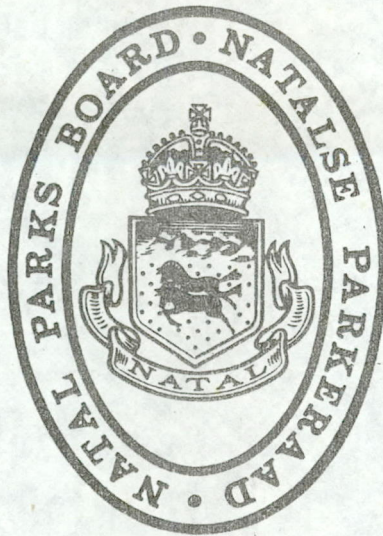


ST LUCIA DOCUMENT COLLECTION



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Title ISTOPE STUDIES AT ST LUCIA LAKE

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NATIONAL PHYSICAL RESEARCH LABORATORYISOTOPE STUDIES AT ST LUCIA LAKE

Since June, 1970 monthly samples have been taken of rain-, ground-, sea- and lakewater in the St Lucia area for isotope analysis. The stations from where samples have been taken are shown in Fig. 1. They are as follows:

1. Lister Point: rain- and lakewater.
2. Charter's Creek: rain- and lakewater.
3. Essengeni: lakewater.
4. Old Jetty: groundwater.
5. Sengwane: groundwater.
6. Mission Rocks: oceanwater.

Some samples have also been taken from Bhangazi Pan, but they have little value in this study. In their place riverwater samples from the Umfolozi and Mkuzi rivers have been taken since July 1971. However, the results are too few to draw any conclusions.

1. Stable isotope analyses

The O^{18} -concentrations have been determined for all samples and the deuterium concentrations for some. The relative concentrations is given by

$$R^{18} = \frac{[O^{18}]}{[O^{16}]} \quad (\text{or } R^D = \frac{[D]}{[H]})$$

and the property measured is the deviation δ from the so-called SMOW-standard (Standard Mean Ocean Water) which is given by the formula

$$\delta = \frac{R_{\text{sample}} - R_{\text{std}}}{R_{\text{std}}}$$

Thus δ^{18} and δ^D are indications of the relative O^{18} -concentration and D-concentration respectively.

The deuterium measurements are made to observe the effect, if any, of evaporation. With the exception of oceanwater the isotope concentrations of natural unevaporated water are related by $\delta^D = 8 \delta^{18} + \text{const.}$ The relative O^{18} and D-concentrations will, by definition, always be close to zero. If evaporation

occurs the lighter molecules will, under normal circumstances, evaporate faster than the heavier ones and thus the remaining water will be more concentrated in the heavier isotopes. The relation between the O^{18} and D-concentrations during evaporation is given by $(\delta^D - \delta_0^D) = 5 (\delta^{18} - \delta_0^{18})$ where δ_0^D and δ_0^{18} are the isotope concentrations of the original unevaporated water. Thus on a $\delta^D - \delta^{18}$ graph the points for evaporated water will be located on a line with slope 5 which goes through the point corresponding to the original water which may be on the line $\delta^D = 8 \delta^{18} + \text{const.}$

In table 1 the mean values for the period June 1970 - August 1971 are given for each of the stations. It appears that the O^{18} concentration of the lakewater at Essengeni does not differ much from that of the oceanwater: the influence of the tides is clear. The lakewater at Charter's Creek has a much higher O^{18} concentration and at Lister Point it is even higher. There is no feedwater with such a high concentration and thus the only explanation is that the water has strongly evaporated.

Groundwater		ca - 3‰
Riverwater		ca - 3‰
Oceanwater	Mission Rocks	+ 0,5 ‰
Lakewater	Essengeni	+ 0,4 ‰
	Charter's Creek	+ 1,2 ‰
	Lister Point	+ 2,4 ‰
Rainwater	Charter's Creek	- 3,4 ‰
	Lister Point	- 2,5 ‰
	Durban	- 3,1 ‰

Table 1. Mean relative O^{18} -concentrations of the different types of water.

