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A REPORT ON THE SALINITY OF GROUNDWATER  
IN THE ALLUVIAL AQUIFER IN PARTS OF BERNARD LODGE  
AND CAYMANAS AREAS AND THE ADJOINING COASTAL AREA  
ST. CATHERINE PLAINS

**NATIONAL IRRIGATION COMMISSION LIMITED**

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14-20 PORT ROYAL STREET  
JAMAICA CONFERENCE CENTRE  
3rd FLOOR KINGSTON

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ST. CATHERINE PLAINS**

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**LAND UTILIZATION DEPARTMENT  
AGRO-21 CORPORATION LIMITED  
PORT ROYAL STREET  
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### INTRODUCTION

The Crop Diversification and Irrigation Project (CDI) started functioning officially from October 1985, to reinforce the institutional capacity of Agro-21 Corporation Limited to promote and develop private commercial agricultural investment in Jamaica. One of the activities of the CDI project was to rehabilitate and construct irrigation infrastructure such as wells, canals, pumping stations, fencing and storage facilities. On the reorganization of the activities of the Agro-21 Corporation Limited, with effect from April 1, 1989, the CDI project was merged with the National Irrigation Commission. The area of activity is a part of the St. Catherine Plains mostly on the western outskirts of Kingston where it is divided into five (5) sub-areas which are designated as Project - A, Project - B, Project - C (Horticulture), Project-C (small farmers' area) and Project-E. Other areas of small farmer activity include Hill-Run, and Bushy Park. The Hydrogeologist working with the project executed the programme of rehabilitating the old wells and constructing the new ones and also carried out other hydrogeological activities all of which are indicated below:

- a) Three old wells in Project-A were rehabilitated in late 1985.
- b) Fourteen (14) wells were constructed in Projects - A, B, C (Horticulture) and E during the period September, 1985 to February, 1988.
- c) Six (6) old wells in Project-E and two (2) old wells in Project-C (small farmers' area) were tested for their yield and quality of water during the period April, 1987 to February, 1988.
- d) Four (4) observation wells were constructed in coastal area to the east, south-east and south of the project areas and one in the Hill-Run area to monitor the quality of groundwater.
- e) Two (2) exploratory wells were drilled in the Hill-Run area tapping the limestone aquifer.
- f) Water levels and quality of groundwater in the general area were monitored.

As specified in the project document, environmental monitoring of the project activities will be the responsibility of the Underground Water Authority which will include monitoring of:

- a) Water quality with respect to both salinity and contamination by pesticides and other pollutants.
- b) Groundwater extraction.

Monitoring of groundwater levels is necessary to relate any changes in the quality of groundwater with extraction. Monitoring of water levels and the quality of groundwater and preparation of respective project reports were done in collaboration with Underground Water Authority.

Major hydrological work carried out has been described in the following reports:

1. Ramanamurty, D.V. December, 1988. A report on the groundwater resources of horticulture Project-C, Caymanas area, St. Catherine Plains. Land Utilization Department, Agro-21 Corporation Limited, Kingston.

Contains reports on the construction, development and testing of two wells viz. Watson Grove #3 and Riversdale #1 and the recommended rates of extraction of groundwater from these wells. Describes the chemical characteristics of water required for use in horticulture and the suitability of groundwater in the area for this purpose.

2. Ramanamurty, D.V., and B. Fernandez. March, 1989. A report on the salinity of and groundwater in the alluvial aquifer in parts of Bernard Lodge and Caymanas Areas and the adjoining coastal area, St. Catherine Plains. Land Utilization Department, Agro-21 Corporation Limited, Kingston.

Contains chemical analyses data of groundwater from 38 wells in the area; historical data from 1963 to 1982 and recent data from 1985 to 1988; shows areas of groundwater contamination with sea water and other pollutants.

3. Ramanamurty, D.V. May, 1989. A report on the groundwater resources of Project-A, Bernard Lodge area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on testing of one old well, Half Way Tree #6, reconstruction, development and testing of three old wells, Half Way Tree #4, #5 and Cookson #3 and construction, development and testing of five new wells, Half Way Tree #2, Cookson #4, Newlands #2, #2A and #3, recommended rates of groundwater extraction from the wells, chemical characteristics of water required for irrigation and the suitability of groundwater for this purpose.

4. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-B, Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on the construction development and testing of wells, Cowpark-A, North Syndicate #2, South Syndicate #2, Naggo Head and Guinep Pen and testing of old well, Cedar Grove #2, recommended rates of groundwater extraction from the wells, chemical characteristics of water for irrigation and suitability of groundwater in the area for this purpose.

5. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-E, Bernard Lodge area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on the construction, development and testing of three new wells Goshen #3A, Clifton #B, and Clifton #5 and testing of 6 old wells, Limetree #1, Government Park, Clifton #3 Congrieve Park #4, Salt Pond #7, and Reidspen #1, recommended rates of groundwater extraction from the wells, chemical characteristics of water required for irrigation and suitability of groundwater in the area for this purpose.

6. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-C (small farmers area), Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on testing of two old wells, Phoenix Park #1 and #3 and drilling of five coreholes, Lawrencefield, Riversdale #2 and #3 Cowpark B and C.

7. Ramanamurty, D.V., K. Mulchansingh and B. Fernandez. July, 1989. A report on the ground water levels in parts of Bernard Lodge and Caymanas areas and adjoining coastal area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains water level data and hydrographs for 27 wells and descriptions on the fluctuations in water levels.

8. Ramanamurty, D.V., and B. Fernandez. July, 1989. A note on the salinity of and groundwater from Riversdale #1 well, Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains chemical analyses results of water samples collected from Riversdale #1 well from August, 1986 to March 1989 and description on the changes in the quality of groundwater with pumping time. Attempts to explain the unusually high concentrations of sodium and chloride in water just at the beginning of pumping.

9. Ramanamurty D.V. and B. Fernandez. July, 1989. A note on the water levels and quality of groundwater from the observation well at Hill-Run, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains water level data, hydrographs and chemical analyses results of water samples from the Hill-run observation well.

Reports on the construction of five (5) observation wells along the coast and in the Hill-Run area, and on the drilling of two (2) exploratory wells tapping the limestone Aquifer in the Hill-Run area and on the organic contamination of groundwater in parts of Bernard Lodge area have been issued by the Underground Water Authority under the titles listed below:

1. Fernandez, B. January, 1988. The drilling of monitoring wells, South St. Catherine. Underground Water Authority, Kingston.

The Crop Diversification Project on the South St. Catherine alluvial plains, required high quality groundwater, necessitating the replacement of older sand pumping wells. The quality of groundwater must remain high and the monitoring well network is one early warning system put in place to detect any changes in groundwater quality. The five monitoring wells are aligned in a crescent between the well field and the sea. Multi-level (piezometers) and single level completion using 3" O pvc have been constructed.

2. Fernandez, B. July, 1988. Well completion report, Hill-Run Drive #1, exploratory Well, South St. Catherine. Underground Water Authority, Kingston.

Contains drilling, and testing information. The hole was drilled down to 200 ft. Groundwater from the well was highly saline in the deep zone and moderately saline in the top zone. The well was abandoned.

3. Fernandez, B. August 1988. Well completion report, Pepper Pot Drive exploratory well #2, Hill Run area, St. Catherine. Underground Water Authority, Kingston.

Contains drilling and testing information. The hole was drilled down to 80 ft. Testing could not be completed due to caving of the hole and it was abandoned.

4. Fernandez, B. and D.V. Ramanamurty. July 1989. Ground-water monitoring for organic contamination. Bernard Lodge, St. Catherine Plains. Underground Water Authority, Kingston.

Six water samples one each from six wells in and around the project areas were analysed. Concentration of organophosphorous pesticides in the groundwater were below the detectable limit. Concentration of organochlorine pesticides were also less than the detectable limit except in one sample.

Facilities extended by Agro-21 Corporation Limited, Underground Water Authority and National Irrigation Commission Limited, in furtherance of the work and in the preparation of the reports are gratefully acknowledged.

