BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

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GROUNDWATER SEEPAGE AND THE WATER BALANCE OF LAKE WINDERMERE, COMMONWEALTH TERRITORY OF JERVIS BAY

by

G. Jacobson and A.W. Schuett

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CONTENTS

ABSTRACT

Water level fluctuations of Lake Windermere, a closed lake in the Commonwealth Territory of Jervis Bay on the east coast of Australia, are a response to climatic variations. An approximate water balance for the lake indicates that groundwater seepage is the most significant component (84%) of the outflow from the lake, whereas surface streams are the most significant component (89 percent) of the inflow to the lake. Groundwater flows westwards from the lake through Pleistocene sand aquifers. There are large resources of good quality groundwater to supplement lake water should the latter prove inadequate for the Territory water supply.

INTRODUCTION

The Commonwealth Territory of Jervis Bay is on the east coast of Australia, and covers a land area of 65 km^2 (Fig 1). It contains a naval college and a nature reserve, and the total permanent population is 1 000.

Two lakes - Windermere and McKenzie - are the present sources of water supply for the Territory. Water from Lake Windermere is pumped to the settlements, and water from Lake McKenzie is used for park irrigation. The two lakes are closed lakes, with no surface outlet, and are subject to considerable water level fluctuations.

BMR became involved in the study of the hydrogeology of Jervis Bay in the late 1960's when Lake Windermere was low (Jackson, 1969). At that time increase in water consumption was anticipated as a result of a proposal to site a nuclear power station in the Territory (MacGregor, 1972), and concern was felt that the lake might dry up. Seepage of water was suspected, and a number of observation bores were constructed (Fig. 2) to monitor groundwater levels. However, the power station was not built, the withdrawal of water from Lake Windermere remained small, and a series of wet years in the mid-1970's again raised lake levels. Since then lake levels have again dropped and the withdrawal of water has steadily increased. At the present time, there is a proposal that use of water be increased still further, mainly for irrigation.

GEOLOGICAL SETTING

The geology of the study area is shown in Figure 2, which is based on mapping by Jackson (1969).

The main hydrogeological units that have been differentiated are the unconsolidated sands and the consolidated sandstone. Seismic surveys (Taylor & McDowell, 1973) and drilling (Jackson, 1970) have shown that the sands are of variable thickness, several tens of metres in places, and have been deposited on erosion platforms in the underlying sandstone. The sands are of various colours and grain size and contain gravel, clay, and peat interbeds; they are, however, considered as a homogenous aquifer. The sandstone has been mapped as Jervis Bay

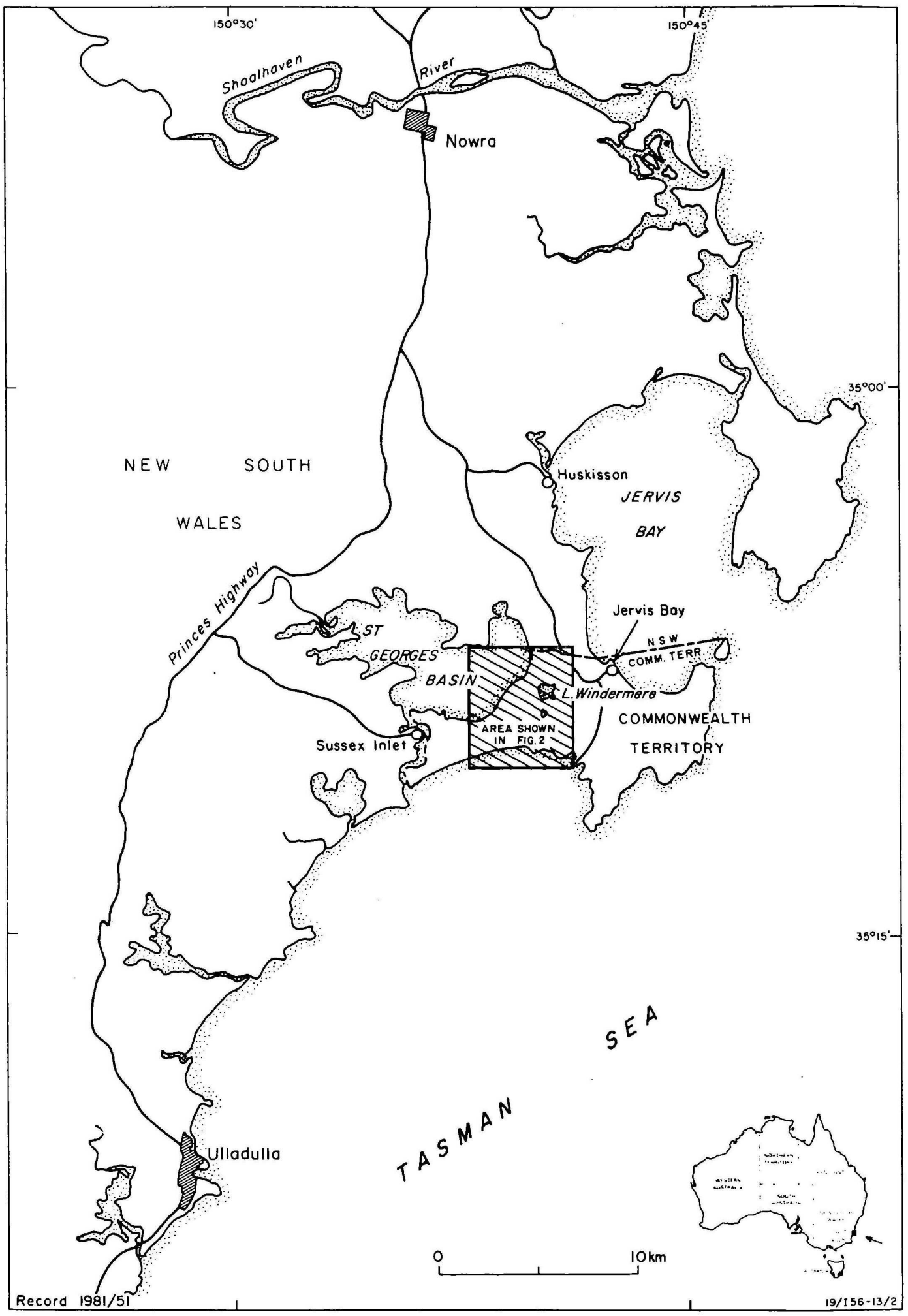
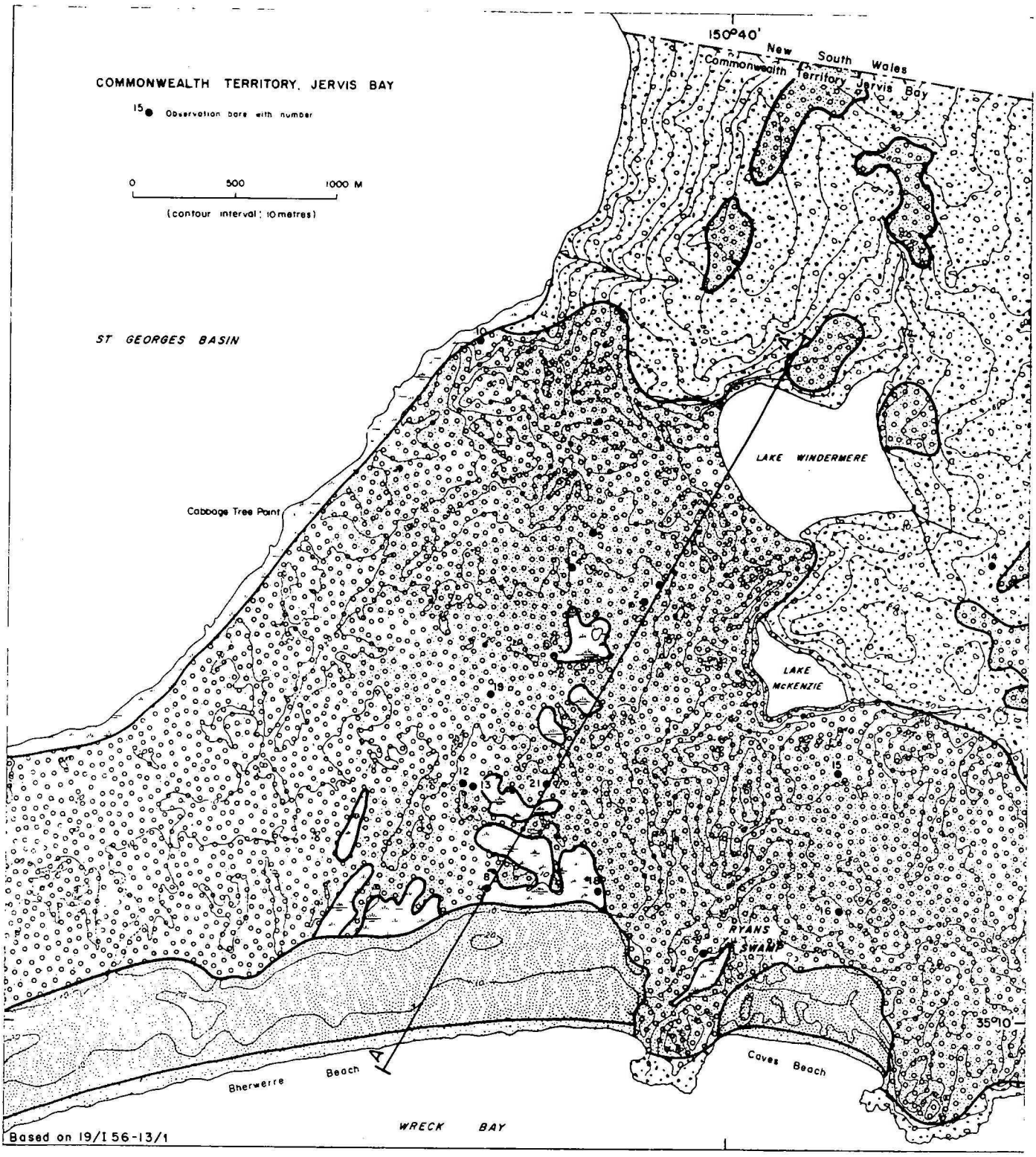


Fig.1 Locality map Commonwealth Territory, Jervis Bay.



HOLOCENE
- Active sand dunes
- Beach sand
- Marsh and coastal alluvium: sand, clay, peat

PLEISTOCENE
- Older, fixed dunes: sand, some gravel, clay, peat

LOWER PERMIAN
- Jervis Bay Sandstone: sandstone, conglomerate, siltstone

Record 1981/51

19/I56-13/3

Fig. 2 Geology

Sandstone (Perry & Dickins, 1952; McElroy & others, 1969), and is probably of early Permian age. It is horizontal to gently dipping and is vertically jointed.

