J.R., 1967 - Seismicity of the Gunning and surrounding areas, 1958-1961. J. geol. Soc. Aust., 14, 23-9.

GALLOWAY, R.W., 1965 - Late Quaternary climates in Australia. J. Geol., 73, 4, 603-18.

HILL, R.M., 1969 - Geology of the Gearys Gap - Sutton - Gundaroo Area. Bur. Miner. Resour. Aust. Rec., 1969/148 (unpubl.).

HUTCHINSON, G.E., 1957 and 67 - A TREATISE ON LIMNOLOGY. (2 Vols - Vol. 1, 1957; Vol. 2, 1967). Wiley, N.Y.

IASH, 1966 - Symposium on hydrology of lakes and reservoirs, Italy 1966. Intern. Assoc. of Hydrol. Publ. 70.

JENNINGS, J.W., NOAKES, L.C., & BURTON, G.M., 1964 - Notes on the Lake George and Lake Bathurst excursion (ANZAAS 1964), in Canberra Excursions, Bur. Miner. Resour. Aust. Pamph.

KEVI, L., 1964 - Lake George gravity survey, N.S.W., 1963. Bur. Miner. Resour. Rec., 1964/21 (unpubl.).

LAMB, H.H., 1967 - Recent high levels of East African lakes. J. Hydrol., 5, (1967), 107-16.

MATVEYEV, A.A., & BASHMAKOVA, O.I., 1967 - Chemical composition of atmospheric precipitation in some regions of U.S.S.R. Soviet Hydrol. Select. Paps, 5, 480-91.

NOAKES, L.C., 1951 - Notes on fluctuations of water-level at Lake George. Bur. Miner. Resour. Aust. Rec., 1951/17 (unpubl.).

POLAK, E.J., & KEVI, L., 1964 - Lake George seismic refraction survey, N.S.W., 1964. Bur. Miner. Resour. Aust. Rec., 1964/118 (unpubl.).

REEVES, C.C. (Jr.), 1968 - INTRODUCTION TO PALAEOLIMNOLOGY. Elsevier Amsterdam.

RUSSELL, H.C., 1885 - Anniversary Address. J. & Proc. Roy. Soc. N.S.W.

TARASOV, M.N., 1967 - Water and salt balance of L. Balkhash during periods of falling and rising levels. Soviet Hydrol. Select. Paps., 5, 470-4.

WEBB, E.K., 1966 - A pan-lake evaporation relationship. J. Hydrol., 4(1), 1-11.