6

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CONTENTS

	Page
1. Introduction	1
2. Status of Wells	1
2.1 In The Project Areas	1
2.2 Observation Wells	4
2.3 Wells outside the Project Areas	4
3. Quality of Water	
3.1 Source of Data	4
3.2 Classification and Quality of Groundwater	5
3.3 Project-A	6
3.4 Project-B	6
3.5 Project-C	7
3.6 Project-E	7
3.7 Observation Wells	9
3.8 Wells outside the Project Areas	10
4. Conclusions	10
5. Recommendations	13
References	15

Tables

1 - 49	Chemical Analyses Results of Water Samples
50	Chemical Characteristics of Well Waters
51	Pumping Water Levels in the Wells on the Dates of Water Sampling

Maps

1. Map of parts of Bernard Lodge and Caymanas areas showing the location of wells.
  2. Map of parts of Bernard Lodge and Caymanas areas showing the types of groundwater
  3. Map of parts of Bernard Lodge and Caymanas areas showing stages of contamination of groundwater.
- 6



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1. INTRODUCTION

The areas under consideration include the Projects A, B, C (Horticulture) and E of the Agro-21 Corporation Limited and the adjoining coastal area. There are 31 tube-wells and one dug well in these areas of which 29 tube-wells and one dug well are in the project areas and 2 tube-wells are in the adjoining coastal area. Of these, 18 tube-wells are in operation and 9 tube-wells are to be put into operation soon. The remaining 4 tube-wells viz. Watson Grove #2, Reids Pen #2, Goshen #2 (all old wells) and Newlands #2 (recently constructed) and one dug well Half-Way-Tree #2 were abandoned but the available data on the quality of groundwater from these wells has been used in this report. Collection of data on the quality of groundwater from Newlands #2 well is continuing. In order to detect any deterioration in the quality of groundwater which may result due to regular use of the wells in the areas under consideration, the Agro-21 Corporation Limited had constructed, in 1987, 4 observation wells between the project areas and the coast. The drilling and construction of these wells was done by the Underground Water Authority. Of the two pumping wells which are outside the project areas, Portmore #2 is owned by the National Water Commission and the other Cumberland Pen is owned by an individual. The locations of all the wells are shown in Map 1 and their status is given in the following sections:

2. STATUS OF WELLS

2.1 In The Project Areas

Project A

1. Half-Way-Tree #2                      This was an old dug well. It used to pump sand and gradually caved in.
  
2. Half-Way-Tree #2                      As a replacement for the old well this tube well was constructed in December 1985, at about a hundred feet away from the old well

- |                     |  |
|---------------------|--|
| 3. Half-Way-Tree #4 | This is an old well. It was pumping sand. It was reconstructed in October 1985 by installing a 14 inch diameter well assembly consisting of the required lengths of plain pipe and well screens in the existing 20 inch diameter well and filling the annular space with proper size gravel. |
| 4. Half-Way-Tree #5 | This is also an old well reconstructed in September 1985 like the one above.   |
| 5. Half-Way-Tree #6 | This is an old well used in the same condition.  |
| 6. Cookson #3       | This is an old well partly reconstructed in November 1985.   |
| 7. Cookson #4       | A new well constructed in December 1985  |
| 8. Newlands #2      | A new well constructed in February 1986 but abandoned due to poor yield. Used as an observation well.  |
| 9. Newlands #2A     | A new well constructed in April 1987   |
| 10. Newlands #3     | A new well constructed in December 1985.   |

(All these wells, except Newlands #2 have been in regular use from the time the project started in September 1985)

#### Project B

- |                                   |  |
|-----------------------------------|--|
| 11. North Syndicate<br>(old well) | This well was abandoned due to sand pumping and dislocation of the casing.                                   |
| 12. North Syndicate #2            | This is a replacement well constructed in November 1986 at about 2000 ft. to the south east of the old well. |

13. South Syndicate (old well) The well was abandoned due to low yield coupled with sand pumping
14. South Syndicate #2 A replacement well for the old one, constructed in September 1986 at about 1000 ft. to the west north west of the old well.
15. Cow Park A A new well constructed in August 1986
16. Naggo Head A new well constructed in September 1986
17. Guinep Pen A new well constructed in September 1986
18. Cedar Grove #2 An old well used in the same condition

#### Project C

19. Watson Grove #2 An old well abandoned due to sand pumping and deterioration in the condition of well casing
20. Watson Grove #3 A new well constructed in April 1986 at about 100 ft. to the east of the old well
21. Riversdale #1 A new well constructed in August 1986

#### Project E

22. Limetree #1 All these are old wells and in use since their construction.
23. Government Park
24. Clifton #3 Goshen #2 was recently abandoned due to excessive sand pumping.
25. Goshen #2
26. Congrieve Park #4 Reids Pen #2 well was also abandoned a few years ago.
27. Salt Pond #7
28. Reids Pen #1
29. Reids Pen #2
30. Goshen #3A A new well constructed in March 1987

31. Clifton B                    A new well constructed in May 1987
32. Clifton #5                    A new well constructed in January 1988

## 2.2 Observation Wells

33. Waterford                    Constructed in July 1987
34. Cumberland Pen                Constructed in June 1987. It has two piezometers one 30 ft. deep and the other 102 ft. deep
35. Naggo Head                    Constructed in August 1987.
36. Reidspen                      Constructed in July 1987.

(These wells were constructed with 3" dia. PVC pipes)

## 2.3 Wells Outside the Project Areas

37. Cumberland Pen                | These are old wells and  
  | have been in use since  
38. Portmore #2 (NWC)            | their construction

## 3.0 QUALITY OF GROUNDWATER

### 3.1 Source of Data

The chemical analyses results of water samples collected from the old wells from time to time were obtained from the records of the Underground Water Authority. This data generally covered the period from 1963 to 1982 and is given in Tables 1 to 18.

Reconstruction of 3 old wells and construction of 15 new wells and 4 observation wells were taken up by the Agro-21 Corporation Limited during the period August 1985 to January 1988. Some of these production wells were put into operation immediately after their construction/reconstruction. Water samples were collected from most of these wells during the testing which was conducted immediately after their construction/reconstruction. Subsequently, water samples are being collected periodically from those wells which have been in operation (Projects A and C).

Out of the six old wells in Project E, provision for collecting water samples exists for two wells viz. Reidspen #1 and Salt Pond #7. Water samples from Reidspen #1 well are being collected from July 1986. Salt Pond #7 well is not in regular use. All the six old wells were tested in 1987 for their yield and quality of water when a temporary provision for collecting water samples was made on the other four wells. Water samples were collected from all the six wells during the testing.

Water samples are also being collected from the two wells outside the project areas from 1986.

The four observation wells constructed in 1987 are of 3 inches in diameter and no pumps are installed on them. In November 1987, water was pumped out from these wells with an air compressor and water samples were collected. Subsequently water samples are being collected from these wells with a water sampler from a depth of 50 ft. (from 25 ft. depth in case of Cumberland Pen shallow piezometer). One sample was collected from Reidspen observation well on July 31, 1987, when the well was developed with an air compressor.

Chemical analyses results of well water samples collected till November 1988, are given in Tables 19 to 49.

### 3.2 Classification and Quality of Groundwater

Chemical analyses results given in Tables 1 to 49 are in parts per million (ppm) milligrams per litre (mg/l). These have been converted to milliequivalents per litre (meq/l) and these units have been used in the preparation of graphs and in the classification of groundwater. Graphs 1-35 show the concentrations of principal cations and anions in meq/l and Durov Diagrams 1-7 show the classification of waters. A summarized account on the chemical characteristics of the waters is given in Table-50. Maps 2 and 3 show the areas with different types of groundwater and different stages of contamination of groundwater respectively. The description of the constituents and the comparison made between them is with respect to their concentrations in meq/l. The types and quality of groundwater project wise/area wise are described in the following sections. Pumping water levels in the wells at the time of water sample collection from the wells are given in Table-51.

### 3.3 Project A

The water was mostly of calcium bicarbonate type in the western part tending to be calcium-magnesium bicarbonate type towards the east. Chloride was low being mostly less than 0.75 meq/l. Sodium was more in the waters on the eastern side than on the western side. It was more than magnesium in the waters from Half Way Tree #6 (from 1975), Cookson #3 (Nov. 1985 and July 1986), Cookson #4 (from 1987), Newlands #2 (September - October 1988) and Newlands #3 (all samples). There was a slight increase in sodium and chloride when compared to the 1963 levels. Specific conductance of recent water samples was in the range of 500 to 700  $\mu$ -mhos/cm and was in line with the historical data. The chloride to carbonate plus bicarbonate ratio varied from 0.040 to 0.198 and there appears to be no steady increase in this ratio over the years. The variations appear to be more due to the decrease in the carbonate plus bicarbonate content than due to an increase in the chloride content. Bicarbonate was low in almost all the samples in March 1988.