The area southwest of Lakes Windermere and McKenzie is mainly Pleistocene sand (Fig. 3) and the two lakes are "dune barrage" lakes, formed by drifting sand dunes which dammed a west-flowing stream system. Inflow to the lakes is from small streams which flow off the sandstone on the east side. Outflow is by groundwater seepage through the sand.

Active sand dunes on the south coast have now been stabilised by remedial afforestation works completed in 1981.

WATER LEVEL FLUCTUATIONS OF LAKE WINDERMERE

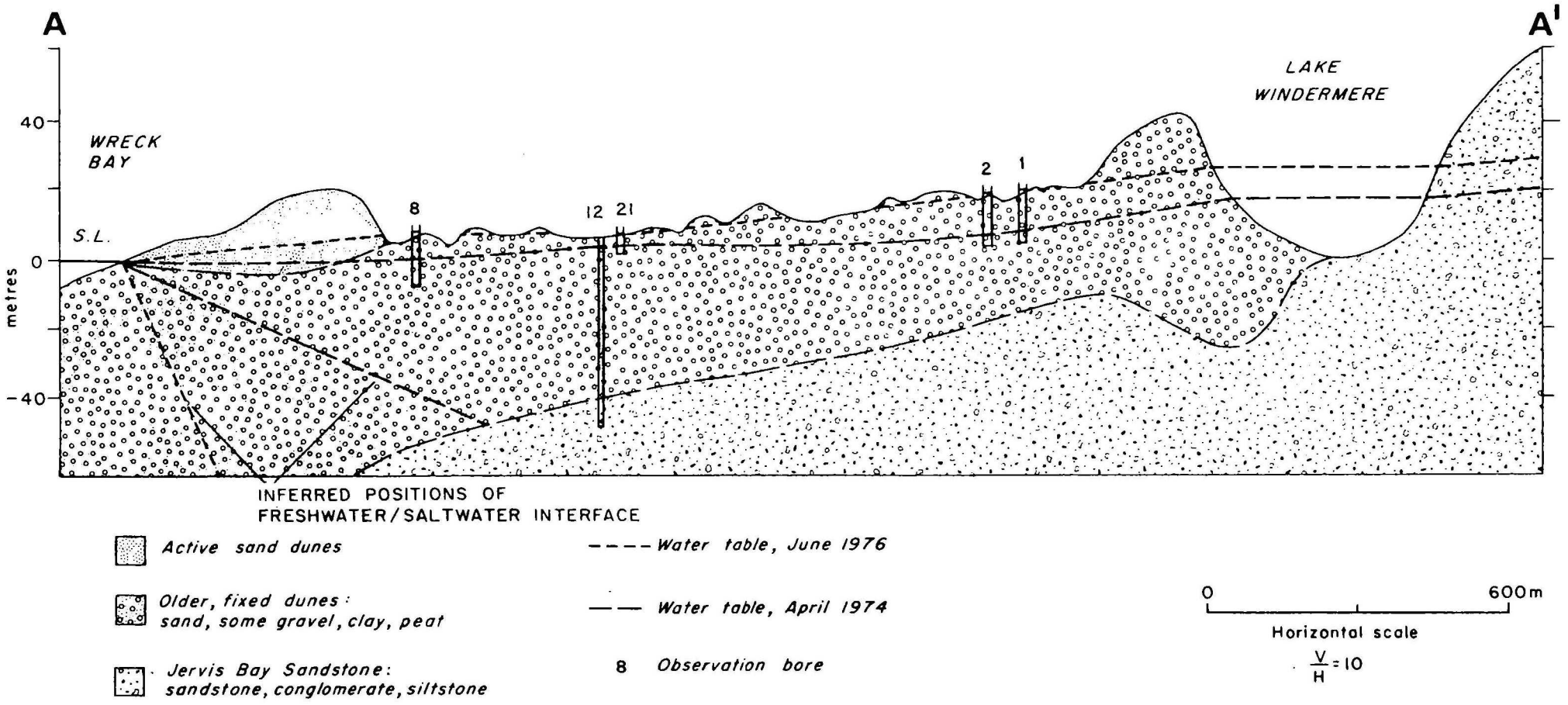
Water levels of Lake Windermere have been measured by staff gauge at least monthly since 1961. The lake area and volume depend on the shape of the basin and are related to depth as shown in Figure 4. The lake bottom dips steeply, with the lowest point 0.78 m above sea level datum, which is mean low water at Captains Point, Jervis Bay. A consistent record of Lake McKenzie levels is not available, but fluctuations are believed to be similar.

Flutuations in depth and volume of Lake Windermere between 1961 and 1980 are shown in Figure 5. The rainfall variation graph indicates that the periods of low lake level were periods of below-average rainfall. In the early 1960's above-average rainfall was recorded for several years and Lake Windermere levels were high. Between 1964 and 1973, rainfall was generally below average and lake levels were low. In the mid-1970's several years of above-average rainfall again resulted in high lake levels. The lake hydrograph is similar to that of Lake George, New South Wales, which is 100 km inland but influenced by the same broad climatic variations (Jacobson & Schuett, 1979).

The lowest gauged level of Lake Windermere during the 20-year observation period was 15.01 m in June 1973, when the volume of lake water was about 2.5 million m^3. The highest level recorded was 27.99 m in October 1976, when the lake water volume was about 9.8 million m^3.