APPENDIX 1

LAKE GEORGE N.S.W
WATER LEVEL,MAXIMUM DEPTH,TEMPERATURE,CONDUCTIVITY,SALINITY,TOTAL SALT CONTENT,STORAGE

MEASUREMENTS BY BUREAU OF MINERAL RESOURCES
A.C.T. GROUNDWATER FIELD PARTY

BMR GAUGING STATION - GEARYS GAP TRIG

TIME		LAKE DEPTH		WATER	WATER		AIR		ELECT.	APPROX.TDS		V.APPROX.	WATER IN STORAGE		
HOUR	DATE	MAXIMUM (STAGE) FEET	APPROX. MEAN FEET	LEVEL (ASL) FEET	TEMPERATURE C	F	TEMPERATURE C	F	CONDUCT. UMHOS/CM 25 C	EST.AV. LAKE PPM	AT BMR GAUGE PPM	SALT CONTENT OF LAKE TONS	VOLUME MILLION GALS	ACRE-FT	AREA ACRES
	2 1 58	11.06	7.8	2218.66						2114			77868	286840	36691
	21 2 58	10.61	7.4	2218.21						2243			73387	270330	36547
	27 3 58	10.09	6.9	2217.69						2412			68245	251390	36331
	9 5 58	9.90	6.7	2217.50						2480			66375	244500	36240
	19 6 58	9.85	6.7	2217.45						2499			65883	242690	36216
	28 7 58	10.12	6.9	2217.72						2402			68540	252480	36346
	28 8 58	10.43	7.2	2218.03						2300			71594	263730	36490
	27 9 58	10.38	7.2	2217.98						2316			71098	261900	36470
	25 10 58	10.37	7.2	2217.97						2319			71000	261540	36466
	22 11 58	10.22	7.0	2217.82						2368			69524	256100	36394
	22 12 58	9.98	6.8	2217.58						2451			67162	247400	36278
	22 1 59	9.42	6.3	2217.02						2670			61652	227100	36010
	1 4 59	9.89	6.7	2217.49						2484			66277	244140	36235
	16 5 59	9.53	6.4	2217.13						2624			62734	231090	36062
	20 6 59	9.46	6.3	2217.06						2654			62045	228550	36029
	25 7 59	11.27	8.0	2218.87						2059			79959	294540	36758
	15 8 59	11.19	7.9	2218.79						2080			79163	291610	36733
	19 9 59	11.28	8.0	2218.88						2056			80059	294910	36762
	24 10 59	13.14	9.7	2220.74						1666			98841	364090	37517
	21 11 59	13.56	10.1	2221.16						1596			103128	379890	37677
	19 12 59	13.57	10.1	2221.17						1595			103231	380260	37682
	27 1 60	12.88	9.5	2220.48						1711			96198	354360	37434
	6 3 60	12.50	9.1	2220.10						1783			92335	340130	37312
	6 5 60	12.28	8.9	2219.88						1827			90111	331940	37222
	2 6 60	12.31	8.9	2219.91						1821			90413	333050	37237
	20 9 60	13.75	10.2	2221.35						1567			105080	387080	37768
	14 11 60	13.49	10.0	2221.09					2270*	1608	1521	696542	102408	377240	37643
	16 12 60	13.90	10.4	2221.50						1544			106622	392760	37840
	31 1 61	13.42	10.0	2221.02					2350	1619	1575	716024	101689	374590	37610
	2 3 61	13.27	9.8	2220.87					2350	1644	1575	705273	100162	368960	37558
	7 4 61	13.36	9.9	2220.96						1629			101077	372330	37587
	11 5 61	13.23	9.8	2220.83					2500	1650	1675	747245	99756	367460	37546
	27 6 61	13.05	9.6	2220.65					2420	1681	1621	710066	97926	360720	37488
	25 7 61	13.61	10.1	2221.21					2450	1589	1642	760827	103642	381780	37701
	26 9 61	13.68	10.2	2221.28					2400	1578	1608	750473	104361	384430	37734
	25 10 61	13.71	10.2	2221.31					2040*	1573	1367	639787	104669	385560	37749
	24 11 61	14.30	10.7	2221.90					2475	1487	1658	821176	110733	407900	38032
	21 12 61	14.13	10.6	2221.73					2304*	1511	1544	752380	108986	401460	37950
	25 1 62	14.31	10.7	2221.91					2230*	1485	1494	740575	110835	408280	38037
	28 2 62	14.32	10.7	2221.92					2304*	1484	1544	765859	110938	408660	38042
	30 3 62	13.89	10.4	2221.49					2380*	1546	1595	759609	106519	392380	37835
	8 5 62	13.54	10.1	2221.14					2460*	1600	1648	758630	102922	379130	37667
	30 5 62	13.51	10.0	2221.11					2380*	1604	1595	731761	102614	377990	37653
	28 6 62	13.37	9.9	2220.97					2380*	1627	1595	721525	101179	372710	37590
	1 8 62	13.59	10.1	2221.19					2230*	1592	1494	691135	103436	381020	37691
	28 9 62	14.05	10.5	2221.65					2380*	1522	1595	771335	108163	398440	37912