### 3.4 Project B

The type of water varied from calcium bicarbonate to calcium magnesium bicarbonate. Chloride was low being less than 0.76 meq/l. Sodium was 1.5 - 2.5 meq/l (except for Guinep Pen Well) which was somewhat high when compared to that normally found in groundwater in the area (Half-Way-Tree #2 and Half-Way-Tree #5 wells) and it increased towards the coast the highest found (3.22 meq/l) being in the Guinep Pen well water. It exceeded magnesium in the waters from Cow-Park A, Naggo Head and South Syndicate #2 wells and both magnesium and calcium in the water from Guinep Pen well. Both sodium and chloride show an increase with respect to those found in the North Syndicate and South Syndicate well waters before 1975.

Specific conductance varied from 600 to 700  $\mu$ -mhos/cm in the recent water samples and it was in line with the historical data.

The chloride to carbonate plus bicarbonate ratio varied from 0.053 to 0.120 and it was in line with that found in the waters of Project A.

## 2.5 Project C

The water from Watson Grove #3 well was of calcium bicarbonate type except once on July 7, 1987, when it was of calcium-magnesium bicarbonate type. Chloride was low being less than 1 meq/l and was in line with that found in Watson Grove #2 well water. Sodium of more than 1 meq/l was conspicuously more than that recorded for Watson Grove #2 well water which was less than 1 meq/l. There was a slight but steady increase from 1962 to 1988. It also slightly exceeded the magnesium content only once on February 2, 1987, but this is not considered significant.

Water from Riversdale #1 well was distinctly of calcium bicarbonate type. Sodium of 1 to 2 meq/l did not exceed magnesium. Chloride increased from 1.24 meq/l on July 21, 1988 to 3.5 meq/l on November 4, 1988. A test was conducted on November 24, 1988, to study any variation in the quality of water with pumping time. Chloride of 3.78 meq/l at the start of the test decreased to 1.46 meq/l after 5.5 hours of pumping and then slightly increased to 1.56 meq/l after 23.5 hours of pumping. Sodium also showed the same trend. Further studies are in progress to identify the source of contamination and a separate report on the results of the studies will follow.

Specific conductance of water from Watson Grove #3 well varied from 506 to 670  $\mu$ -mhos/cm and it was in line with that for Watson Grove #2 well water for the period 1972-1976. Specific conductance of water from Riversdale #1 well varied from 698 to 1056  $\mu$ -mhos/cm.

The chloride to carbonate plus bicarbonate ratio for Watson Grove #3 well water was less than 0.160 (except once when it was 0.40 due to very low bicarbonate but not due to high chloride) and it was in line with that found in groundwater in Projects A and B. This ratio for water from Riversdale #1 well increased from 0.223 in August 1986 to 0.546 on November 24, 1988, which is considered high. Further studies are in progress to find out the source of high chloride in water.

## 3.6 Project E

The water was of calcium bicarbonate to calcium magnesium bicarbonate type. Chloride was generally around 1 meq/l.

It was around 2 meq/l in Reidspen area and upto 2.28 meq/l in Limetree area. Sodium generally increased and also exceeded magnesium southwards.

A steady increase in sodium and chloride in the water from Limetree #1 well from 1974 to 1987 is conspicuous. In April 1987 chloride exceeded sodium which in turn exceeded magnesium. The pumping water levels are not known as there is no provision to measure the water levels in the well. Specific conductance in April 1987 was 813 to 838  $\mu$ -mhos/cm which was 200 to 300  $\mu$ -mhos/cm more than that before 1974.

In the water from Government Park well, calcium and magnesium were higher than those found in the waters from other wells in the area. Sodium was less than magnesium except once on March 3, 1970. Specific conductance in 1987 was upto 1210  $\mu$ -mhos/cm and it was much higher than that before 1975. As the pumping water levels in the well were much above the sea level it is likely that the high mineralization of groundwater in the area resulted from the contamination with sugar factory affluent which flows through a channel close to the well.

Though there was no marked increase in sodium or chloride in the water from Reidspen #1 well between 1974 and 1988, they were conspicuously more than those found in the waters from other wells like Government Park. Sodium was more than magnesium and sometimes more than calcium too.

Chloride in the water from Salt Pond #7 well does not show any increase between 1963 and 1987 being less than 1 meq/l all through. Sodium which was more than 3 meq/l in 1963 decreased to less than 2.5 meq/l in 1970 and 1972 and again increased to more than 3.5 meq/l in 1987. It exceeded magnesium in 1963 and calcium and magnesium in 1987.

Specific conductance of recent water samples from Reidspen #1 and Salt Pond #7 wells varied from 630 to 880  $\mu$ -mhos/cm and it was in line with the historical data. That from other wells ranged from 700 to 900  $\mu$ -mhos/cm and was slightly more than the historical range of 600 to 800 micromhos/cm.



The chloride to carbonate plus bicarbonate ratio was less than 0.2 (except for Clifton B, Limetree #1 and Reidspen #1 well waters) and there was no marked increase in this value with reference to the historical data. For Clifton-B well water it was upto 0.328 due to low bicarbonate and not due to high chloride. For Limetree #1 well water, it was 0.2 till 1978 but increased to 0.386 in April 1987 due to an increase in chloride. For Reidspen #1 well water, it varied from 0.202 to 0.360 between January 1981 and August 1988. However after heavy rains in September 1988, the value decreased to 0.172 due to very low chloride and then increased to 0.180 in November 1988.

### 3.7 Observation Wells

The Waterford Observation Well is located very close to the coast. The water was of sodium chloride type. Concentration of chloride was the highest being around 25-32 meq/l, followed by sodium (16.6 to 22.5 meq/l) and calcium (8.9 to 12 meq/l). Sodium and chloride increased with depth as is seen from the analytical results of water samples collected from depths of 40 ft. and 60 ft. on February 23, 1988. Specific conductance varied from 3250 to 4000  $\mu$ -mhos/cm.

Waters from Cumberland Pen piezometers, both deep and shallow were of sodium bicarbonate type with carbonate plus bicarbonate (5.5 to 8 meq/l) exceeding all other ions for most part. Sodium was next to bicarbonate and the difference in the concentrations of bicarbonate and sodium was generally more in the water from the deep piezometer than in the water from the shallow one. Chloride was generally less than 1 meq/l in the waters from both the piezometers except once in November 1987, when it was 5 meq/l and 4.24 meq/l in the waters from deep and shallow aquifers respectively. Specific conductance of water from the deep and shallow aquifers varied from 691 to 827  $\mu$ -mhos/cm and 736 to 836  $\mu$ -mhos/cm respectively.

Water from the Naggo Head observation well was also of sodium bicarbonate type. Both sodium and chloride were higher than those found in the Cumberland Pen well water. Sodium was the highest being around 10 to 12 meq/l. Chloride with concentrations of about 3 to 4 meq/l was the third highest with carbonate plus bicarbonate (6 to 8.4 meq/l) in between sodium and chloride. Specific conductance varied from 1030 to 1190  $\mu$ -mhos/cm.

The Reidspen Observation Well is at the extreme south-western end of Block E and about 1.6 miles inside the coast. Water from this well was of sodium chloride type. Sodium (19.2 to 25.2 meq/l) was the highest followed by chloride (10 to 20 meq/l). Both sodium and chloride were less than those found in the water from Waterford Well. Specific conductance varied from 2250 to 3500  $\mu$ -mhos/cm.

### 3.8 Wells Outside the Project Areas

The Portmore #2 well is closer to the coast than all the pumping wells in Block A. The water varied from calcium bicarbonate to calcium-magnesium bicarbonate type. Sodium fluctuated widely generally exceeding magnesium and once calcium too. Fluctuations in sulphate were also high.