GROUNDWATER HYDROLOGY

In the Jervis Bay Territory, groundwater occurs in unconsolidated



Record 1981/51

Fig. 3 Cross-section showing hydrogeology

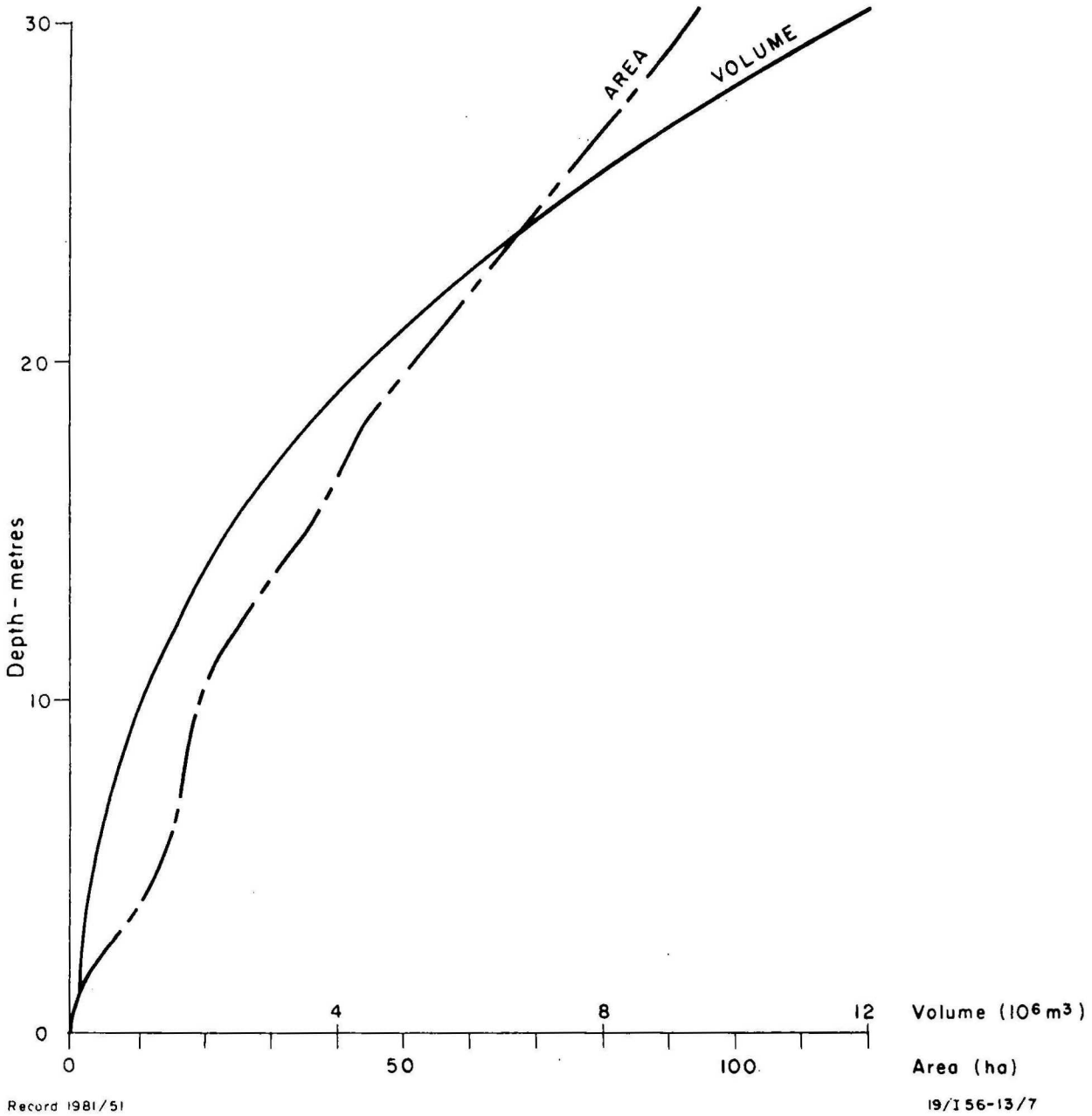


Fig.4 Area and volume of Lake Windermere as a function of depth

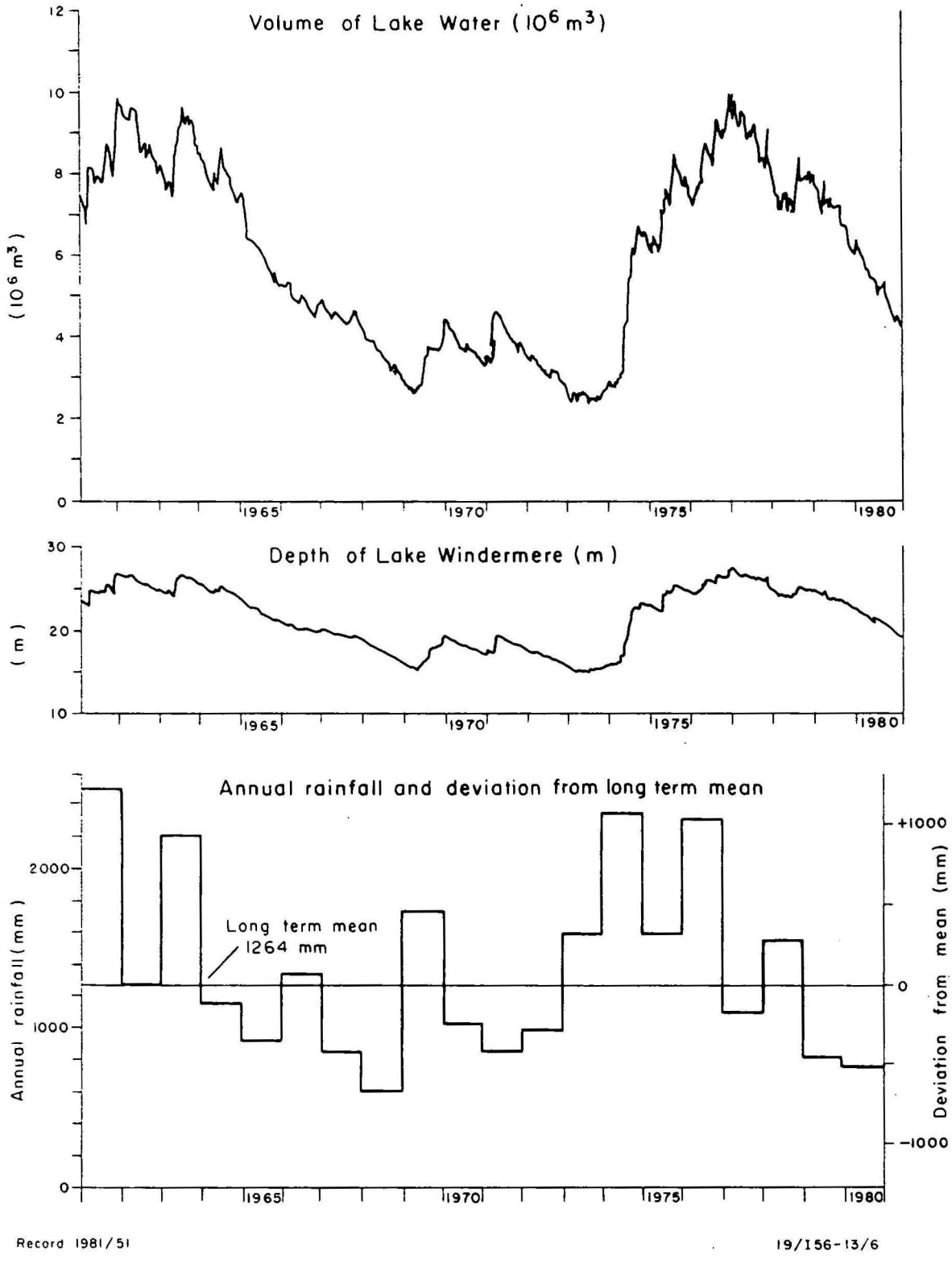


Fig.5 Fluctuations in depth and volume of Lake Windermere; and annual rainfall, 1961-80

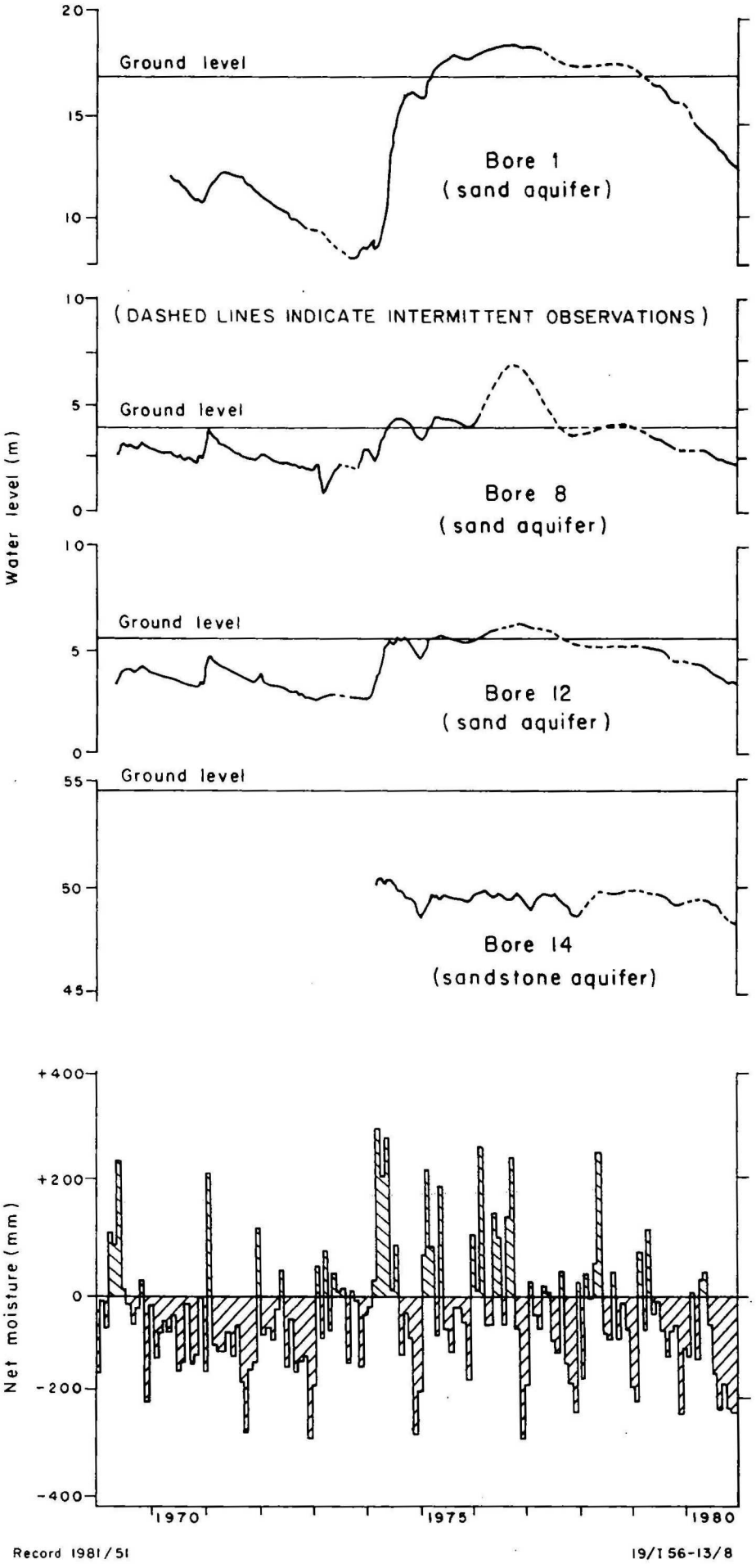


Fig.6 Fluctuations in groundwater levels, 1969 – 80 and net moisture

sand and in jointed sandstone aquifers. There are production bores in the sand at Sussex Inlet, just outside the study area. The 16 bores in the study area are observation bores constructed for investigation purposes; details are given in Appendix 1. Bore No. 4 monitors the sandstone aquifer; the remainder are in sand.

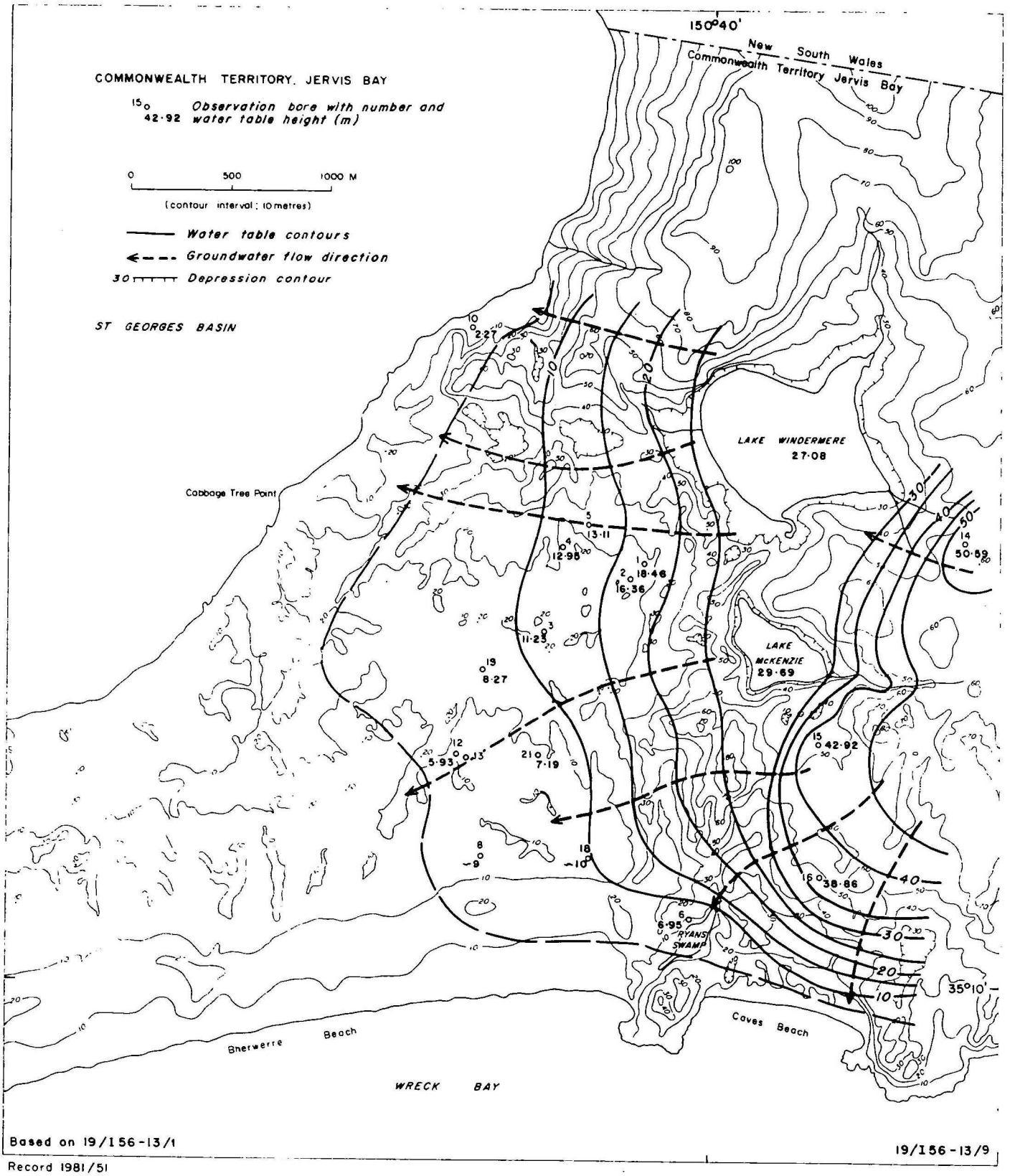
Fluctuations in groundwater levels in selected bores are shown in Figure 6 and are compared with a net moisture (rainfall minus evaporation) histogram. Bore 1 is in a shallow sand aquifer close to Lake Windermere and its hydrograph shows a rapid response to climatic variations. Groundwater levels in this bore ranged from 8.23 m in November 1973, a time of low lake level, to 18.43 m in June 1976, a time of high lake level. Bore 8, further from the lake, has a similar but more subdued response, whereas bore 12, which monitors a deep sand aquifer, has much less response to climatic variations. Bore 14, in the sandstone aquifer, has only been slightly affected by variations in climate.