TIME		LAKE DEPTH		WATER	WATER		AIR		ELECT.	APPROX.TDS		V.APPROX.	WATER IN STORAGE		
		MAXIMUM (STAGE)	APPROX. MEAN	LEVEL (ASL)	TEMPERATURE		TEMPERATURE		CONDUCT. UMHOS/CM	EST.AV. LAKE	AT END GAUGE	SALT CONTENT OF LAKE	VOLUME		AREA
HOUR	DATE	FEET	FEET	FEET	C	F	C	F	25 C	PPM	PPM	TONS	MILLION GALS	ACRE-FT	ACRES
	25 10 62	14.04	10.5	2221.64						1524			108061	398060	37907
	6 12 62	13.74	10.2	2221.34						1568			104978	386700	37763
	7 1 63	13.85	10.3	2221.45					2380	1552	1595	756678	106108	390600	37816
	30 1 63	13.83	10.3	2221.43	20.5	68.9			2380	1555	1595	755212	105903	390110	37806
	27 2 63	13.32	9.9	2220.92					2460	1635	1648	742032	100670	370830	37574
	1 4 63	13.09	9.7	2220.69	17.5	63.5			2550*	1674	1709	751317	98333	362220	37501
	1 5 63	13.04	9.6	2220.64	13.5	56.3			2460*	1683	1648	721053	97824	360350	37485
	4 6 63	13.52	10.0	2221.12	10.5	50.9			2550*	1603	1709	784815	102717	378370	37658
	2 7 63	13.72	10.2	2221.32	8.5	47.3			2380*	1571	1595	747151	104772	385940	37754
	1 8 63	13.94	10.4	2221.54	7.5	45.5			2550*	1538	1709	817793	107033	394270	37659
	3 9 63	14.32	10.7	2221.92	9.0	48.2			2460*	1484	1648	817714	110938	408660	38042
	10 10 63	14.59	11.0	2222.19	22.0	71.6				1447			113747	419000	38262
	31 10 63	14.46	10.9	2222.06	20.0	68.0				1465			112388	414000	38138
	4 12 63	14.04	10.5	2221.64	25.0	77.0			2460	1524	1648	796505	108061	398060	37907
	7 1 64	13.53	10.1	2221.13	24.0	75.2				1601			102819	378750	37662
	5 2 64	13.11	9.7	2220.71	33.0(2)	91.4			2750*	1671	1643	811918	98536	362970	37507
	27 2 64	12.76	9.4	2220.36	26.0	78.8				1733			94978	349870	37395
	6 4 64	12.31	8.9	2219.91	22.5	72.5			3100*	1821	2077	839606	90413	333050	37237
	4 5 64	12.52	9.1	2220.12	13.5	56.3			3020	1779	2023	837367	92539	340860	37318
	2 6 64	12.54	9.2	2220.14	7.5	45.5			2700	1775	1809	750284	92742	341630	37325
	2 7 64	12.54	9.2	2220.14	8.5	47.3			2750	1775	1643	764179	92742	341630	37325
	3 8 64	13.14	9.7	2220.74	6.0	42.8			2640	1666	1769	781854	98841	364090	37517
	4 9 64	13.36	9.9	2220.96	11.0	51.8			2640	1629	1769	799543	101077	372330	37587
	2 10 64	13.51	10.0	2221.11	13.5	56.3			2530	1604	1695	777680	102614	377990	37653
	2 11 64	14.31	10.7	2221.91	16.0	60.8			2420	1485	1621	803673	110835	408280	38037
	15 12 64	13.65	10.2	2221.25	19.0	66.2			2420	1582	1621	754492	104053	383290	37720
	11 1 65	13.20	9.8	2220.80					2692	1655	1804	802173	99451	366340	37536
	8 2 65	12.86	9.4	2220.46	23.4	74.1			2750	1715	1643	790980	95995	353610	37427
	8 3 65	12.14	8.8	2219.74	23.0	73.4			2910	1856	1950	773415	88702	326750	37155
	1 4 65	11.85	8.5	2219.45	18.5	65.3				1919			85783	316000	37016
1625	12 5 65	11.57	8.3	2219.17	14.5	58.1				1984			82965	305610	36882
1430	3 6 65	11.39	8.1	2218.99					3570	2029	2392	868094	81155	298940	36797