Water from Cumberland Pen pumping well was distinctly of calcium bicarbonate type. Though this well is close to coast and has been in use since 1972, there appears to be no appreciable increase in chloride in the well water. Sodium however, increased steadily and also exceeded magnesium from November 1987.

## 4. CONCLUSIONS

- (a) Groundwater in and around the project areas was mostly of calcium bicarbonate type tending to be sodium bicarbonate and sodium chloride types towards the coast.
- (b) Groundwater in Project E area appears to be more mineralized than that in other project areas.
- (c) In normal groundwater (like that from Half-Way-Tree #2 and Half-Way-Tree #5 wells), the ionic concentrations in decreasing order were bicarbonate plus carbonate, calcium, magnesium, sodium, chloride and sulphate. The last two sometimes exceeded sodium. The type of water was calcium bicarbonate to calcium-magnesium bicarbonate. Any deviation from this normal trend is attributed to the contamination of groundwater either with the sea water or other contaminants.
- (d) Water from Government Park Well was more mineralized than usual, and this is considered due to the contamination of the groundwater in the area with sugar factory affluent.

- (e) Sodium and chloride were more than magnesium in the water from Limetree #1 well in 1987. Further studies need to be carried out to trace the source of contamination.
- (f) Chloride in the water from Riversdale #1 Well sharply increased from July 1988 to November 1988. However, it is observed that the chloride content was high in the water immediately after the pumping started and considerably reduced after four hours of pumping. Further studies need to be carried out to trace the source of contamination.
- (g) High sodium in groundwater is considered as one of the indications of contamination with sea water. However, sodium in the water from some of the wells inland like Cow Park A (which is not in use since its construction), Congrieve Park #4 and Goshen #3A was high being 2 to 2.5 meq/l while that in the water from Cumberland Pen Well which is closer to the coast than any of these wells and which has been in operation since 1972 was less than 2 meq/l. The source for high sodium in the water from some of the wells need to be identified.
- (h) Assuming that the high sodium in groundwater towards the coast where it exceed magnesium is due to the contamination with sea water, the following stages of contamination have tentatively been identified:
  - i) Sodium first exceeded magnesium and then both magnesium and calcium. In the former case the water remained mostly as calcium bicarbonate type and when it changed to calcium magnesium bicarbonate type sodium formed upto 35 percent of the total of cations. In the latter case sodium formed upto 45 percent of the total of cations. Water from some of the pumping wells close to the coast was of this type.
  - ii) In the next stage sodium further increased and formed more than 50 percent of the total of cations resulting in the formation of sodium bicarbonate type of water. Initially bicarbonate was dominant (6 to 8 meq/l) followed by sodium. The other constituents were distinctly less than bicarbonate and sodium. Water from Cumberland Pen deep and shallow piezometers was of this type. The trend of sodium to exceed bicarbonate points to an increasing trend in contamination.

Finally sodium with concentrations of 10-12 meq/l exceeded bicarbonate (6 to 8 meq/l) with concomitant increase in chloride. Chloride with concentrations 3 to 4 meq/l (much more than that in the initial period) exceeded the remaining ions. Water from Naggo Head observation well was of this type.

- iii) In the final stage the sodium bicarbonate type water changed to the sodium chloride type. In the initial periods of this stage sodium with concentrations of 19 to 25 meq/l exceeded all other ions followed by chloride with concentrations of 10 to 16 meq/l. Chloride distinctly exceeded bicarbonate the concentration of which remained more or less the same as in the previous stage (6 to 9 meq/l). Water from Reidspen Observation Well was of this type.

Finally chloride with concentrations of 25-32 meq/l exceeded sodium with concentrations of 17 to 21 meq/l (less than those in the previous period). Concentrations of other ions were calcium - 9 to 11 meq/l, magnesium - 5 to 7 meq/l (both distinctly more than those in the previous period) and bicarbonate plus carbonate - 3 to 5 meq/l (distinctly less than those in the previous period). Water from Waterford Observation Well was of this type.

- (i) Any increase in the contamination of groundwater with sea water can possibly be identified using the following guidelines:
- i) increasing trend in sodium which may exceed magnesium and ultimately calcium in the waters from pumping wells. Where this situation already exists (like Guinep Pen Well), sodium may exceed carbonate plus bicarbonate.
  - ii) increasing trend in sodium which may ultimately exceed bicarbonate (plus carbonate) and increasing trend in chloride which may exceed magnesium and ultimately calcium in the water of Cumberland Pen piezometers.
  - iii) increasing trend in sodium and increasing trend in chloride which may ultimately exceed bicarbonate (plus carbonate) in Naggo Head observation well water.

- iv) increasing trend in chloride which may ultimately exceed sodium and increasing trend in calcium and magnesium which may ultimately exceed bicarbonate (plus carbonate) in Reidspen observation well water.
- v) increasing trend in chloride calcium magnesium and possibly sodium in Waterford observation well water.

## 5. RECOMMENDATIONS

- (a) Monitoring quality of water from the pumping wells and the observation wells may be continued. Water samples may be collected from all the pumping wells and three observation wells viz: Naggo Head, Cumberland Pen Piezometers and Reidspen for complete analysis during the months of March, June, September and December.
- (b) Monthly water samples may be collected for partial chemical analyses from all the 4 observation wells and 13 pumping wells as indicated below:

### Observation Wells

- |   |  |
|---|--|
| i) Waterford  | calcium, magnesium,<br>sodium and chloride                   |
| ii) Cumberland Pen<br>Piezometers<br>(shallow and deep) | sodium, carbonate,<br>bicarbonate and chloride               |
| iii) Naggo Head   | sodium, carbonate,<br>bicarbonate and chloride               |
| iv) Reidspen  | calcium, sodium,<br>carbonate, bicarbonate<br>and chloride   |
| v) Newlands #2  | sodium, magnesium,<br>carbonate, bicarbonate<br>and chloride |

### Pumping Wells

- i) Cumberland Pen
- ii) Cow Park-A
- iii) Cedar Grove #2



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St. Catherine Plains

Table-1

Chemical Analyses of Water Samples

Location: Half Way Tree #2

Area: Bernard Lodge East Project "A"

SL. NO.	DATE	pH	① Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR
												HCO3	CO3	Total		
1	1963	6.7	-	358	83.6	19.4	19.2	0.6	-	16.5	5.7			355	358	0.49
2	3.3 70	7.2	595	182	82.4	12.7	15.0	1.2	-	9.0	19.0	104	60	164	182	0.30
3	28.5 73	7.3	685	379	76.0	35.8	16.0	1.7	-	20.0	6.5			298	379	0.38
4	24.1 74	7.1	550	410	99.0	22.0	21.0	3.0	-	19.0	22.0			189	410	0.50
5	14.1 75	7.3	660	440	100.0	22.0	16.0	1.5	-	16.0	9.0			350	340	0.38
6	12.11 75	7.4	1330	650	26.0	30.0	-	-	-	304.0	0.0			176	188	-
7	28.11 78	-	-	-	90.2	21.8	23.0	1.1	-	-	9.0			301	315	-

①  $\mu$ /mhos/cm at 25°C

\* as CaCO3

(From records of Underground Water Authority)

22



St. Catherine Plains

Table-2

Chemical Analyses of Water Samples

Location: Half-Way-Tree #4

Area: Bernard Lodge

SL. NO.	DATE	pH	@ Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total* Hardness	SAR	
												HCO3	CO3	Total			
1	1963	7.3	-	368	84.0	23.5	17.8	1.5	-	16.0	11.5		0	372	-	0.44	-
2	3.3 70	7.1	660	344	75.2	34.8	15.0	0.6	-	8.0	41.0			242	330	0.35	-
3	5.2 72	7.1	601	384	86.4	21.5	20.0	0.7	-	17.0	7.6			356	304	0.50	-
4	19.5 72	7.05	651	432	86.4	30.0	15.5	0.85	-	15.0	4.1	300	24	324	338	0.36	-
5	28.5 73	7.6	685	402	70.4	49.0	20.0	1.2	-	22.0	9.8			312	376	0.44	-
6	24.1 74	7.1	615	420	98.0	40.0	22.0	0.0	-	17.0	18.0			198	420	0.47	-
7	1974	-	-	-	103.0	29.0	21.0	0.7	-	16.0	-			376	376	0.47	-
8	1974	-	-	-	101.0	27.4	20.0	0.7	-	12.6	9.3			361	364	0.45	-
9	1974	-	-	-	76.2	32.8	15.5	0.7	-	23.0	5.2			336	324	0.35	-
10	21.9	-	-	-	97.0	29.0	19.0	0.8	-	40.0	11.1			360	360	0.43	-
11	22.10 74	-	-	509	104.2	29.4	20.5	1.8	-	13.8	14.0			380	380	0.45	-
12	14.11 74	-	-	396	102.6	26.4	19.0	0.8	-	6.0	11.3			378	364	0.43	-
13	13.2 75	-	-	443	89.6	29.4	19.0	0.8	-	11.2	7.0			354	366	0.44	-
14	5.3 75	7.3	680	430	100.0	24.0	21.0	-	-	15.0	11.0			350	347	0.29	-

@ μ/mhos/cm at 25°C

\* as CaCO3

41

St. Catherine Plains

Table-2 (Contd.)