The sand aquifer is unconfined, and water levels in bores represent the water table, which appears to be continuous throughout the main area of sand cover. Contours drawn on the water table are shown in Figure 7, and indicate that groundwater flow is to the west and southwest, away from Lakes Windermere and McKenzie. The two lakes appear to be in hydraulic continuity with the water table, and groundwater levels fluctuate in sympathy with lake levels. Recharge to the lakes is by stream flow on the east side and by direct precipitation; groundwater seeps through the west shores of both lakes.

The transmissivity of the sand aquifer has been determined by a pump test on bore 13. Drawdown of the water table was measured in observation bores and analysis indicated transmissivity of about 2 700 m^2/d (Fig. 8). For an aquifer thickness of 33 m the hydraulic conductivity is 82 m/d. The amount of groundwater outflow can be quantified by the relationship

$$Q = W\ T\ i$$

where Q is the groundwater outflow, W is the width of aquifer outcrop, T is transmissivity and i is the hydraulic gradient. The groundwater outflow has been calculated as ranging from about 7 800 m^3/d in mid-1973 a period of low lake level to about 32 500 m^3/d in late 1976, a period of high lake level.



Record 1981/51

Fig. 7 Water table contours and groundwater flow directions, June 1976

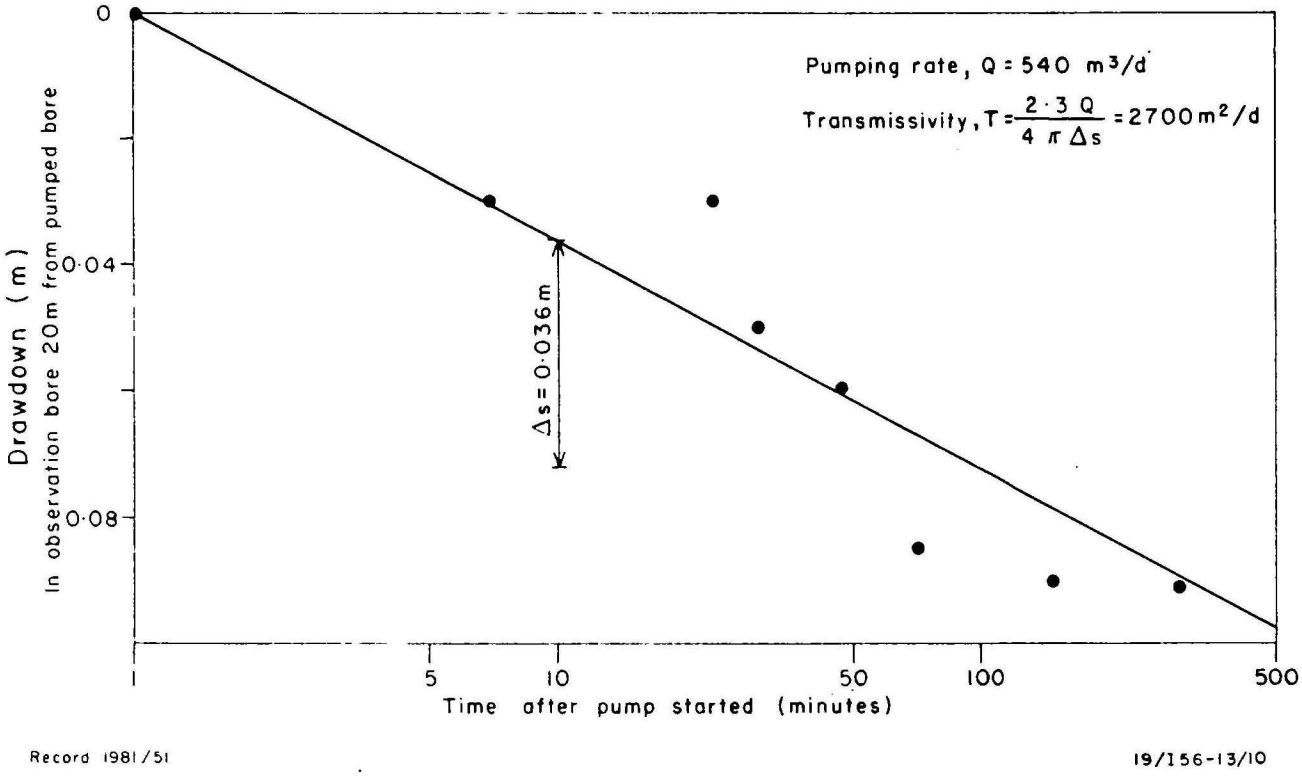


Fig. 8 Time-drawdown plot for pump test in bore 13

The amount of groundwater in storage is very large, and there is considerable scope for development by pumping from bores. The pump test on bore 13 resulted in a drawdown of 5.86 m in the pumped bore at a pumping rate of 6.25 1/s. The specific capacity (yield to drawdown ratio) of the bore is thus about 1.1 1/s per metre of drawdown, suggesting that a producing bore in a thick sand aquifer section could yield 10-20 1/s.

A wedge of saltwater probably underlies freshwater near the coast (Fig. 3) and any proposals for development of a bore field should take this into account.

LAKE WATER BALANCE

The water balance derived from Lake Windermere is based on an equilibrium equation:

$$I + P\ (A_L) = E\ (A_L) + G + W$$

where I is inflow from the catchment, P is precipitation on the lake surface, E is the gross evaporation rate, A_L is the lake surface area, G is the natural groundwater outflow from the lake and W is the withdrawal of lake water by pumpage. Variations in the Factors I, P, E, G, W, produce fluctuations in water level with corresponding changes in lake area and volume. This can be represented by the equation:

$$\Delta S = I + (P - E)\ A_L - G - W$$

where ΔS is the change in lake volume.

The approximate water balance for Lake Windermere has been calculated for the past 11 years (Table 1). The data used for computation are precipitation and evaporation, which are based on meteorological station data; withdrawal of water by pumpage, based on measurements; groundwater outflow, calculated from hydraulic parameters; and the monthly change in lake level obtained by gauging. Inflow from catchment is not gauged, but is estimated by difference and is assumed to be surface inflow. One of the streams on the northeast side, is perennial. One small spring has been observed in sandstone on the north side of the lake, at a time of very low level. A small proportion of the inflow component of the water balance may therefore be groundwater. The lake area has ranged from 37 to 85 ha during the period under review, and

the total catchment area is 432 ha.

Precipitation is taken as the average monthly rainfall for two rain gauges - Jervis Bay Forestry Station, and Point Perpendicular. The long term mean rainfall at Point Perpendicular is 1 264 mm. The mean monthly rainfall ranges from 79 mm in September to 135 mm in June, and there is generally a peak in the months March to June (Fig. 9). The total precipitation on the lake is estimated as about 848 000 m^3 annually. This represents 11% of the inflow side of the lake water budget.

The evaporation component is based on monthly measurements at Nowra, 30 km north of the Jervis Bay Territory (Fig. 1). The mean pan evaporation at Nowra is 1 863 mm, and the mean monthly evaporation is highest from October to March. The lake water losses from evaporation are estimated as about 1 096 000 m^3 annually. This represents 13 percent of the outflow side of the lake water budget.

TABLE 1

LAKE WINDERMERE - APPROXIMATE MEAN MONTHLY WATER BALANCE 1970-80

(thousand m^3)

	Change in lake volume	Volume in rain on lake	Inflow to lake	Water Consumption	Evaporation from lake	Ground water outflow
January	- 43.8	75.6	524.3	20.8	114.1	508.8
February	+ 109.2	88.3	666.0	16.2	108.0	520.9
March	+ 152.6	126.5	691.4	16.0	97.7	551.6
April	+ 48.4	66.6	637.7	14.6	73.2	568.1
May	- 52.1	67.2	524.7	16.5	60.6	566.9
June	+ 306.4	119.6	875.1	17.2	60.0	611.1
July	- 27.2	43.4	569.6	14.1	69.2	583.9
August	- 137.9	39.6	480.6	16.1	78.1	563.9
September	- 125.4	59.2	454.6	16.9	84.6	537.7
October	+ 13.1	75.3	605.1	16.8	105.2	545.3
November	- 106.3	55.1	501.4	18.2	106.6	538.0
December	- 117.0	31.2	532.9	20.0	139.0	522.1
Annual Total	+ 20.0	847.6	7090.4	203.4	1096.3	6618.3