Deuterium measurements were made on a number of samples to verify this theory. In fig. 2 the δ^D -values are plotted against the δ^{18} -values. This plot shows that the points for the lakewater do indeed deviate from the line with slope 8 and a line with slope 5,6 can be drawn through those points. The two lines cross at $\delta^{18} \approx -6\%$. However, it is not possible that the junction represents the original unevaporated water, since there is no feedwater with such a low concentration. Thus the original water must be a mixture of oceanwater and fresh water and the possibility that only fresh water and no oceanwater enters the lake can therefore be excluded.

The influence of the fresh water that enters the lake can be observed from fig. 3 and fig. 4. Fig. 3 shows for every month the total rainfall, the δ^{18} -value of that rain and the δ^{18} -value of the lakewater at Charter's Creek. Fig. 4 is the corresponding graph for Lister Point. The amount of rain, as well as its O^{18} -content is considered to be a measure for the total fresh water inflow and its O^{18} -concentration.

At Charter's Creek the O^{18} -concentration in the lake follows that of the rain reasonably well. During periods with little precipitation the O^{18} -concentration of the lakewater increases as a result of evaporation, whereas during months with heavy rainfall the O^{18} -concentration of the lake drops because of the lower O^{18} -concentration of the rainwater. The higher O^{18} -concentration on December 1st, may have been caused by the irregular distribution of the rainfall during the previous month.

At Lister Point the same effects are observed as at Charter's Creek with the difference that the O^{18} -concentration of the lakewater at Lister Point seems not to exceed a certain value. The explanation for this might be that the water has reached its maximum O^{18} -concentration at which point a steady state exists between the isotopic composition of the lake water and that of the air moisture. From the theory it is known that a water body without additional supply, under circumstances such as those existing in the St Lucia area, can reach a maximum O^{18} -concentration $\delta^{18} \approx +3\%$. If so much water is supplied that the amount of inflowing water equals the amount of evaporating water, the maximum O^{18} -concentration will vary between $\delta^{18} = +2\%$ and $\delta^{18} = +2,5\%$, depending on the concentration of the inflowing water.

During the first four months of the observation period (June - September), little rain fell at Lister Point and the O^{18} -concentration of the lakewater remained at its maximum value during that time. In October and November there was a lot of precipitation and the O^{18} -concentration dropped considerably. One month later, however, the concentration was back at its maximum value and remained at this level for four months in spite of the fact that a reasonable amount of rain fell in that time. Apparently the evaporation exceeded the total inflow. It was not until April that the O^{18} -concentration decreased, followed by an increase again in the next months. In this latter period the amount of water evaporated was probably about equal to or slightly less than the total amount of inflowing water.

The total supply is defined as the total amount of inflowing rain-, river- and groundwater in addition to the inflow of saline water from other parts of the lake. However, it is impossible to determine the influence of these different types of water with the data available. It would therefore be necessary to obtain groundwater samples from a series of sample points along the lakeside and lakewater samples from all over the lake. Then the extent of the influence of the oceanwater and of the different freshwater supplies can be determined.

2. Tritium Analyses

The concentration of the radio-active isotope tritium was measured in some representative samples. This concentration is also referred to an international standard and is expressed in tritium units (T.U.). The results of the measurements are shown in table 2. The tritium content of rainwater should be about 20 T.U. and that of the seawater is about 2 T.U.

Groundwater	Old Jetty	1/12/70	15,4 ± 0,9 T.U.
	"	1/4/71	11,1 ± 1,0 T.U.
Oceanwater	Mission Rocks	1/12/70	2,1 ± 0,6 T.U.
Lakewater	Essengeni	1/12/70	6,6 ± 0,6 T.U.
	"	1/4/71	8,1 ± 0,6 T.U.
	Charter's Creek	1/12/70	10,9 ± 0,9 T.U.
	"	1/4/71	11,2 ± 0,9 T.U.
	Lister Point	1/12/70	17,7 ± 1,2 T.U.

Table 2. Tritium contents of some representative samples.

Assuming the two groundwater samples from Old Jetty to be representative of the groundwater seepage into the lake, the only possible explanation for the low tritium concentrations at Essengeni and Charter's Creek is that a considerable portion of the samples consists of seawater. This finding could be further substantiated by the measurement of more samples from the lower part of the lake.