Chemical Analyses of Water Samples

Location: Half-Way-Tree # 4 Contd.

Area: Bernard Lodge

SL. NO.	DATE	pH	Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR	
												HCO3	CO3	Total			
15	12.11 75	-	-	-	98.6	24.8	20.5	0.8	-	14.0	9.5			345	348	0.47	-
16	16.6 76	7.5	840	470	102.0	27.0	14.0	-	-	24.0	7.0			350	365	0.31	-
17	4.7 78	8.1	-	-	95.2	-	25.0	-	-	18.4	-			-	-	-	-
18	28.11 78	8.0	-	-	94.2	23.0	23.0	1.1	-	17.0	13.0			304	330	-	-
19	24.1 80	-	-	-	-	-	20.0	-	-	15.4	-			-	-	-	-
20	25.4 80	-	-	-	-	-	26.5	-	-	33.6	-			-	-	-	-
21	25.5 80	-	-	-	-	-	21.5	-	-	16.2	-			-	-	-	-
22	24.7 80	-	-	-	68.1	14.6	-	-	-	16.8	-			208	230	-	-
23	5.2 82	7.5	-	-	76.2	-	16.0	-	-	15.4	-			340	-	-	-
24	11.6 82	7.2	-	-	89.9	-	15.0	-	-	10.1	-			-	-	-	-
25	14.10 82	7.7	-	-	44.3	-	12.0	-	-	27.2	-			-	-	-	-

@ μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-3

Chemical Analyses of Water Samples

Location: Half-Way-Tree #5

Area: Bernard Lodge - Project A

SL. NO.	DATE	pH	① Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	B	SAR
												HCO3	CO3	Total			
1	1963	8.4	-	330	78.8	21.1	24.0	0.5	-	15.5	6.7	369	-	369			
2	30 <u>8</u> 82	7.6	-	-	-	-	16.0	-	-	18.5	-	141.4	-	141.4			

① μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-4

Chemical Analyses of Water Samples

Location: Half-Way-Tree #6

Area: Bernard Lodge

SL. NO.	DATE	pH	e Speci- fic Conduc- tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR	
												HCO3	CO3	Total			
1	28.5 73	7.5	745	341	88.0	43.1	29.0	1.6	-	17.0	15.3			328	396	.63	-
2	2.11 75	-	-	-	85.0	16.5	36.5	1.2	-	13.0	15.0			310	280	0.94	-
3	30.8 82	7.9	-	-	-	-	25.0	-	-	39.1	-			278	-	-	-

e μ/mhos/cm at 25°C

\* as CaCO3

76

St. Catherine Plains

Table-5

Chemical Analyses of Water Samples

Location: Cookson #3

Area: Bernard Lodge

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR	
												HCO3	CO3	Total			
1	1963	7.6	-	359	85.2	16.1	18.0	1.5	-	18.5	9.6		-	333	-	0.27	-
2	28.5 73	7.4	620	360	88.0	34.3	31.0	1.7	-	22.0	11.7		-	278	360	0.71	-
3	24.1 74	7.2	560	445	80.0	36.0	30.0	1.00	-	19.0	40.0		-	174	346	0.70	-
4	3.3 70	7.0	284	302	77.6	22.1	24.0	0.2	-	9.0	19.0		-	154	284	0.61	-
5	5.2 72	7.1	607	364	89.6	23.6	30.0	1.1	-	17.0	16.0		-	388	320	0.73	-
6	24.1 73	7.2	552	406	95.2	38.2	29.0	1.26	-	14.0	11.6		-	294	394	0.70	-

e μ/mhos/cm at 25°C

\* as CaCO3

51

St. Catherine Plains

Table-6

Chemical Analyses of Water Samples

Location: North Syndicate

Area: Caymanas

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR
												HCO3	CO3	Total		
1	1963	8.0	-	362	76.4	24.7	21.6	0.5	-	16.8	19.2		-	355	-	0.55
2	18.5 72	7.0	409	407	96.0	16.4	14.0	0.65	-	18.0	15.0		-	358	308	0.34
3	6.10 72	7.33	515	334	88.8	21.6	13.8	0.59	-	17.0	3.0		-	332	310	0.33
4	14.1 75	7.4	730	420	89.4	18.0	13.0	0.57	-	18.0	5.0		-	296	296	0.33

e μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-7

Chemical Analyses of Water Samples

Location: South Syndicate

Area: Caymanas

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR
												HCO3	CO3	Total		
1	1963	8.1	-	341	84.4	18.0	13.0	0.5	-	16.0	5.8			342	-	0.34
2	26.10 70	7.0	830	355	90.4	20.1	13.0	0.9	-	10.0	55.0	164	80	244	308	0.31
3	3.2 72	7.1	651	351	80.0	17.1	18.0	1.85	-	16.0	13.2			424	270	0.47
4	6.10 72	7.3	682	457	89.6	34.8	17.8	-	-	16.0	6.1			400	366	0.40
5	14.1 75	7.3	690	420	81.0	34.0	19.0	1.0	-	18.0	12.0			346	346	0.45

e μ/mhos/cm at 25°C

\* as CaCO3

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St. Catherine Plains

Table-8

Chemical Analysis of Water Samples

Location: Cedar Grove #2

Area: Caymanas

SL. NO.	DATE	pH	Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR
												HCO3	CO3	Total		
1	29.5 73	7.7	685	376	98.4	21.1	23.0	3.3	-	25.0	30.0			294	332	0.55
2	25.1 74	7.4	625	395	60.0	43.0	48.0	2.0	-	25.0	39.0			187	326	1.16

① μ/mhos/cm at 25°C

\* as CaCO3



St. Catherine Plains

Table-9

Chemical Analyses of Water Samples

Location: WATSON GROVE # 2

Area: CAYMANAS

SL. NO.	DATE	pH	Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total Hardness	B	SAR
												HCO3	CO3	Total			
1	2/2/72	7.1	651	433	88.0	25.4	16.0	1.2	-	32.0	11.2	-	-	388	-	0.39	
2	18 5/72	7.2	527	359	106.4	22.0	19.0	1.0	-	18.0	6.2	-	-	364	-	0.43	
3	29 9/72	7.35	620	410	97.6	22.5	15.5	-	-	17.0	9.0	-	-	350	-	0.36	
4	24 1/73	7.1	620	427	114.4	27.0	22.6	1.2	-	18.0	10.0	-	-	302	-	0.46	
5	29 5/73	7.6	687	404	106.4	22.5	14.0	1.9	-	22.0	20.5	-	-	272	-	0.32	
6	25 1/74	7.2	545	360	74.0	25.0	20.0	1.0	-	25.0	47.0	-	-	171	-	0.51	
7	13 1/75	7.3	660	400	96.0	24.0	20.0	1.4	-	22.0	19.0	-	-	310	-	0.47	
8	11 11/75	-	-	-	104.2	16.5	23.0	1.2	-	20.0	16.4	-	-	306	-	0.55	
9	7 6/76	7.7	700	400	112	20.0	19.0	-	-	36.8	13.0	-	-	331	-	0.43	
10	27 7/78	8.0	-	-	-	-	26.0	-	-	27.7	-	-	-	-	-	-	
11	21 1/80	-	-	-	-	-	25.0	-	-	26.9	-	-	-	-	-	-	
12	21 7/80	-	-	-	80.1	-	-	-	-	24.8	-	-	-	282	-	-	

@ μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table 9 (Contd.)