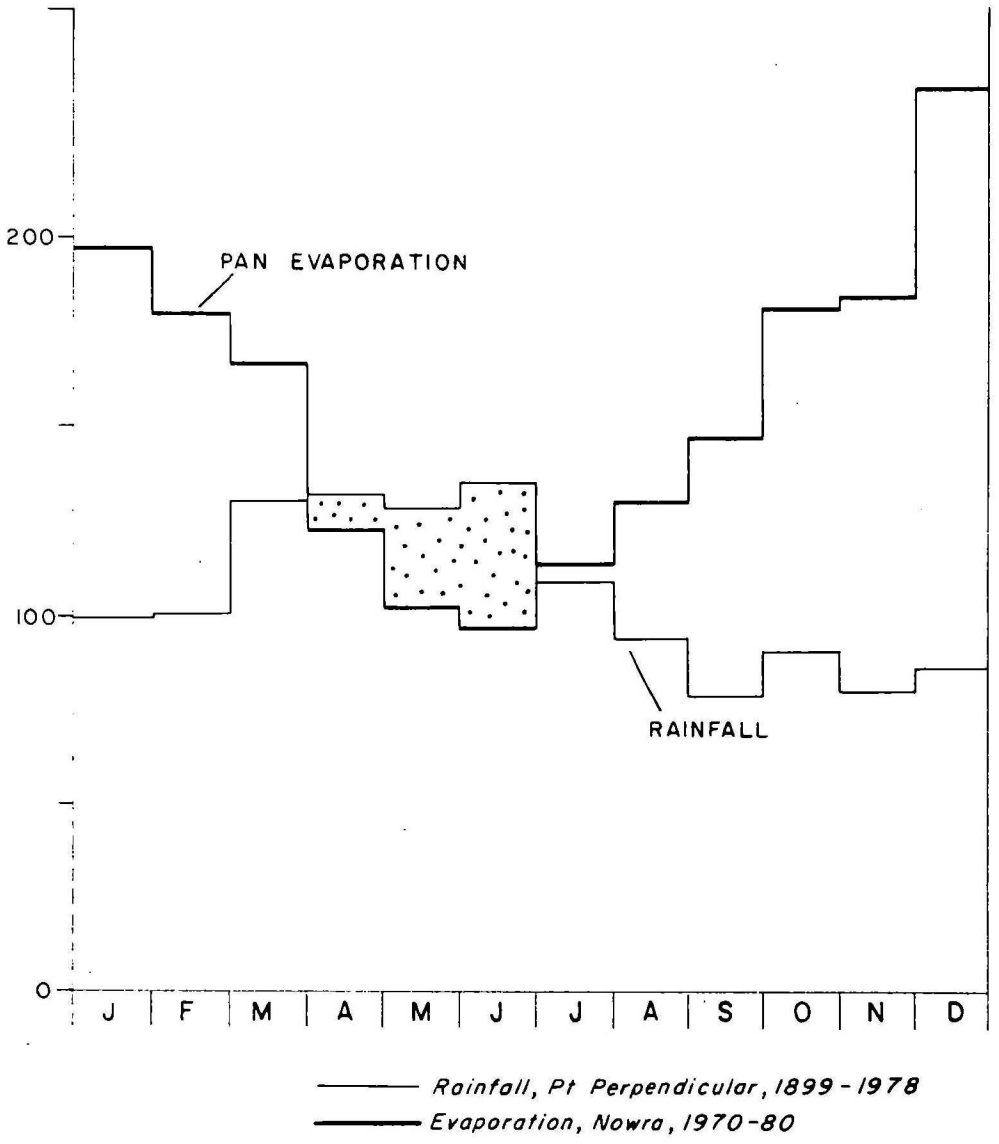
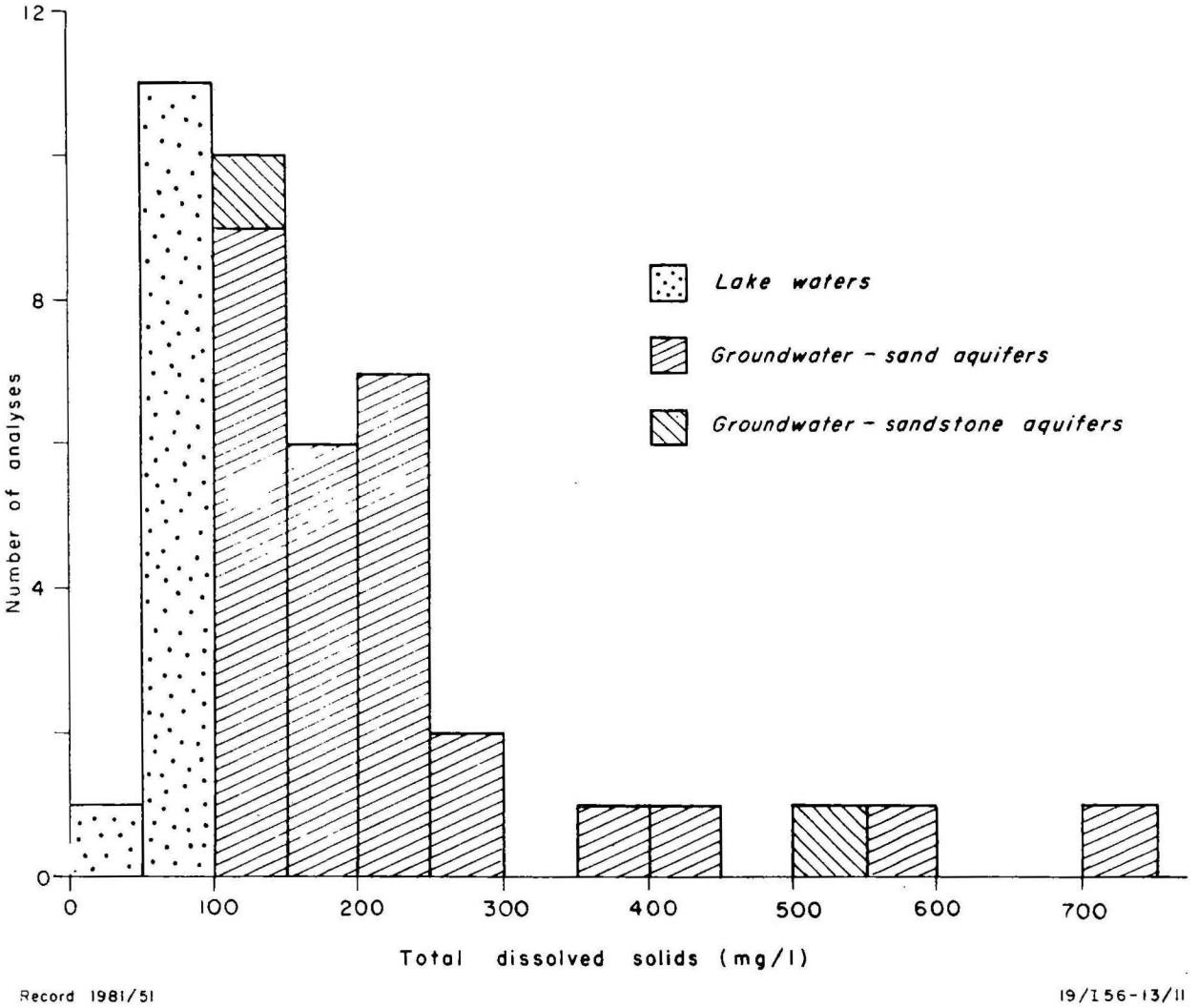


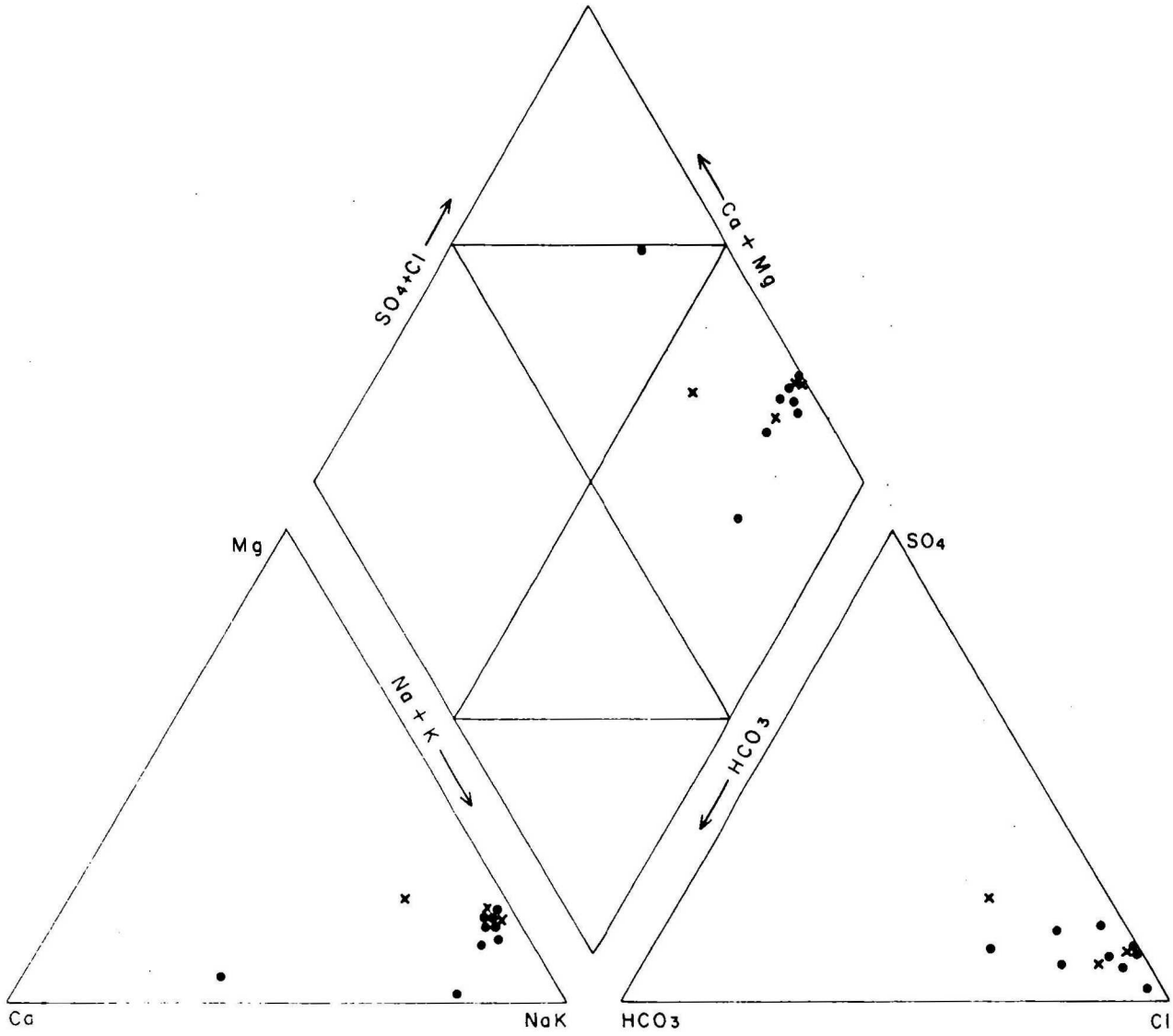
Fig. 9 Mean monthly rainfall and evaporation