Dr J.C. Vogel,
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21.10.71

2. Results of D-measurements; δ^D -values in ‰.

Date	1.7.70	1.8.70	1.11.70	1.1.71
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Precipitation

Lister Point	0		-21	+7
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Surface Water

Lister Point	+22		+19	+19
Charter's Creek	+12		+ 2	+14
Essengeni	+ 5		+ 4	+ 5
Bhangazi Pan	+15			

Ground water

Old Jetty	- 9	-10		
Sengwane	- 5	- 5		

Ocean water

Mission Rocks	- 5			+ 9
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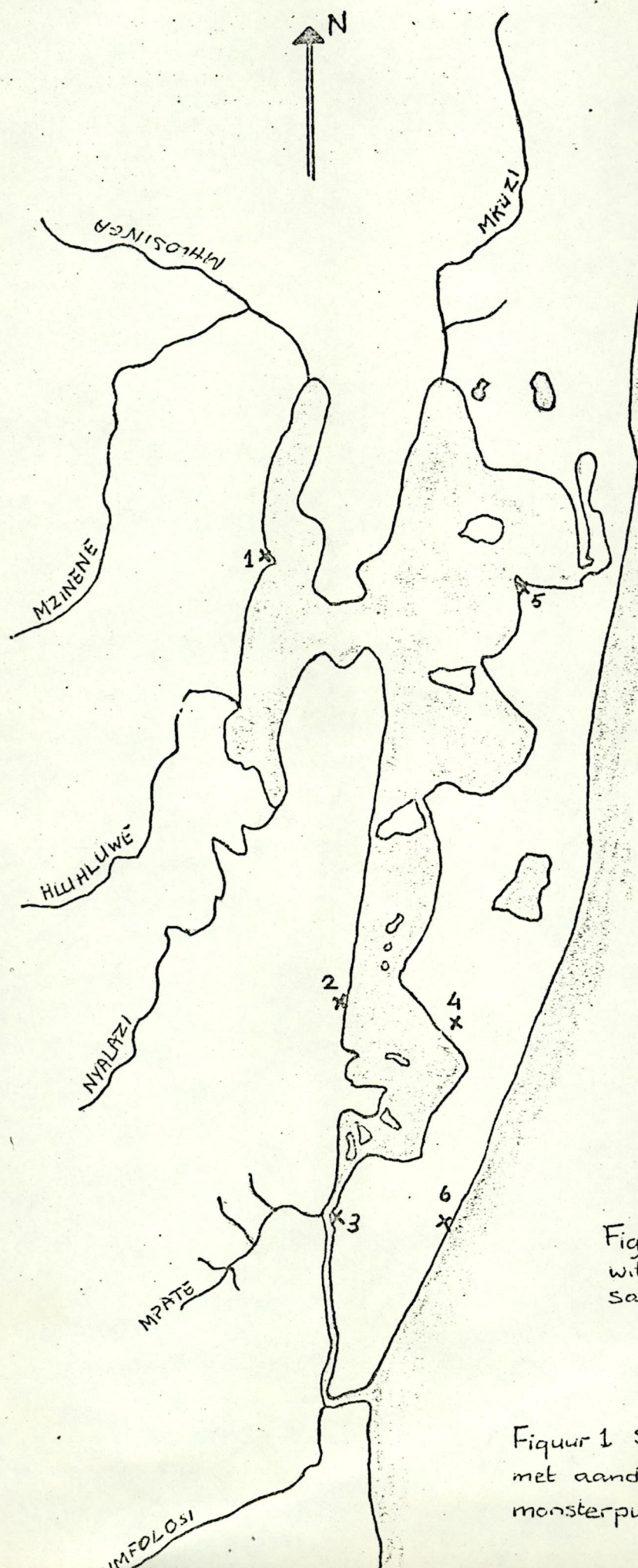
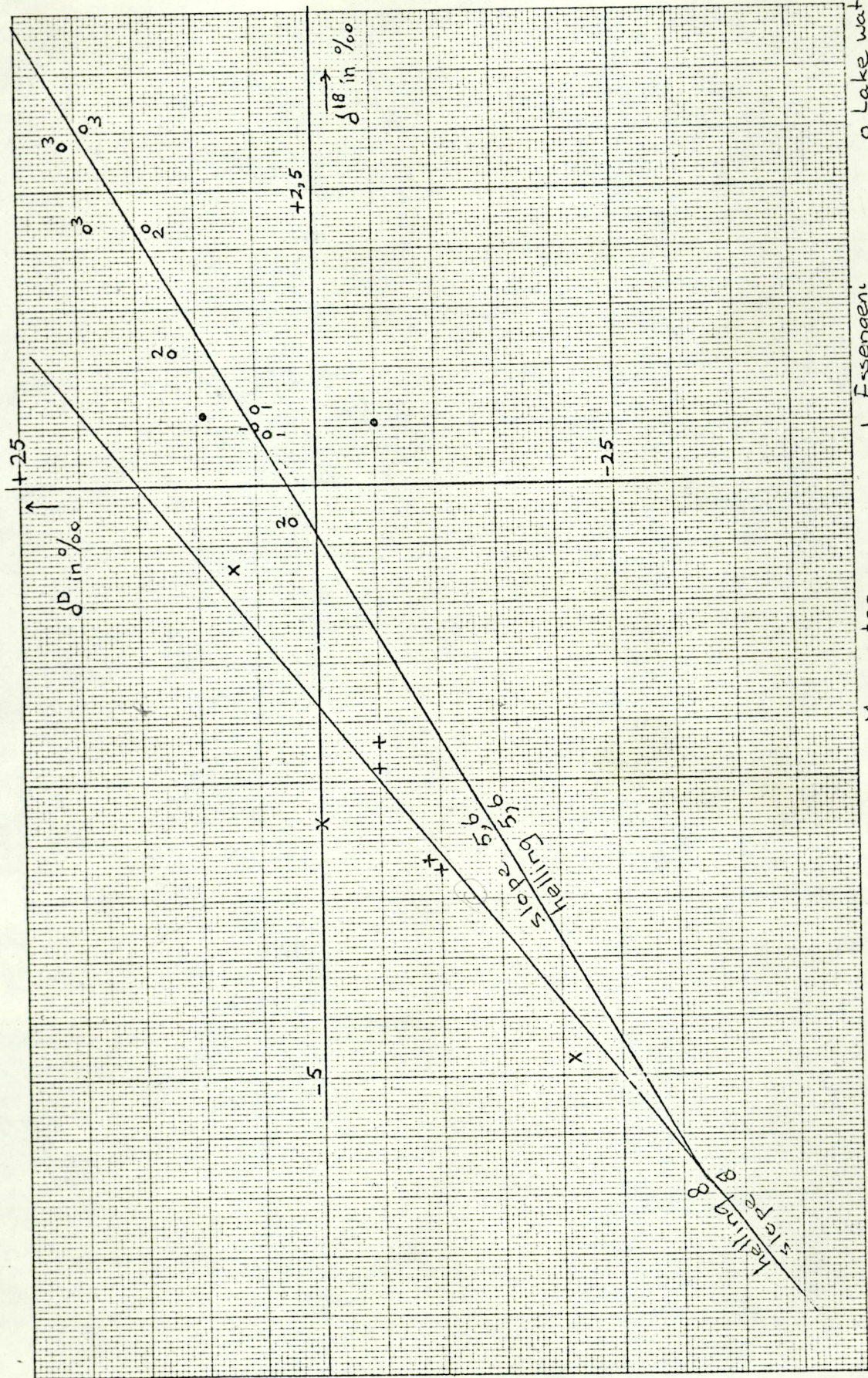


Fig. 1. St. Lucia lake with locations of sample points.