Chemical Analyses of Water Samples

Location: Watson Grove #2

Area: Caymanas

SL. NO.	DATE	pH	e Speci- fic Conduc- tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total Hardness
												HCO3	CO3	Total	
13	5 2 82	7.45	-	-	44.1	-	12	-	-	11.5	-	-	-	336	-
14	2 3 82	8.70	-	-	-	-	25	-	-	27.0	-	-	-	195.7	-
15	4 9 82	-	-	-	-	-	17	-	-	22.7	-	-	-	307.3	-
16	4 10 82	8.40	-	-	44.1	-	15	-	-	54.5	-	-	-	357.8	-

e μ/mhos/cm at 25°C

\* as CaCO3.

(From records of Underground Water Authority)

St. Catherine Plains

Table-10

Chemical Analyses of Water Samples

Location: Limetree #1

Area: Bernard Lodge - Project E

SL. NO.	DATE	pH	e Speci- fic Conduc- tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total *	B	SAR
												HCO3	CO3	Total			
1	1963	7.3	-	381	87.2	16.6	25.6	0.65		20.5	10.6	364		364	-		0.66
2	4.2.72	7.2	651	396	88.0	25.4	28.0	0.9		24.0	11.2	396		396	324		0.68
3	18.5.72	7.55	508	378	100.8	16.1	21.4	0.9		19.0	9.0	320		320	318		0.52
4	1.6.73	7.4	620	364	84.0	17.6	11.0	0.9		23.0	7.0	276		276	282		0.19
5	23.1.74	7.2	560	415	92.0	16.0	27.0	1.0		20.0	22.0	169		169	300		0.68
6	8.74	-	-		89.77	17.64	25.5	1.0		23.0	5.0	287		287	296		0.64
7	5.7.78	7.9			101.2		52			59	-						

e μ/mhos/cm at 25°C

\* as CaCO3

2/2

St. Catherine Plains

Table-11

Chemical Analyses of Water Samples

Location: Government Park

Area: Bernard Lodge - Project E

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total* Hardness	SAR	
												HCO3	CO3	Total			
1	1963	7.4	-	377	82.0	25.7	23.2	0.6	-	20.0	13.4	-	-	389	-	-	0.57
2	3/3/70	7.2	775	414	76.0	0.9	47.0	1.8	-	15.0	41.0	220.0	60.0	280.0	316	-	1.46
3	4/2/72	7.1	620	390	80.0	20.5	36.0	1.25	-	23.0	11.2	336.0	-	336.0	284	-	0.93
4	1/6/73	8.0	685	347	52.8	36.3	33.0	0.8	-	37.0	12.5	290.0	24.0	314.0	280	-	0.60
5	24/1/74	7.1	620	420	92.0	31.0	33.0	1.0	-	27.0	59.0	-	-	207.0	366	-	0.76
6	14/1/75	7.2	720	470	93.0	27.0	30.0	1.6	-	28.0	9.0	-	-	358.0	348	-	0.70

e μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-12

Chemical Analysis of Water Samples

Location: Clifton

Area: Bernard Lodge - Project 'E'

SL. NO.	DATE	pH	Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR	
												HCO3	CO3	Total			
1	29/5/73	7.7	685	321	85.6	33.8	13.0	1.9	-	23.0	25.0	-	-	280	352	-	0.30
2	12/11/75	-	-	-	107.4	28.2	41.5	2.1	-	24.8	18.5	-	-	401	384	-	0.92

@ μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-13

Chemical Analyses of Water Samples

Location: Goshen #2

Area: Bernard Lodge - Project E

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total* Hardness	B	SAR
												HCO3	CO3	Total			
1	1963	7.4	-	451	75.2	30.9	45.6	0.55	-	26.0	22.1			355	-		1.12
2	3.3.70	7.2	625	450	84.0	30.9	36.0	3.8	-	15.0	63.0			330	336		0.84
3	5.2.72	7.5	744	479	94.4	24.0	40.0	3.7	-	29.0	22.8	364	72	436	334		0.95
4	28.5.73	7.5	810	437	100.8	28.4	59.0	4.8	-	30.0	16.2			318	368		1.34
5	24.1.74	7.4	625	435	87.0	37.0	49.0	8.0	-	33.0	88.0			209	376		1.11
6	8/74	-	-	420	92.18	37.72	43.0	3.7	-	29.0	43.0			387	384		0.95
7	12/11/75	-	-	-	101.0	32.0	54.0	7.6	-	30.0	28.0			408	376		1.20

e μ/mhos/cm at 25°C

\* as CaCO3

9/6

St. Catherine Plains

Table-14

Chemical Analysis of Water Samples

Location: Congrieve Park

Area: Bernard Lodge - Project 'E'

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total Hardness	B	SAR
												HCO3	CO3	Total			
1	19/5 72	7.6	620	467	84.8	7.2	41.0	0.8	-	24.0	16.0	336	44	380	334	-	0.97
2	30/8 82	8.3	-	-	-	-	36.0	-	-	28.8	-	-	-	380.4	-	-	-

e μ/mhos/cm at 25°C

\* as CaCO3

31

St. Catherine Plains

Table-15

Chemical Analysis of Water Samples

Location: Great Salt Pond #1 (Salt Pond #7)

Area: Bernard Lodge - Project 'E'

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total* Hardness	B	SAR
												HCO3	CO3	Total			
1	1963	7.7	-	439	55.6	17.0	76.0	1.0	-	36.0	14.4	-	-	380	-	-	2.3
2	4/3/70	7.2	560	303	68.8	16.7	29.0	3.9	-	16.0	18.0	-	-	140	240	-	0.81
3	25/5/72	7.15	744	365	64.8	16.6	-	-	-	33.0	8.5	266	60	326	230	-	-
4	4/10/72	7.5	620	435	63.2	18.6	55.0	-	-	34.0	2.7	-	-	338	234	-	1.56

e μ/mhos/cm at 25°C

\* as CaCO3

2/5



St. Catherine Plains

Table-16

Chemical Analyses of Water Samples

Location: Reids Pen #1

Area: Bernard Lodge - Project 'E'

SL. NO.	DATE	pH	e Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total* Hardness	B	SAR
												HCO3	CO3	Total			
1	19/5 72	7.05	744	253	70.4	21.0	-	-	-	-	11.0	290	56	346	262	-	-
2	28/5 73	7.4	810	458	84.0	16.2	19.0	0.9	-	-	14.4	-	-	276	276	-	0.50
3	8/74	-	-	-	86.57	15.68	75.0	1.2	-	-	19.0	-	-	318	280	-	1.95
4	17/1 75	7.4	800	490	79.0	17.0	71.0	1.9	-	-	21.0	-	-	316	266	-	1.89
5	24/4 80	-	-	-	-	-	78.0	-	-	31.8	-	-	-	-	-	-	-
6	20/1 81	7.5	-	-	-	-	110.0	12	-	72.5	-	-	-	332	-	-	-

e μ/mhos/cm at 25°C

\* as CaCO3

St. Catherine Plains

Table-17

Chemical Analyses of Water Samples

Location: Reids Pen #2

Area: Bernard Lodge - Project 'E'