1015	30 6 65	11.48	8.2	2219.08	6.1	43.0			3540	2006	2372	870396	82059	302250	36838
1615	9 8 65	11.40	8.2	2219.00	7.2	45.0			3550	2006	2379	870396	82059	302280	36838
920	2 9 65	11.55	8.3	2219.15	7.8	46.0			3550	1989	2379	880349	82764	304870	36872
1000	12 11 65	11.24	8.0	2218.84	15.5	59.9				2067			79661	293440	36749
1500	3 12 65	11.18	7.9	2218.78					3700	2082	2479	876520	79063	291240	36730
1125	5 1 66	10.68	7.5	2218.28	23.0	73.4			3800	2222	2546	843514	74084	272900	36570
1005	2 2 66	10.25	7.1	2217.85	26.4	79.5			3850	2358	2580	805417	69819	257190	36408
950	7 3 66	9.92	6.8	2217.52	23.0	73.4			4250	2473	2648	847744	66572	245230	36250
1105	1 4 66	9.78	6.6	2217.38	20.0	68.0			4300	2525	2681	839968	65194	240150	36182
1020	6 5 66	9.56	6.4	2217.16	11.0	51.8			4180	2612	2801	789412	63029	232150	36077
1030	2 6 66	9.45	6.3	2217.05	9.0	48.2			3950	2658	2647	733164	61947	228190	36024
950	8 7 66	9.57	6.4	2217.17	5.9	42.6	4.3	39.7	4120	2608	2760	779296	63128	232540	36082
1010	5 8 66	9.58	6.5	2217.16	7.0	44.6	9.0	48.2	4160	2604	2787	788085	63226	232900	36086
1415	10 9 66	9.55	6.4	2217.15	10.5	50.9	10.0	50.0	3950	2616	2647	744811	62931	231810	36072
950	26 10 66	9.60	6.5	2217.20	19.0	66.2	19.5	67.1	4180	2596	2801	794342	63423	233630	36096
1500	24 11 66	9.84	6.7	2217.44	24.0	75.2	24.5	76.1	4180	2503	2801	823922	65785	242330	36211
1540	8 12 66	9.87	6.7	2217.47	24.0	75.2	21.5	70.7	4070	2492	2727	805840	66080	243410	36226
1130	6 1 67	9.63	6.5	2217.23	23.0	73.4	22.0	71.6	3950	2584	2647	754128	63718	234710	36110
1130	20 1 67	9.42	6.3	2217.02	22.5	72.5	25.5	77.9	4510	2670	3022	833117	61652	227100	36010
930	24 2 67	9.04	5.9	2216.64	25.0	77.0	31.5	88.7	4675	2841	3132	811783	57953	213480	35885
1400	7 4 67	8.63	5.6	2216.23	18.0	64.4	21.0	69.8	4700	3051	3149	759954	53964	198780	35754
1040	4 5 67	8.20	5.2	2215.80	15.5	59.9	17.5	63.5	4750	3305	3183	708963	49813	183490	35520
1410	24 5 67	8.14	5.1	2215.74	10.5	50.9	9.0	48.2	4600	3344	3082	678664	49239	181380	35472
1000	11 7 67	8.14	5.1	2215.74	7.0	44.6	8.0	46.4	4600	3344	3082	678664	49239	181380	35472
1200	1 8 67	8.03	5.0	2215.63	9.5	49.1	10.0	50.0	4800	3417	3216	693036	48187	177500	35384
1030	9 8 67	8.17	5.1	2215.77	7.0	44.6	8.5	47.3	4300	3324	2881	638100	49526	182440	35496
1130	25 8 67	8.25	5.2	2215.85	12.0	53.6	10.5	50.9	4600	3274	3082	693167	50291	185260	35560
1030	1 9 67	8.24	5.2	2215.84	7.5	45.5	9.7	49.5	4700	3280	3149	706889	50196	184900	35552
1120	7 9 67	8.67	5.6	2216.27	9.5	49.1	9.0	48.2	3800	3029	2546	618661	54353	200220	35766
1000	12 9 67	8.66	5.6	2216.26	10.0	50.0	8.5	47.3	4500	3035	3015	731551	54256	199860	35763
1000	6 10 67	8.51	5.4	2216.11	16.0	60.8	17.0	62.6	4500	3118	3015	711675	52797	194480	35715