Record 1981/51

19/156-13/11

Fig. 10 Jervis Bay waters: frequency distribution of total dissolved solids



Lake waters, total dissolved solids 40 - 96 mg/l

• Lake Windermere
× Lake McKenzie

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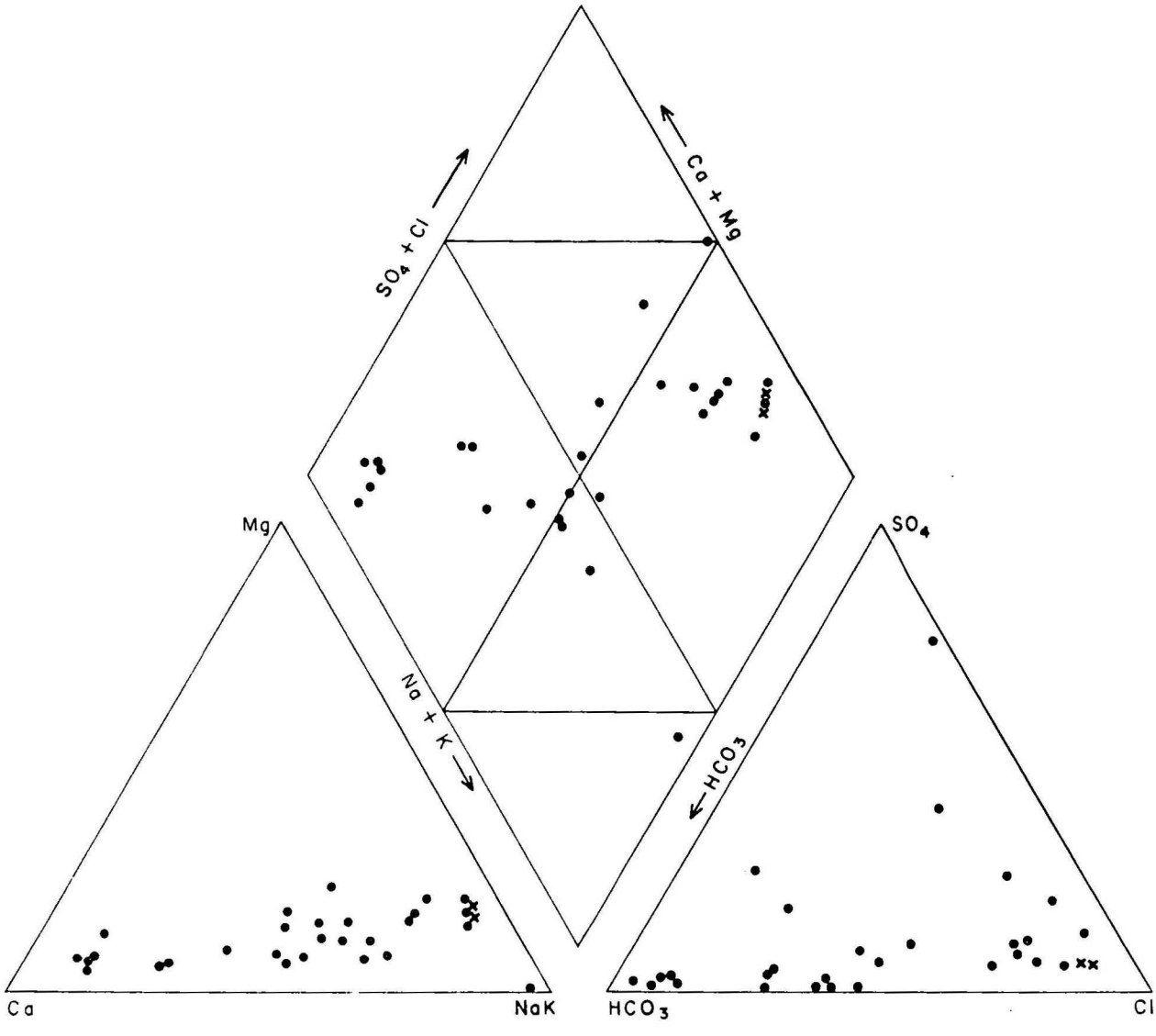
Fig. 11 Ionic composition of Jervis Bay lake waters, plotted on a Piper trilinear diagram



Groundwaters, total dissolved solids 104 - 722 mg/l

• Sand aquifers
× Sandstone aquifers

Record 1981/51

19/156-13/13

Fig.12 Ionic composition of Jervis Bay groundwaters, plotted on a Piper trilinear diagram

The withdrawal of water by pumpage was measured for a few months in 1974 and 1981 and these figures have been extrapolated, assuming a steady 14 percent annual increase. The withdrawal averages 201 000 m^3 annually, or 3 percent of the outflow side of the lake water budget.

Groundwater outflow has been calculated using the hydraulic parameters obtained by pump testing, and the hydraulic gradient between the lake and bore 1. The groundwater outflow is estimated as about 6.6 million m^3 annually. The groundwater component thus forms 84 percent of the outflow side of the lake water budget.

The mean annual inflow of streams is estimated by subtraction from the water balance as about 7.1 million m^3 representing 89 percent of the inflow side of the lake water budget. Groundwater inflow through joints in the Permain sandstone is assumed to be negligible.

The aggregate gain in water volume between 1970 and 1980 was about 20 000 m^3. The annual volume change varied from a gain of 3.3 million m^3 in 1974 to a loss of 2.5 million m^3 in 1977.

WATER CHEMISTRY

Chemical analyses of selected lake and groundwater samples are given in Table 2.

Figure 10 shows the frequency distribution of total dissolved solids in 40 analysed samples. Lake Windermere waters generally contain 70-100 mg/l total dissolved solids when the lake level is 16-18 m, and 40-60 mg/l when the lake level is 24-25 m. Lake McKenzie waters also contain less than 100 mg/l total dissolved solids. Figure 11 shows the ionic composition of the lake waters based on chemical analyses of 12 samples taken at different times. The lake waters are chloride waters with sodium the dominant cation.

Groundwaters range from 104-722 mg/l total dissolved solids A plot of ionic composition of 28 samples taken at various times (Fig. 12) shows that they are chloride - bicarbonate waters with calcium and sodium the main cations.

Both lake waters and groundwaters are potable, and suitable for irrigation.

TABLE 2

CHEMICAL ANALYSES OF WATER SAMPLES

	Lake Windermere April 1981	Lake McKenzie April 1981	Bore 1 Nov. 1974	Bore 13 July 1974
Calcium	0.9	0.9	18	15
Magnesium	2.5	3.7	6	4
Sodium	20	27.5	37	24
Potassium	0.9	2.1	3	1
Bicarbonate	1	5	47	70
Sulphate	7	9	9	1
Chloride	37	49	73	35
Nitrate	<1	<1	1	1
Total dissolved solids	98	133	174	132
Total hardness	12	18	70	54
Electricial conductivity	154	210	373	236
pH	5.9	6.4	7.1	7.1

CONCLUSIONS

1. The inflow components of the Lake Windermere water balance are rainfall (11 percent) and stream inflow (89 percent).

2. Groundwater seepage is the most significant component of the outflow from the lake (84 percent); the other outflow components are evaporation (13 percent) and water consumption (3 percent).

3. Groundwater outflow is westwards through sand from the western shores of both Lake Windermere and Lake McKenzie. The quantity of outflow varies with lake level and has ranged from about 8 000 m^3/d to about 32 000 m^3/d from Lake Windermere.

4. Lake Windermere has cyclical water level fluctuations related to climatic variations.

5. The volume of lake water has varied between 2.5 and 9.8 million m^3 in the last 20 years. The amount remaining in storage at the 1973 low stage - 2.5 million m^3 - is equivalent to the greatest annual loss of water, in the dry year of 1977.

6. There are large resources of good quality groundwater which could supplement lake water for the Jerivs Bay water supply.

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APPENDIX 1

SUMMARY OF BORE DATA

SUMMARY OF BORE DATA

Bore No	Elevation (m)	Depth (m)	Water quality - total dissolved solids (mg/l)	Strata
1	16.0	12.8	170	Yellow sand
2	15.5	12.8	110	Yellow sand
3	9.3	12.8	110-210	Yellow/grey sand
4	13.5	12.8	240-390	Black/yellow/brown sand
5	16.3	12.8	130-215	Multicoloured sand
6	4.5	4.1	205	-
8	4.1	10.7	190-720	-
10	2.4	12.8	110	Sand
12*	5.7	51.7	156-284	Sand to 41.4 m, with some clay bands; sandstone below.
13	5.5	57.6	130	Sand to 46 m; sandstone below.
14	55.5	36.5	120-145	Sandstone
15	44.5	11.5	120	Clayey sand
16	45.0	7.4	130-180	Sand to 7.1 m; sandstone below 7.1m
18	4.3	12.8	-	Yellow sand
19	8.1	12.8	210	Yellow sand
21	6.8	12.8	190	Yellow sand

Bores equipped with slotted casing, except 12 and 13 which are screened in sand aquifers.

*Bore 12 is stratigraphic bore BMR Ulladulla 2 (Jackson, 1970).

APPENDIX 2

APPROXIMATE MONTHLY WATER BALANCE

LAKE WINDERMERE

LAKE WINDERMERE,JERVIS BAY
WATER LEVEL,MAXIMUM DEPTH,WATER CONSUMPTION,APPROXIMATE MONTHLY WATER BALANCE.

WATER BALANCE IS RAINFALL ON LAKE + SURFACE INFLOW
LESS (EVAPORATION + WATER CONSUMPTION + GROUNDWATER OUTFLOW)
+- CHANGE IN VOLUME

CALCULATED DEPTH,VOLUME AND MONTHLY CHANGES IN VOLUME AT BEGINNING OF MONTH BY LINEAR INTERPOLATION FROM STAFF GAUGE MEASUREMENTS

RAINFALL IS MEAN OF TWO STATIONS
POINT PERPENDICULAR AND JERVIS BAY FORESTRY

EVAPORATION IS PAN EVAPORATION AT NOWRA
CLASS A PAN INSTALLED AT NOWRA 1969

WATER CONSUMPTION MEASURED APRIL 1973 TO FEBRUARY 1975 AND MARCH 1981 ONWARDS
---OTHERWISE ESTIMATED, ASSUMING 14% ANNUAL INCREASE IN MONTHLY CONSUMPTION.

GROUNDWATER OUTFLOW ESTIMATED FROM LAKE STAGE,HYDRAULIC GRADIENT AND TRANSMISSIVITY.

SURFACE INFLOW COMPUTED BY SUBTRACTION FROM WATER BALANCE.