SL. NO.	DATE	pH	e Speci- fic Conduc- tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	SAR
												HCO3	CO3	Total		
1	29/9 72	7.55	651	420	68.0	22.1	57.0	-	-	37.0	1.2	-	387	260	1.53	
2	28/5 73	7.4	745	444	74.4	27.4	54.0	1.4	-	40.0	10.2	-	298	298	1.36	
3	23/1 74	7.3	620	485	88.0	7.0	68.0	2.0	-	27.0	44.0	-	182	252	1.88	
4	8/74	-	-	430	80.96	18.12	65.0	0.9	-	35.0	16.0	-	356	276	1.70	
5	7/6/76	7.7	850	..	98.89	16.00	69.0	-	-	25.0	14.0	-	377	287	1.77	
6	22/1 80	-	-	-	-	-	75	-	-	33.6	-	-	-	287	-	
7	8/7/81	8.1	-	-	24.0	-	40	-	-	38.2	-	-	294	-	-	
8	14/10 81	-	-	-	-	-	150	-	-	25.4	-	-	-	-	-	
9	24/9 82	-	-	-	-	-	40	-	-	25.5	-	-	369	-	-	

e μ/mhos/cm at 25°C

\* as CaCO3

## Chemical Analyses of Water Samples

Location: CUMBERLAND PEN

Area: CAYMANAS

SL. NO.	DATE	pH	① Specific Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO4	*Alkalinity			Total * Hardness	B:	SAR
												HCO3	CO3	Total			
1	18 $\frac{5}{72}$	7.6	527	421	88.0	24.5	21.0	0.30	-	19.0	8.5	257.0	26.5	283.5	320.0	-	
2	17 $\frac{1}{75}$	7.6	740	420	90.0	24.0	24.0	0.90	-	20.0	24.0	320.0	-	320.0	326.0	-	
3	11 $\frac{11}{75}$	-	-	-	94.6	28.2	26.50	0.06	-	16.1	18.8	330.0	-	330.0	352.0	-	
4	7 $\frac{6}{76}$	7.8	660	400.0	85.0	21.0	27.0	-	-	20.0	14.8	317.0	-	317.0	299.0	-	
5	24 $\frac{7}{80}$	-	-	-	60.1	19.4	-	-	-	17.0	-	-	-	-	-	-	

①  $\mu$ /mhos/cm at 25°C\* as CaCO<sub>3</sub>

St. Catherine Plains

Table-19

Chemical Analyses of Water Samples

Location: Half Way Tree #2

Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.12.85	8.7	645	377	76.2	19.84	26.0	1.0	-	17.12	-	-	-	-	-	212.6	62.53	275.13	273	0.7/1.6
2	3.12.85	8.7	626	373	74.2	21.0	26.0	1.0	-	16.64	-	-	-	-	-	187.6	100.06	287.66	273	0.7 /1.7
3	28.2.86	8.24	534	362.5	76.95	14.40	26.0	1.15	-	17.23	2.94	-	-	-	-	268.69	0	268.69	252	0.7/1.7
4	14.5.86	8.22	520	320	79.16	15.24	27.5	1.2	0.40	17.74	13.73	-	-	-	-	271.46	0	271.46	261	0.7/1.7
		(7.16)	(560)	- on the spot measurements																
5	16.7.86	8.07	418	351.4	77.35	15.84	27.5	1.3	-	19.00	9.81	-	-	-	-	271.46	0	271.46	259	0.7/1.7
6	9.2.87	7.88	570	354.0	78.56	15.60	25.23	1.0	0.18	19.99	2.94	0.13	0.02	0.0	293.49	259.0	13.85	272.9	261.00	0.7/1.6
7	5.3.87	7.04	537	-	-	-	-	-	-	19.30	-	-	-	-	-	-	-	-	-	-
8	12.8.87	7.4	564	277.4	57.7	15.1	24.0	0.9	0.14	20.3	0	0.57	-	-	-	233.0	39.0	272.0	207.0	0.7/1.6
9	7.10.87	7.6	558	275.2	81.0	16.1	18.0	0.85	-	17.4	24.5	-	-	-	-	225.1	38.3	263.4	268.5	0.5/1.1
10	5.11.87	7.8	560	346.4	79.4	14.9	26.0	1.1	-	14.0	28.4	-	-	-	-	234.7	38.3	273.0	259.6	0.07/0.2
11	27.11.87	7.9	550	317.0	80.9	22.1	24.5	0.9	0.05	23.9	35.3	0.07	-	-	-	211.0	48.8	259.8	294.0	0.6/1.5
12	8.2.88	7.9	515	316.6	78.2	16.3	28.3	1.0	0.03	19.9	19.6	0.02	-	-	-	274.1	0.0	274.1	263	0.7/1.8
13	8.3.88	7.6	515	-	-	-	29.0	-	-	19.3	-	-	-	-	-	199.9	9.8	209.7	-	-

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analyses by Jamaica Bauxite Institute, Kingston)

4/11

St. Catherine Plains

Table-20

Chemical Analyses of Water Samples

Location: HALF WAY TREE NO. 4

Area: BERNARD LODGE PROJECT A'

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	8 10 85	8.1	595	366.6	71.2	24	21	0.7	-	17.37	-	-	-	-	-	295.7	0	295.7	278	0.5/1.5
2	15 10 85	8.3	610	392.1	67.6	20.4	42	0.7	-	17.37	-	-	-	-	-	322.6	0	322.6	254	1.1/2.8
3	28 2 86	8.3	567	354	76.55	21.12	22.5	0.6	-	23.23	11.77	-	-	-	-	282.54	0	282.54	279	0.6/1.4
4	9 2 87	7.95	605	371.9	79.76	22.08	20.5	0.6	0.20	21.99	10.79	0.26	0.17	14.37	714.3	267.3	11.08	278.4	291.0	0.5/1.2
5	5 3 87	7.06	575	-	-	-	-	-	-	20.78	-	-	-	-	-	-	-	-	-	-
6	12.8.87	7.3	601	315.0	76.2	22.1	20.0	0.6	-	23.7	23.5	0.21	-	-	-	215.9	34.1	250.0	282.0	0.5/1.2
7	3.9.87	8.2	560	419.0	70.50	20.4	17.0	0.38	-	22.4	0	-	-	-	-	222.1	14.4	236.5	259.9	0.5 /1.1
8	15.1.88	7.9	575	457.6	73.8	21.4	23.0	0.5	-	24.8	14.6	-	-	-	-	211.0	43.9	254.9	272.2	0.6 /1.4
9	8.3.88	7.6	557	-	-	-	25.5	-	-	26.7	-	-	-	-	-	198.7	16.8	215.5	-	-

µmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

17

St. Catherine Plains

Table-21

Chemical Analyses of Water Samples

Location: Half Way Tree #5

Area: Bernard Lodge East - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAMDJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	6.9.85	7.60	640	338.2	83.60	18.24	21.50	0.80		20.36						284.94	0	284.94	285	0.5/1.3
2	7.9.85	8.3	630	331	83.60	18.00	21.50	0.80		19.86						284.94	0	284.94	284	0.5/1.3
3	8.9.85	7.65	630	328	82.40	19.20	22.00	0.80		19.36						284.94	0	284.94	282	0.5/1.4
4	9.9.85	7.67	640	366	82.40	18.24	22.00	0.80		19.36						284.94	0	284.94	285	0.5/1.4
5	28.2.86	8.00	506	341.3	63.73	18.72	24.0	0.80		13.69	13.73					261.76	13.68	275.44	237	0.7/1.6
6	16.7.86	7.90	460	357.7	50.10	18.00	23.5	0.80		20.49	Nil					277.0		277.0	200.0	0.7/1.6
7	6.11.86	8.10	570	351.1	79.76	18.84	23	0.80	0.32	19.99	25.98					277.75		277.75	277.5	0.6/1.4
8	9.2.87	8.02	563	353	77.76	18.00	20.5	0.70	0.12	19.99	8.82	0.12	0.02	0.0	204.89	250.7	19.39	270.1	269.0	0.5/1.3
9	6.3.87	7.21	540							19.30										
10	27.11.87	7.3	558	-	-	-	-	-	-	20.3	-	-	-	-	-	-	-	-	-	-
11	8.2.88	7.8	580	-	-	-	-	-	-	23.3	-	-	-	-	-	271.1	-	271.1	-	-

@/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

100

St. Catherine Plains

Table-22

Chemical Analyses of Water Samples

Location: HALF WAY TREE #6

Area: BERNARD LODGE EAST - PROJECT 'A'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /AD SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	28 $\frac{2}{86}$	7.93	579	356.9	74.55	13.73	32.5	0.80	-	18.25	9.81	-	-	-	-	289.46	-	289.46	257	0.9/2.1
2	16 $\frac{7}{86}$	7.92	399	411.1	49.50	15.60	34.5	0.90	-	19.0	Nil	-	-	-	-	271.46	13.85	285.31	190.5	1.1/2.5
3	23 $\frac{10}{86}$	8.35	586	354	73.15	6.36	32.0	0.90	0.12	18.74	Nil	0.02	-	-	-	236.83	22.16	258.99	209.0	0.9/1.6
4	6 $\frac{3}{87}$	6.95	542	-	-	-	-	-	-	18.30	-	-	-	-	-	-	-	-	-	-
5	27.11.87	7.4	540	-	-	-	-	-	-	20.5	-	-	-	-	-	-	-	-	-	-