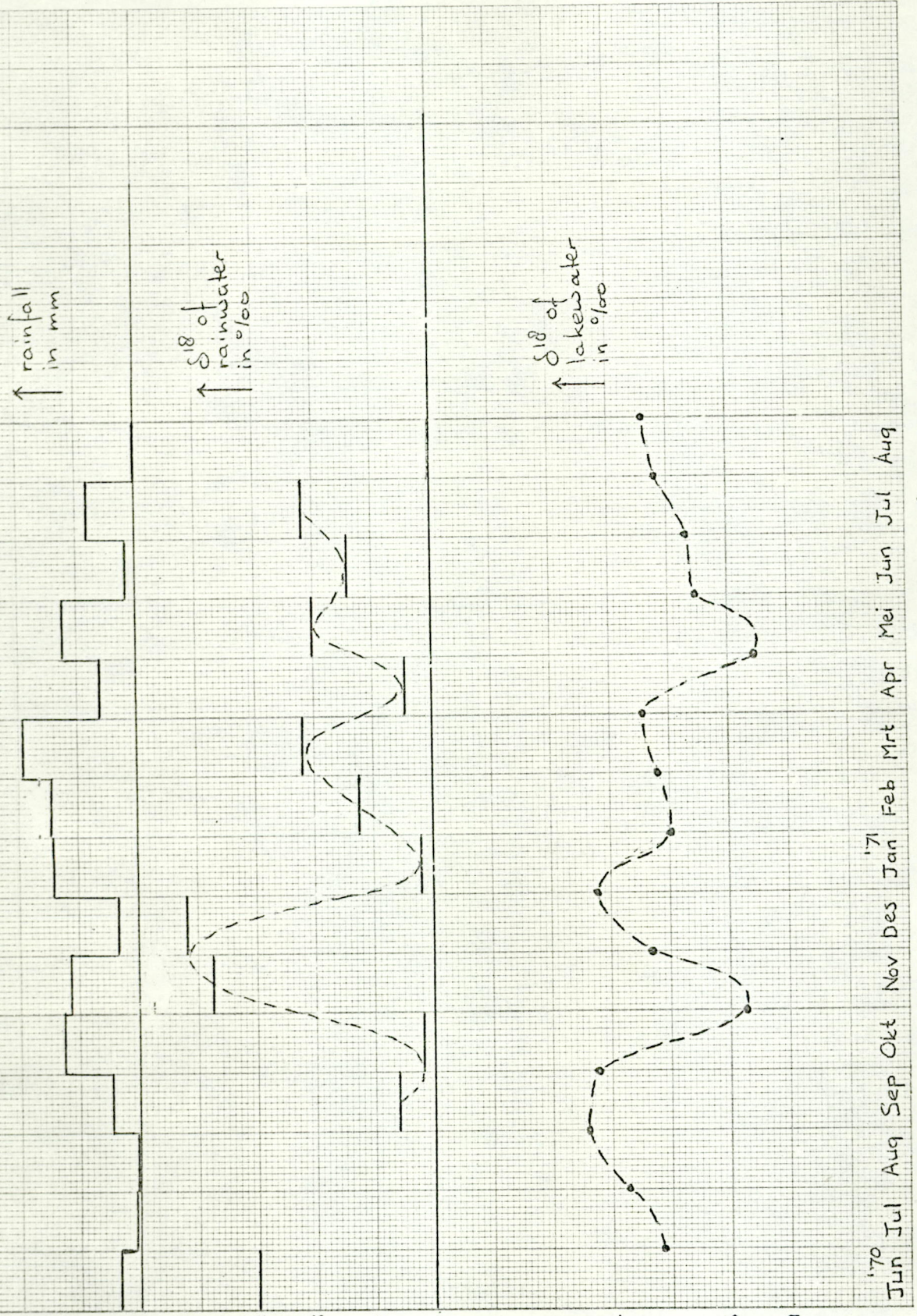
Figuur 1 St. Luciameer met aanduiding van monsterpunten.