TIME		LAKE DEPTH MAXIMUM (STAGE) FEET	APPROX. MEAN FEET	WATER LEVEL (ASL) FEET	WATER TEMPERATURE C	WATER TEMPERATURE F	AIR TEMPERATURE C	AIR TEMPERATURE F	ELECT. CONDUCT. UMHOS/CM 25 C	APPROX. TDS EST. AV. LAKE PPM	APPROX. TDS AT BMR GAUGE PPM	V. APPROX. SALT CONTENT OF LAKE TONS	WATER IN STORAGE VOLUME MILLION GALS	WATER IN STORAGE VOLUME ACRE-FT	AREA ACRES
HOUR	DATE														
930	17 10 67	8.52	5.5	2216.12	18.0	64.4	19.5	67.1	4400	3113	2948	697336	52894	194840	35718
930	1 11 67	8.33	5.3	2215.93	19.0	66.2	17.5	63.5	4800	3225	3216	734312	51057	188080	35624
1030	4 12 67	7.78	4.8	2215.38	18.0	64.4	14.5	58.1	5000	3595	3350	686084	45795	168690	35184
1000	29 12 67	7.03	4.2	2214.63	22.0	71.6	29.5	85.1	5600	4248	3752	650271	38754	142760	34170
1110	19 1 68	6.86	4.0	2214.46	23.0	73.4	22.0	71.6	5950	4427	3987	663016	37190	136990	33843
1500	24 1 68	6.71	3.9	2214.31	28.5	83.3	34.5	94.1	5600	4598	3752	600847	35809	131910	33555
930	23 2 68	6.11	3.5	2213.71	26.5	79.7	21.0	69.8	9500	5411	6365	866047	30425	112080	32450
1050	7 3 68	6.16	3.5	2213.76	17.5	63.5	19.7	67.5	9900	5335	6633	915453	30861	113680	32538
1010	12 3 68	5.84	3.2	2213.44					10500	5865	7035	883096	28069	103400	31974
950	26 3 68	5.81	3.2	2213.41	21.0	69.8	20.5	68.9	8500	5921	5695	708221	27808	102430	31922
1000	5 4 68	5.58	3.0	2213.18	20.5	68.9	18.0	64.4	10500	6381	7035	811727	25801	95040	31517
1000	19 4 68	5.68	3.1	2213.28	14.5	58.1	13.5	56.3	10000	6172	6700	799215	26673	98260	31693
1000	9 5 68	5.60	3.0	2213.20	12.7	54.9	12.0	53.6	9400	6338	6298	731603	25975	95680	31552
1000	3 6 68	5.87	3.3	2213.47	7.0	44.6	5.0	41.0	6750	5811	4523	572998	28331	104360	32027
1000	1 7 68	6.16	3.5	2213.76	1.0	33.8	0.5	32.9	8500	5335	5695	785995	30861	113680	32538
950	5 8 68	5.91	3.3	2213.51	6.0	42.8	8.0	46.4	8500	5741	5695	730442	28680	105650	32098
1000	14 8 68	6.23	3.5	2213.83	7.5	45.5	7.0	44.6	7500	5231	5025	707250	31472	115930	32661
1050	26 8 68	6.22	3.5	2213.82	13.0	55.4	14.0	57.2	8250	5246	5528	775818	31385	115610	32643
1200	18 9 68	6.22	3.5	2213.82	17.5	63.5	13.0	55.4	8750	5246	5863	822837	31385	115610	32643
1710	27 9 68	6.08	3.4	2213.68	17.5	63.5	10.0	58.0	7940*	5458	5320	717606	30163	111110	32397
950	10 10 68	6.21	3.5	2213.81	11.3	52.3	14.5	58.1	8100	5260	5427	759595	31298	115290	32626
1030	31 10 68	5.91	3.3	2213.51	17.8	64.0	17.5	63.5	8250	5741	5528	708958	28680	105650	32098
1120	19 11 68	5.82	3.2	2213.42	26.2	79.2	27.3	81.1	12000(Q)	5902	8040	1002978	27895	102750	31939
1130	9 12 68	5.23	2.8	2212.83	29.0	84.2	28.0	82.4	11500	7193	7705	788738	22890	84320	30466
1000	20 12 68	4.94	2.6	2212.54	27.5	81.5	27.0	80.6	14250	7991	9548	879733	20604	75900	29213
1000	8 1 69	4.72	2.5	2212.32	27.0	80.6	29.5	85.1	13200	8725	8844	746313	18870	69510	28262
1000	30 1 69	4.55	2.3	2212.15	22.5	72.5	20.5	68.9	12050*	9392	8074	632905	17529	64570	27528
930	13 2 69	5.30	2.8	2212.90	23.0	73.4	23.5	74.3	8800	7023	5896	618107	23442	86358	30768
940	28 2 69	4.75	2.5	2212.35	18.8	65.8	19.0	66.2	12100	8617	8107	692695	19106	70380	28392