DATE	DEPTH METRE	MONTH CHANGE METRE	CATCHM. LAKE HA	AREA LAND HA	VOLUME CUB.M	MONTHLY VOLUME CHANGE CUB.M	RAIN M/M	VOLUME OF RAIN CUB.M	EVAP M/M	VOLUME OF EVAP CUB.M	SURFACE INFLOW ESTIM. CUB.M	GROUNDW OUTFLOW CUB.M	WATER CONSUMP CUB.M	WATERBALANCE INFLOW SIDE CUB.M	WATERBALANCE OUTFLOW SIDE CUB.M
2 70	19.07	19.88	49.	384.	4179186.	-58964.	158.	76962.	170.	82816.	377361.	420471.	10000.	454323.	513287.
3 70	18.83	-.23	47.	385.	4013047.	-166139.	62.	29671.	183.	86264.	298193.	399838.	7900.	327864.	494003.
4 70	18.68	-.16	44.	386.	3902305.	-110742.	111.	51746.	180.	82835.	314445.	386298.	7800.	366190.	476933.
5 70	18.51	-.17	45.	387.	3781930.	-120374.	70.	31680.	111.	50134.	273576.	368397.	7100.	305257.	425631.
6 70	18.29	-.22	44.	388.	3668793.	-113138.	44.	19597.	112.	49447.	266878.	342065.	8100.	286475.	399612.
7 70	18.17	-.12	45.	388.	3878413.	209621.	70.	31095.	103.	46334.	558513.	325252.	8400.	589607.	379987.
8 70	17.94	-.23	44.	388.	3734214.	-144199.	1.	445.	138.	60869.	240339.	317215.	6900.	248784.	384983.
9 70	17.76	-.18	44.	389.	3619545.	-114669.	49.	21498.	175.	76223.	259005.	311048.	7900.	280502.	395172.
10 70	17.66	-.10	43.	389.	3559858.	-59687.	126.	54551.	137.	59446.	269794.	316286.	8300.	324345.	384032.
11 70	17.43	-.23	43.	390.	3414091.	-145767.	53.	22569.	182.	77580.	227257.	309814.	8200.	249826.	395593.
12 70	17.24	-.19	42.	390.	3294442.	-119649.	74.	31143.	184.	77535.	242568.	306924.	8900.	273711.	393359.
1 71	17.56	.32	43.	389.	3495414.	200972.	238.	101081.	238.	102278.	549353.	337384.	9800.	650434.	449462.
2 71	17.43	-.13	43.	390.	3415205.	-80208.	69.	29561.	211.	89916.	329330.	336682.	12500.	358890.	439099.
3 71	19.71	2.28	53.	380.	4640552.	1225347.	379.	180756.	141.	74298.	1639738.	510949.	9900.	1820494.	595147.
4 71	19.55	-.17	52.	381.	4521892.	-118661.	60.	31059.	151.	77813.	403487.	465694.	9700.	434546.	553207.
5 71	19.33	-.22	50.	382.	4363328.	-156564.	41.	20897.	143.	71631.	329643.	426573.	8900.	350540.	507104.
6 71	19.11	-.22	49.	384.	4207292.	-158036.	33.	16355.	139.	67758.	290578.	387211.	10000.	306933.	464969.
7 71	18.90	-.21	48.	385.	4060901.	-146391.	27.	12772.	89.	42502.	259326.	365587.	10400.	272098.	418489.
8 71	18.70	-.20	46.	386.	3919180.	-141721.	34.	15714.	151.	70057.	273679.	352457.	8600.	289393.	431115.
9 71	18.54	-.16	45.	387.	3802315.	-116864.	71.	32482.	125.	56307.	261268.	344507.	9800.	293751.	410615.
10 71	18.29	-.25	44.	389.	3651110.	-151205.	22.	9569.	183.	80305.	262590.	332758.	10300.	272159.	423364.

11	71	17.96	-.34	40.	388.	3743831.	92720.	31.	13416.	291.	128488.	533530.		315537.	10200.	546945.	454225.		
12	71	17.71	-.24	41.	389.	3591225.	-152605.	52.	22572.	192.	83601.	227278.		307755.	11100.	249850.	402455.		
1	72	17.50	-.21	43.	390.	3458811.	-132414.	89.	38202.	213.	91459.	236323.		303481.	12000.	274525.	406939.		
2	72	17.65	.15	43.	389.	3554122.	95311.	285.	122561.	152.	65732.	381809.		328328.	15000.	504370.	499859.		
3	72	17.51	-.15	43.	390.	3463113.	-91009.	87.	37273.	160.	68605.	278022.		325900.	11800.	315295.	406304.		
4	72	17.29	-.22	42.	390.	3325644.	-137469.	79.	33621.	137.	58035.	217708.		319162.	11600.	251328.	388797.		
5	72	17.06	-.23	42.	391.	3178345.	-147300.	46.	19272.	127.	52772.	201275.		304475.	10600.	220547.	367847.		
6	72	16.91	-.15	41.	391.	3084691.	-93653.	64.	26454.	85.	34990.	227172.		300290.	12000.	253626.	347280.		
7	72	16.83	-.08	41.	392.	3036476.	-48216.	128.	52485.	77.	31282.	244236.		301154.	12500.	296721.	344937.		
8	72	16.59	-.24	42.	390.	3197791.	161315.	5.	2076.	143.	60069.	517720.		288211.	10200.	519796.	358481.		
9	72	16.48	-.11	42.	391.	3133326.	-64465.	89.	37311.	130.	53990.	251131.		287218.	11700.	288442.	352907.		
10	72	16.22	-.26	41.	392.	2984173.	-149153.	3.	1029.	149.	60441.	208885.		286325.	12300.	209913.	359067.		
11	72	16.02	-.20	40.	393.	2867730.	-116443.	67.	26734.	190.	75468.	219824.		275333.	12200.	246558.	363001.		
12	72	15.77	-.25	39.	394.	2723220.	-144510.	80.	31214.	191.	73924.	176642.		265242.	13200.	207856.	352366.		
1	73	15.43	-.33	37.	395.	2529789.	-193431.	15.	5707.	288.	107395.	178382.		255626.	14500.	184089.	377520.		
2	73	15.16	-.27	40.	393.	2639873.	110084.	70.	26715.	240.	94973.	429576.		235034.	16200.	456290.	346207.		
3	73	15.31	.14	37.	395.	2473812.	-166061.	234.	89591.	176.	65209.	71154.		248796.	12800.	160745.	326805.		
4	73	15.12	-.18	39.	393.	2618602.	144790.	89.	33758.	170.	66862.	420734.		234240.	12600.	458492.	313702.		
5	73	15.19	.07	39.	393.	2607712.	-10890.	225.	87926.	134.	52228.	206439.		241628.	11400.	294366.	305256.		
6	73	15.07	-.12	39.	394.	2594588.	-13124.	72.	27889.	139.	53978.	261351.		235386.	13000.	289240.	302364.		
7	73	15.34	.26	37.	396.	2472461.	-122126.	164.	62016.	118.	43556.	129769.		256855.	13500.	191785.	313911.		
8	73	15.39	.06	37.	395.	2506662.	34200.	73.	26873.	61.	22573.	303060.		262059.	11100.	329932.	295732.		
9	73	15.48	.09	38.	395.	2556306.	49644.	118.	44093.	102.	38446.	330477.		273780.	12700.	374570.	324926.		
10	73	15.37	-.11	37.	395.	2493765.	-62541.	36.	13249.	163.	60318.	272148.		274320.	13300.	285397.	347938.		
11	73	15.55	.17	39.	395.	2593839.	100074.	173.	64610.	161.	60882.	406669.		297124.	13200.	471280.	371206.		
12	73	15.99	.44	40.	393.	2850438.	256599.	183.	70888.	188.	74677.	615815.		341127.	14300.	686702.	430104.		
1	74	15.98	-.01	40.	393.	2843548.	-6889.	90.	35472.	227.	89833.	420246.		356975.	15800.	455718.	462608.		
2	74	16.00	.03	40.	393.	2858057.	14509.	138.	54732.	171.	67909.	374461.		329275.	17500.	429194.	414685.		
3	74	16.23	.23	41.	392.	2988926.	130869.	150.	60074.	169.	68705.	505420.		352180.	13700.	565494.	434625.		
4	74	17.13	.90	42.	391.	3227277.	238351.	308.	123650.	269.	112180.	643503.		403123.	13500.	767153.	528802.		
5	74	19.29	2.16	53.	382.	4339107.	1111830.	438.	201069.	116.	57988.	1681607.		700559.	12300.	1882676.	770646.		
6	74	20.91	1.62	57.	375.	5227539.	888431.	326.	174476.	98.	55640.	1613673.		830078.	14000.	1788149.	899717.		
7	74	22.89	1.98	61.	371.	5840750.	613212.	390.	230129.	85.	51801.	1429535.		980051.	14600.	1659664.	1046453.		
8	74	22.95	.06	63.	369.	6145522.	304771.	136.	84584.	125.	78721.	1133904.		822996.	12000.	1218488.	913717.		
9	74	23.53	.58	67.	366.	6728723.	583201.	235.	152873.	135.	90549.	1340880.		806403.	13600.	1493754.	910552.		
10	74	23.31	-.22	65.	367.	6506896.	-221827.	46.	30113.	160.	104651.	566748.		699638.	14400.	596861.	818688.		
11	74	23.34	.02	66.	367.	6531840.	24944.	123.	80319.	152.	99779.	718293.		659688.	14200.	798612.	773668.		
12	74	23.29	-.04	65.	367.	6489849.	-41991.	103.	67479.	180.	117557.	640073.		616586.	15400.	707551.	749503.		
1	75	22.95	-.35	63.	369.	6143627.	-346222.	7.	4501.	269.	170246.	402639.		566116.	17000.	407140.	753362.		
2	75	22.63	-.32	64.	368.	6318558.	174931.	52.	32885.	234.	150711.	853703.		541046.	19900.	886588.	711657.		
3	75	22.56	-.07	64.	368.	6256045.	-62513.	233.	149756.	154.	98326.	446290.		544632.	15600.	596046.	658559.		
4	75	24.41	1.85	70.	363.	7169154.	913109.	374.	249614.	133.	92437.	1524112.		752780.	15400.	1773726.	860616.		
5	75	24.94	.53	73.	360.	7672464.	503311.	206.	146527.	113.	82243.	1201757.		748729.	14000.	1348283.	844972.		
6	75	24.72	-.22	71.	361.	7425136.	-247329.	33.	23369.	109.	77702.	500589.		677585.	16000.	523958.	771286.		
7	75	25.67	.95	77.	355.	8470199.	1045063.	342.	254171.	131.	101657.	1689499.		780450.	16500.	1943670.	898607.		
8	75	25.57	-.09	77.	356.	8365834.	-104365.	40.	30867.	104.	79694.	718717.		760654.	13600.	749584.	853948.		
9	75	25.29	-.29	75.	358.	8051324.	-314510.	24.	18216.	130.	97505.	498469.		718189.	15500.	516685.	831195.		
10	75	25.09	-.20	74.	359.	7833102.	-218222.	95.	70572.	117.	85847.	479466.		666112.	16300.	550038.	768260.		
11	75	25.09	-.00	74.	359.	7830742.	-2360.	142.	104170.	166.	122268.	693650.		661711.	16200.	797820.	800180.		
12	75	24.80	-.29	72.	361.	7512358.	-318384.	143.	103523.	191.	136772.	370156.		637691.	17600.	473679.	792063.		
1	76	24.61	-.18	70.	362.	7310125.	-202233.	32.	22388.	193.	135916.	555911.		625316.	19300.	578299.	780531.		
2	76	25.02	.40	73.	359.	7753763.	443638.	289.	207508.	171.	125371.	1049592.		665692.	22400.	1257101.	813463.		
3	76	25.10	.08	74.	359.	7840969.	87206.	154.	113050.	146.	107342.	765061.		666064.	17500.	878111.	790906.		
4	76	26.27	1.18	79.	353.	8802874.	961905.	468.	357390.	180.	142360.	1568980.		804804.	17300.	1926369.	960464.		
5	76	26.37	.10	79.	354.	8712313.	-90561.	55.	43014.	109.	85391.	770346.		802831.	15700.	813360.	903922.		
6	76	26.11	-.26	77.	356.	8400371.	-311942.	38.	22943.	88.	67690.	513763.		763058.	17900.	536706.	848648.		
7	76	26.82	.71	82.	351.	9259156.	857786.	255.	202136.	95.	77374.	1587771.		836148.	18600.	1789907.	932122.		
8	76	26.78	-.04	81.	351.	9212108.	-46048.	206.	167465.	96.	77785.	701846.		822374.	15200.	869311.	915359.		
9	76	26.54	-.24	80.	353.	8921513.	-290596.	87.	69693.	141.	112402.	552763.		783249.	17400.	622456.	913051.		
10	76	26.73	.18	81.	352.	9142736.	221223.	278.	223054.	126.	102285.	924672.		809919.	18300.	1151727.	930504.		
11	76	27.70	.97	84.	349.	9708471.	565736.	420.	346102.	154.	128755.	1321181.		954593.	18200.	1667283.	1101548.		
12	76	27.78	.08	84.	348.	9816871.	108400.	87.	72730.	146.	123133.	1153611.		975108.	19700.	1226341.	1117941.		