Figuur 2. Grafiek van δ^D teen δ^{18} van 'n aantal monsters van 'n aantal monsters of a number of samples

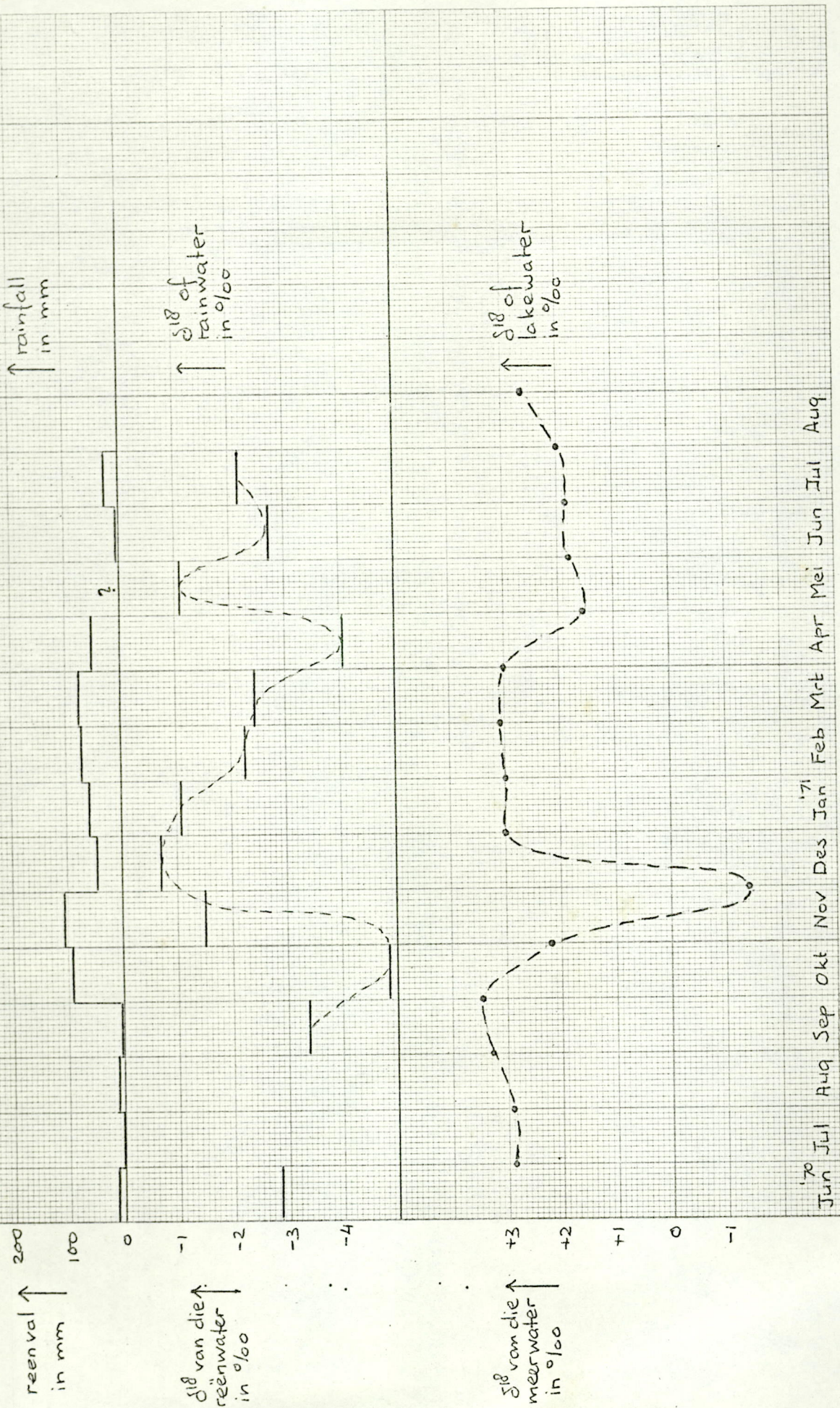
1 Essengen
 2 Charter's Creek
 3 Lister Point

○ Lake water
 × Rainwater
 + Groundwater
 ● Oceanwater



Figuur 3. Maandelikse waardes vir reënval en O^{18} -konsentrasies van reën- en meerwater te Charter's Creek.

Fig. 3. Monthly values of rainfall and O^{18} -concentrations of rain- and lakewater at Charter's Creek.



Figuur 4. Maandelikse waardes vir reënval en O^{18} -konsentrasies van reën- en meerwater te Lister Point.
 Fig. 4. Monthly values of rainfall and O^{18} -concentrations of rain- and lake water at Lister Point.