1030	11 3 69	4.08	2.1	2211.68	29.0	84.2	24.5	76.1	16500	11582	11055	702771	14215	52360	25395
930	28 3 69	4.23	2.1	2211.83	24.0	75.2	22.0	71.6	13200	10821	8844	601741	15214	56040	26091
940	3 4 69	4.85	2.5	2212.45	16.0	60.8	15.5	59.9	8400	8276	5628	500722	19894	73280	28824
1230	17 4 69	4.97	2.6	2212.57	16.0	60.8	17.0	62.6	5900	7900	3953	368421	20840	76770	29342
930	23 4 69	4.96	2.6	2212.56	18.0	64.4	7.0	44.6	10560*	7930	7075	656917	20762	76480	29299
1030	28 5 69	4.84	2.5	2212.44	8.0	46.4	9.5	49.1	10560	8309	7075	626984	19816	72990	28781
930	4 6 69	4.98	2.6	2212.58	9.0	48.2	11.0	51.8	10010	7870	6707	627432	20919	77060	29386
930	17 6 69	5.05	2.7	2212.65	7.0	44.6	8.0	46.4	10400	7668	6968	669074	21471	79090	29688
1030	17 7 69	5.19	2.7	2212.79	10.0	50.0	11.0	51.8	7370	7293	4938	498515	22575	83160	30293
1130	5 8 69	5.51	3.0	2213.11	8.1	46.6	4.0	39.2	8570*	6536	5742	646841	25190	92790	31394
930	18 9 69	5.52	3.0	2213.12	9.0	48.2	11.0	51.8	10100	6513	6767	764961	25277	93110	31411
930	3 10 69	5.35	2.8	2212.95	17.0	62.6	16.5	61.7	10450	6907	7002	746345	23836	87800	30984
930	20 10 69	5.20	2.8	2212.80	16.0	60.8			8250	7268	5528	559988	22654	83450	30336
1410	31 10 69	6.16	3.5	2213.76	17.0	62.6	23.0	73.4	1760*	5335	1179	162747	30861	113680	32538
930	3 11 69	6.52	3.8	2214.12	25.0	77.0	21.0	69.8	3800*	4834	2546	387805	34060	125460	33190
930	5 11 69	6.49	3.8	2214.09	23.0	73.4	24.0	75.2	4940*	4873	3310	500059	33784	124450	33133
930	10 11 69	6.74	4.0	2214.34	17.0	62.6	19.5	67.1	3190*	4563	2137	344908	36085	132920	33613
950	14 11 69	7.03	4.2	2214.63	14.0	57.2	15.0	59.0	2140*	4248	1434	248496	38754	142760	34170
1010	17 11 69	6.96	4.1	2214.56	21.5	70.7	23.0	73.4	3360*	4320	2251	383676	38110	140380	34035
940	26 11 69	6.77	4.0	2214.37	25.1	77.2	22.5	72.5	5290	4528	3544	576340	36361	133940	33670
1000	1 12 69	6.54	3.8	2214.14	22.9	73.2	29.5	85.1	6130*	4808	4107	628971	34244	126140	33229
1000	17 12 69	6.52	3.8	2214.12	26.0	78.8	25.0	77.0	6130*	4834	4107	625590	34060	125460	33190
1320	23 12 69	6.34	3.6	2213.94	22.8	73.0	22.0	71.6	7150	5076	4791	694806	32432	119470	32854
1320	31 12 69	6.19	3.5	2213.79	27.0	80.6	26.0	78.8	8360	5290	5601	779606	31123	114650	32590
900	6 1 70	6.47	3.7	2214.07	18.5	65.3	20.0	68.0	7520*	4900	5038	757075	33600	123770	33094
1250	22 1 70	6.54	3.8	2214.14	16.3	61.3	21.3	70.3	7260	4808	4864	744916	34244	126140	33229
1000	11 2 70	6.25	3.6	2213.85	23.0	73.4	26.5	79.7	7260	5202	4864	688414	31647	116570	32696
1000	12 2 70	6.18	3.5	2213.78	24.0	75.2	27.0	80.6	7040	5305	4717	654670	31036	114330	32573
950	6 3 70	5.97	3.3	2213.57	21.0	69.8	22.0	71.6	7700	5638	5159	673772	29204	107580	32203
1000	13 3 70	5.89	3.3	2213.49	16.0	60.8	15.5	59.9	8910	5776	5970	761016	28506	105000	32062
1030	16 4 70	5.82	3.2	2213.42	15.0	59.0	17.5	63.5	7590	5902	5085	634384	27895	102750	31939
1030	5 5 70	5.72	3.1	2213.32	6.0	42.8	7.5	45.5	9240	6093	6191	748137	27022	99540	31763
1200	5 6 70	5.99	3.4	2213.59					8700	5604	5829	765824	29378	108220	32238
1030	8 7 70	5.91	3.3	2213.51	8.5	47.3	11.5	52.7	8250	5741	5528	708958	28680	105650	32098