1	77	27.30	-.48	85.	348.	9836462.	19591.	35.	29596.	306.	259017.	1196813.	926202.	21600.	1226410.	1206819.
2	77	26.91	-.39	82.	350.	9362756.	-473706.	40.	32978.	210.	172600.	544839.	854122.	24800.	577816.	1051522.
3	77	27.02	.11	83.	350.	9497263.	134507.	293.	241484.	265.	219923.	993861.	861516.	19400.	1235346.	1100839.
4	77	26.96	-.06	83.	350.	9419436.	-77827.	143.	117867.	177.	145779.	830134.	860850.	19200.	948002.	1025829.
5	77	26.66	-.30	81.	[illegible]	9057544.	-361892.	64.	51759.	125.	100729.	536715.	832136.	17500.	588474.	950366.
6	77	26.63	-.03	80.	352.	9023536.	-34008.	131.	105358.	112.	89651.	809733.	839547.	19900.	915091.	949098.
7	77	26.76	.13	81.	351.	9182583.	159047.	110.	88441.	102.	82422.	1037547.	863919.	20600.	1125988.	966941.
8	77	26.44	-.32	79.	353.	8800080.	-382503.	26.	20841.	109.	86545.	535059.	834957.	16900.	555900.	938402.
9	77	26.10	-.34	77.	356.	8386318.	-413763.	2.	1560.	112.	85757.	492186.	802451.	19300.	493746.	907506.
10	77	25.92	-.18	76.	357.	8188110.	-198208.	166.	126278.	118.	89319.	573265.	788131.	20300.	699542.	897750.
11	77	25.58	-.33	77.	356.	8380309.	192199.	46.	35120.	175.	134796.	1070786.	758712.	20200.	1105906.	913707.
12	77	25.16	-.42	74.	358.	7917905.	-462404.	22.	16241.	188.	139159.	386257.	703843.	21900.	402497.	864901.
1	78	24.81	-.35	72.	361.	7527529.	-390376.	34.	24805.	257.	184248.	466028.	672962.	24000.	490834.	881210.
2	78	24.72	-.09	71.	361.	7424964.	-102564.	223.	159010.	195.	138467.	574372.	670180.	27300.	733382.	835946.
3	78	24.37	-.35	72.	360.	7568079.	143115.	30.	21133.	188.	135732.	920540.	641426.	21400.	941673.	798558.
4	78	24.34	-.03	72.	361.	7541756.	-26323.	187.	134352.	143.	103186.	608691.	645081.	21100.	743043.	769366.
5	78	24.23	-.11	71.	361.	7431953.	-109804.	126.	90233.	130.	92936.	557538.	645438.	19200.	647771.	757575.
6	78	24.32	.09	70.	362.	7292293.	-139660.	152.	107658.	89.	62784.	497822.	660556.	21800.	605480.	745140.
7	78	25.48	1.16	76.	356.	8269756.	977462.	379.	277503.	102.	78099.	1616906.	816287.	22600.	1894449.	916987.
8	78	25.43	-.06	76.	357.	8205826.	-63930.	44.	33473.	119.	90375.	802853.	791281.	18600.	836327.	900256.
9	78	25.16	-.27	74.	358.	7910589.	-295237.	36.	26996.	120.	88988.	516958.	729003.	21200.	543954.	839190.
10	78	25.18	.02	74.	358.	7931003.	20414.	150.	111235.	106.	78300.	724147.	714367.	22300.	835381.	814967.
11	78	25.12	-.06	74.	359.	7865670.	-65333.	89.	65878.	174.	128156.	708529.	689384.	22200.	774407.	839740.
12	78	25.15	.04	74.	358.	7904296.	38625.	155.	114606.	168.	124415.	775734.	703300.	24000.	890340.	851715.
1	79	24.86	-.30	72.	360.	7577089.	-327207.	94.	68317.	161.	116186.	429912.	682850.	26400.	498229.	825436.
2	79	24.49	-.37	70.	363.	7173192.	-403897.	41.	28695.	214.	148939.	398756.	652709.	29700.	427451.	831308.
3	79	24.22	-.27	71.	361.	7415240.	242048.	5.	3168.	207.	147455.	1042834.	633199.	23300.	1046002.	803954.
4	79	24.21	-.01	71.	361.	7406884.	-8356.	219.	155440.	133.	94794.	594760.	642763.	23000.	752200.	760557.
5	79	24.29	.08	72.	361.	7483094.	76211.	47.	33535.	114.	81612.	808195.	663007.	20900.	841730.	765519.
6	79	24.08	-.20	70.	362.	7281136.	-201958.	203.	144046.	78.	54504.	384097.	651798.	23800.	528143.	730102.
7	79	24.07	-.01	70.	362.	7269838.	-11298.	45.	31280.	81.	56908.	696018.	654948.	24700.	727298.	738596.
8	79	23.95	-.12	69.	363.	7148591.	-121247.	94.	65685.	105.	73252.	558543.	652024.	20200.	624229.	745476.
9	79	23.60	-.35	67.	365.	6795193.	-353398.	43.	29410.	109.	73010.	346922.	633619.	23100.	376331.	729729.
10	79	23.30	-.30	65.	367.	6498874.	-296319.	11.	6968.	129.	84415.	334726.	529298.	24300.	341694.	638013.
11	79	23.06	-.24	64.	369.	6255827.	-243047.	90.	58211.	158.	101056.	415475.	591577.	24100.	473686.	716733.
12	79	22.93	-.13	63.	369.	6127920.	-127907.	102.	64472.	159.	100361.	527155.	592974.	26200.	591628.	719535.
1	80	22.56	-.37	64.	368.	6261636.	133716.	6.	3498.	233.	149021.	881132.	573193.	28700.	884631.	750914.
2	80	22.34	-.22	63.	370.	6060049.	-201586.	97.	61178.	195.	122451.	454190.	562304.	32200.	515369.	716955.
3	80	22.04	-.30	61.	372.	5784200.	-275850.	75.	45999.	191.	116349.	365457.	545757.	25200.	411456.	687306.
4	80	21.93	-.11	60.	372.	5684479.	-99721.	172.	103660.	164.	98741.	473218.	553058.	24800.	576878.	676599.
5	80	21.42	-.51	59.	373.	5523287.	-161192.	11.	6263.	132.	78148.	448082.	514789.	22600.	454345.	615537.
6	80	21.59	.16	58.	375.	5374395.	-148892.	121.	70878.	90.	52097.	405981.	547854.	25800.	476859.	625751.
7	80	21.41	-.18	57.	376.	5210379.	-164016.	127.	72876.	84.	47724.	377265.	539733.	26700.	450141.	614157.
8	80	21.20	-.21	58.	374.	5414883.	204504.	51.	29399.	105.	61635.	777386.	518746.	21900.	806785.	602281.
9	80	20.91	-.29	57.	375.	5228158.	-186724.	3.	1444.	152.	86602.	437247.	513813.	25000.	438691.	625415.
10	80	20.59	-.33	55.	378.	4963839.	-264320.	9.	5038.	228.	125256.	380375.	498177.	26300.	385413.	649733.
11	80	20.27	-.32	53.	380.	4704950.	-258889.	22.	11593.	189.	100040.	340975.	485317.	26100.	352568.	611457.
12	80	19.91	-.35	51.	381.	4499224.	-205726.	22.	11469.	237.	121727.	400000.	467168.	28300.	411469.	617195.
1	81	19.46	-.46	51.	381.	4456950.	-42274.	20.	9989.	242.	123529.	545858.	443591.	31000.	555847.	598120.
2	81	19.30	-.16	50.	382.	4345172.	-111779.	71.	35664.	210.	105182.	453739.	462399.	33600.	489403.	601181.
3	81	19.22	-.08	50.	383.	4288418.	-56754.	176.	87705.	154.	76351.	403779.	443288.	28600.	491485.	548239.
4	81	18.92	-.30	48.	385.	4073501.	-214917.	15.	7292.	171.	81489.	312633.	429753.	23600.	319925.	534843.
5	81	18.65	-.27	46.	387.	3881410.	-192091.	40.	19484.	147.	67524.	299426.	416677.	25800.	317910.	510001.