TIME		LAKE DEPTH		WATER	WATER		AIR		ELECT.	APPROX.TDS		V.APPROX.	WATER IN STORAGE		
		MAXIMUM (STAGE)	APPROX. MEAN	LEVEL (ASL)	TEMPERATURE		TEMPERATURE		CONDUCT.	EST.AV.	AT RR	SALT CONTENT	VOLUME		AREA
HOUR	DATE	FEET	FEET	FEET	C	F	C	F	UMHOS/CM 25 C	LAKE PPM	GAUGE PPM	OF LAKE TONS	MILLION GALS	ACRE-FT	ACRES
1030	21 7 70	5.77	3.2	2213.37	9.0	48.2	18.0	58.0		5996			27459	101150	31851
930	12 8 70	5.71	3.1	2213.31	4.0	39.2	6.8	42.8	9400*	6112	6298	758635	26935	99228	31746
930	25 8 70	5.87	3.3	2213.47	8.0	46.4	9.0	48.2	8250	5811	5528	700331	28331	104360	32027
930	4 9 70	5.97	3.3	2213.57	8.5	47.3	10.0	50.0	7260	5638	4864	635271	29204	107580	32203
930	25 9 70	6.33	3.6	2213.93	9.0	48.2	5.0	41.0		5090			32345	119158	32837
930	2 10 70	6.53	3.8	2214.13	13.0	55.4	15.0	59.0	6050	4821	4054	619094	34152	125808	33210
1030	9 11 70	6.30	3.6	2213.90	18.0	64.4	15.0	59.0	8000*	5132	5360	769039	32083	118180	32784
1000	1 12 70	6.18	3.5	2213.78	29.0	84.2	27.5	81.5	9000	5305	6030	836935	31036	114330	32573
1200	10 12 70	6.26	3.6	2213.86	25.0	77.0	22.0	71.6	5400*	5188	3618	513455	31734	116900	32714
1000	22 12 70	6.05	3.4	2213.65	22.0	71.6	23.0	73.4	9250	5506	6198	828747	29902	110150	32344
830	1 1 71	5.84	3.2	2213.44	16.2	61.2	24.8	76.6	9240	5865	6191	777124	28069	103400	31974
930	19 1 71	6.18	3.5	2213.78	18.5	65.3	19.0	66.2	9400	5305	6298	874133	31036	114330	32573
930	2 2 71	5.72	3.1	2213.32	19.0	66.2	24.2	75.6	8200	6093	5494	663931	27022	99540	31763
1050	5 2 71	5.96	3.3	2213.56	19.0	66.2	19.0	66.2	8800	5655	5896	767725	29116	107250	32186
1550	8 2 71	5.96	3.3	2213.56						5655			29116	107250	32186
1110	15 2 71	6.14	3.5	2213.74					7600	5365	5092	698798	30687	113040	32502
1030	19 2 71	6.06	3.4	2213.66	21.0	69.8	21.0	69.8	5220	5490	3497	469047	29989	110470	32362
1030	2 3 71	5.97	3.3	2213.57	19.0	66.2	19.5	67.1	6700	5638	4489	586269	29204	107580	32203
1320	23 3 71	5.72	3.1	2213.32	27.0	80.6	21.5	70.7	6500	6093	4355	526287	27022	99540	31763
1300	6 4 71	5.67	3.1	2213.27	21.0	69.8	24.5	76.1	8600	6193	5762	685077	26586	97930	31675
1000	5 5 71	5.30	2.8	2212.90	13.0	55.4	11.5	52.7	8200	7023	5494	575964	23442	86350	38768
1030	8 6 71	4.98	2.6	2212.58	16.0	60.8	10.5	50.9	8600	7870	5762	539053	20919	77060	29386
1030	6 7 71	4.96	2.6	2212.56	8.0	46.4	7.0	44.6	9500	7930	6365	590977	20762	76480	29299
1040	2 8 71	5.28	2.8	2212.88	11.0	51.8	10.5	50.9	9000	7071	6030	627903	23284	85770	30682
1030	1 9 71	5.44	2.9	2213.04	8.0	46.4	11.0	51.8	8500	6698	5695	626002	24579	90540	31270
930	1 10 71	5.25	2.8	2212.85	18.0	64.4	21.0	69.8	11000	7143	7370	759642	23048	84900	30552
1040	1 11 71	4.89	2.6	2212.49	17.5	63.5	17.5	63.5	11500	8147	7705	696378	20210	74450	28997
950	2 12 71	4.72	2.5	2212.32	17.0	62.6	17.5	63.5	11500	8725	7705	650197	18870	69510	28262
1100	7 1 72	4.65	2.4	2212.25	17.0	62.6	14.0	57.2	18600*	8988	12462	1020868	18318	67480	27960
830	18 1 72	4.78	2.5	2212.38	14.5	58.1	16.0	60.8	10400	8512	6968	602744	19343	71250	28522
1000	2 2 72	4.50	2.3	2212.10	28.5	83.3	22.5	72.5	15000*	9608	10850	770132	17135	63120	27312
1040	17 3 72	4.51	2.3	2212.11	23.0	73.4	19.0	66.2	17700*	9564	11859	912937	17214	63410	27355
1100	11 4 72	3.90	2.0	2211.50	19.5	67.1	15.0	59.0	14500	12649	9715	565487	13016	47950	24560
1100	2 5 72	3.85	1.9	2211.45	17.0	62.6	15.0	59.0	14300*	12982	9581	543415	12683	46720	24328
1310	8 6 72	3.69	1.8	2211.29	12.0	53.6	11.5	52.7	15000*	14173	10050	522107	11617	42790	23586
1200	11 7 72	3.52	1.7	2211.12	15.0	59.0	11.0	51.8	16300*	15704	10921	512042	10484	38620	22797
1200	4 8 72	3.43	1.6	2211.03	12.0	53.6	17.0	62.6	15200	16656	10184	450180	9885	36410	22379
1200	1 9 72	3.67	1.8	2211.27	12.1	53.8	10.5	50.9	14300	14337	9581	492033	11483	42300	23493
1200	7 11 72	3.78	1.9	2211.38	22.5	72.5	21.5	70.7	18200	13477	12194	666187	12216	45000	24003
1100	1 12 72	3.66	1.8	2211.26	23.0	73.4	21.5	70.7	19500	14421	13065	667062	11417	42060	23446

(C) INDICATES DOUBTFUL READING
* INDICATES LABORATORY MEASUREMENT
SEE EXPLANATORY NOTES ON FOLLOWING PAGE

1, DEPTH OF WATER IN LAKE HAS BEEN CALCULATED USING THE FOLLOWING
RLS; REFERRED TO MAIN DATUM, TOP OF SOUTH PILLAR 2276.52FT ASL

RL LOWEST POINT OF LAKE FLOOR		2207.6
BMR MAIN GAUGING BENCH MARK		2230.05
BMR SECONDARY GAUGING BENCH MARK		2223.51
BMR NO,3 GAUGING BENCH MARK		2220.29

(SEE NOAKES,L,C,,-NOTES ON WATER LEVEL L, GEORGE, BMR REC. 19 51/17
AND NSW PUBLIC WORKS DEPT WSS BRANCH PLAN NO, B42(3/2/19037)

2, WATER TEMPERATURE IS MEASURED 6 INCHES APPROX BELOW THE SURFACE AND IN APPROXIMATELY 1 TO 2FT DEPTH OF WATER OFF SHORE AT THE GAUGINGSTATION (SINCE THE LAKE FELL BELOW 6 FEET DEPTH IN OCT. 1968 WATER TEMPERATURE MEASUREMENTS HAVE HAD TO BE TAKEN IN 6 INCHES TO 1 FOOT OF WATER.)

3, PUBLIC WORKS PLAN B42, WHICH SHOWS LOWEST POINT OF LAKE TO BE SLIGHTLY BELOW RL 2208 FT(CF, NOAKES-BMR ESTIMATE 2207.6FT) INDICATES THE FOLLOWING CAPACITIES FOR THE LAKE FOR THE FOLLOWING BMR WATER LEVELS-

DEPTH IN (FT.)	CAPACITY IN (CUB.FT.)	CAPACITY IN (ACRE-FT)	AREA IN (SQ.MILES)	AREA IN (ACRE)
0,4	1000000	23	0.33	213
1,4	158000000	3627	14;50	9280
2,4	712000000	16345	25.75	16480
3,4	1554000000	35675	34,75	22240
4,4	2623000000	60216	42.00	26880
5,4	3888000000	89256	48;75	31200
6,4	5288000000	121396	51.50	32960
7,4	6765000000	155303	54;50	34880
8,4	8300000000	190542	55;75	35680
9,4	9861000000	226377	56;25	36000
10,4	11440000000	262626	57.00	36480
11,4	13038000000	299311	57.50	36800
12,4	14653000000	336387	58;25	37280
13,4	16284000000	373829	58,75	37600
14,4	17933000000	411685	59.50	38080
15,4	19611000000	450207	61;00	39040

NOTE, SEDIMENTATION IN LAKE SINCE PUBLIC WORKS SURVEY IN 1902 HAS REDUCED THESE VOLUMES SLIGHTLY.

4, RELATIONSHIP BETWEEN THE ELECTRICAL CONDUCTIVITY AND THE T,D.S, OF L, GEORGE WATER CALCULATED FROM BMR CHEMICAL ANALYSES-

TDS(PPM)=E.C.X 0.67

5, APPROXIMATE TOTAL SALT CONTENT OF LAKE IS CALCULATED BY COMPUTING VOLUME BY LINEAR INTERPOLATION,CONVERTING TO WEIGHT,DIVIDING BY 1000000 AND MULTIPLYING BY TDS IN PPM, (NOTE,,,WHEN LAKE IS BELOW ABOUT 9 FT,STAGE HEAVY RAINFALL OR STRONG SUMMER EVAPORATION COMMONLY CAUSES LOCAL MARKED CHANGES IN SALINITY IN SHALLOW WATER SUCH AS AROUND GAUGING STATION, ESTIMATES OF TOTAL SALT CONTENT BY ABOVE METHOD ARE DISTORTED UNTIL CIRCULATION IN LAKE PRODUCES NEAR UNIFORMITY AGAIN)

6, ESTIMATED AVERAGE T,D,S,OF LAKE IS CALCULATED BY DIVIDING 735,000 TONS(EST,WEIGHT OF DISSOLVED SALT IN LAKE IN1961 - 63)BY WEIGHT OF WATER(TONS)IN STORAGE

APPENDIX 2

Conversion Factors

Inches x 25.40	= Millimetres
Feet x 0.3048	= Metres
Miles x 1.609	= Kilometres
Acres x 4047	= Square metres
Square miles x 2.59	= Square kilometres
Gallons (imp.) x 0.0045	= Cubic metres
Acre-feet x 1234	= Cubic metres
Tons x 1016	= Kilograms