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-23

Chemical Analyses of Water Samples

Location: Cookson #3

Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR /ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	17 7 85	8.0	390	471	83.96	17.76	33.50	1.70	-	21.84	-	-	-	-	-	318.66	0.0	318.66	283	0.9/2.1
2	17 11 85	8.85	745	464	85.2	23.4	44.82	1.2	-	24.56	-	-	-	-	-	300.2	25.01	325.21	311	1.1/2.7
3	16 7 86	8.02	516	411.1	52.1	18.0	34.5	1.4	-	25.49	Nil	-	-	-	-	317.16	0	317.16	205	1.0/2.4
4	9 2 87	8.05	647	418.1	88.98	21.36	32.25	1.2	0.17	24.99	14.71	0.21	0.17	24.37	182.74	306.1	11.08	317.19	311	0.8/2.0
5	6 2 87	7.20	656	-	-	-	-	-	-	24.25	-	-	-	-	-	-	-	-	-	-

@µmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analyses by Jamaica Bauxite Institute, Kingston)



St. Catherine Plains

Table-24

Chemical Analyses of Water Samples

Location COOKSON #4

Area: BERNARD LODGE EAST - PROJECT 'A'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total * Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	29 <sup>10</sup> / <sub>86</sub>	7.80	617	397.85	72.94	27.12	36	0.90	0.0	21.49	23.66	0.23	-	-	-	313.7	0	313.7	295	0.9/2.2
2	9 <sup>2</sup> / <sub>87</sub>	8.08	607	386.0	70.54	18.00	42.0	0.80	0.10	22.99	8.82	0.44	0.02	0.0	132.9	268.7	19.39	288.09	251	1.1/2.7
3	6 <sup>3</sup> / <sub>87</sub>	7.21	578	-	-	-	-	-	-	23.26	-	-	-	-	-	-	-	-	-	-
4	12.8.87	7.4	611	329.0	56.5	18.2	40.0	0.7	0.06	24.2	0	0.21	-	-	-	256.1	24.4	280.5	217.0	1.2/2.7
5	8.2.88	7.8	603	367.2	72.4	18.0	46.0	0.8	0.26	25.4	15.7	0.04	-	-	-	281.6	15.0	296.6	256	1.3 /3.0
6	8.3.88	7.4	591	-	-	-	50.0	-	-	25.2	-	-	-	-	-	216.7	19.2	235.9	-	-

e/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-25

Chemical Analyses of Water Samples

Location: NEWLANDS #2

Area:

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR / ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	27 <u>2</u> 86	8.51	631	434.4	66.93	27.36	61.0	1.20	-	17.4	16.67	-	-	-	-	331.02	13.68	334.86	281	1.58
2	23 <u>2</u> 88	8.2	457	-	-	-	30.0	-	-	18.6	-	-	-	-	-	177.2	0.0	177.2	-	-
3	8.6.88	7.8	533	333.6	60.9	20.6	28.0	4.8	0.85	21.3	2.0	-	-	-	-	222.9	36.1	259.0	236.0	-
4	1.7.88	8.4	510	371.2	52.9	22.6	28.6	4.18	-	18.1	4.9	0.1	-	-	-	179.6	18.8	198.4	255	-
5	21 <u>7</u> 88	7.3	560	-	-	-	28.6	-	-	19.7	-	-	-	-	-	222.9	30.1	253.0	-	-
6	10 <u>8</u> 88	7.7	632	-	-	-	29.5	-	-	21.1	-	-	-	-	-	298.2	39.8	338.0	-	-
7	19 <u>8</u> 88	7.6	582	-	-	-	29.5	-	-	20.8	-	-	-	-	-	328	0.0	328.0	-	-
8	2 <u>9</u> 88	7.95	575	312.8	54.5	22.1	35.5	4.6	5.00	20.8	0.00	-	-	-	-	273.4	31.2	304.6	228	1.02/ 2.4
9	28 <u>9</u> 88	7.2	401	-	-	12.7	28	4.2	-	13.5	-	-	-	-	-	210.9	10.4	221.3	-	-
10	18 <u>10</u> 88	-	413	-	-	15.9	27.15	-	-	12.4	-	-	-	-	-	222.7	0.0	222.7	-	-
11	21 <u>11</u> 88	-	414	-	-	-	13.0	-	-	15.53	-	-	-	-	-	187.5	20.83	208.3	-	-

e/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-26

Chemical Analyses of Water Samples

Location: Newlands #2A

Area: Bernard Lodge - Project A

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR / ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	22.4.87	7.82	665	410.3	77.35	29.52	35	1.35	Trace	21.28	12.76	0.74	0.28		221.50	288.08	30.47	319.55	296.0	0.86/2.0
2	23.4.87	7.45	668	412.4	60.52	24.00	35	1.57	Trace	22.76	0.00	0.25	0.25		276.88	299.92	29.15	329.07	251.0	0.96/2.3
3	24.4.87	7.73	669	408.3	64.93	21.60	36	1.45	0.010	22.76	78.44	0.14	0.25		293.49	265.20	49.99	315.19	252.0	0.99/2.4
4	8.3.88	7.5	650	446.4	79.8	25.0	46.0	1.7	0.02	26.4	14.7	0.07	-	-	-	237.1	14.4	251.5	305	1.2/2.6

e/u/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-27

Chemical Analyses of Water Samples

Location: NEWLANDS #3

Area: BERNARD LODGE - PROJECT 'A'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total * Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	24 <sup>10</sup> / <sub>86</sub>	8.4	582	358	72.74	1.08	40.1	1.1	0.12	17.99	0	0.59	-	-	-	224.36	27.0	251.36	186.0	1.3/2.8
2	9 <sup>2</sup> / <sub>87</sub>	7.93	601	371.8	72.55	15.6	39.0	0.9	0.19	19.99	2.94	0.17	0.02	0.0	132.9	265.9	22.16	288.06	245.0	1.1/2.6
3	6 <sup>3</sup> / <sub>87</sub>	7.37	566	-	-	-	-	-	-	18.31	-	-	-	-	-	-	-	-	-	-
4	12.8.87	7.4	593	288.2	46.9	16.6	37.0	0.9	0.12	19.9	0	1.13	-	-	-	259.8	29.3	289.1	186.0	1.2/2.7
5	27.11.87	7.8	571	335.0	75.3	14.9	38.5	0.8	0.10	18.1	5.9	0.11	-	-	-	231.8	51.2	283.0	250	1.0/2.5
6	8.2.88	7.9	556	347.2	74.9	15.1	41.5	0.9	-	18.5	13.7	0.05	0.05	-	-	293.7	0.0	293.7	250	1.1/2.7
7	8.3.88	7.5	553	-	-	-	44.0	-	-	18.5	-	-	-	-	-	208.3	9.6	217.9	-	-

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-28

Chemical Analysis of Water Samples

Location: North Syndicate #2

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	e Sp. Conduc-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total * Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	20.11.86	8.25	631	418.15	71.34	21.60	17.0	0.65	0.10	19.73	-	-				322.19	0	322.19	268.0	0.4/1.1
2	24.11.86	7.80	630	394.1	94.59	20.88	17.0	0.65	0.06	19.83	13.73	0.07				303.91	0	303.91	323.0	0.4/1.0
3	26.11.86	7.53	652	420.0	94.99	21.60	36.50	0.76	0.27	18.75	14.71					319.41	0	319.41	327.0	0.9/2.2
4	27.11.86	7.63	655	403.10	94.59	22.08	36.50	0.70	0.10	19.24	17.65					318.02	0	318.02	328.0	0.9/2.2

e/u/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-29

Chemical Analyses of Water Samples

Location: South Syndicate-2

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	9.10.86		670	381.30	50.50	21.60	45.00	3.80		26.99	54.91					285.31	24.93	310.24	216.0	1.3/3.0
2	11.10.86		646	376.60	64.93	15.20	35.50	2.80		22.99	50.01					286.01	22.16	308.17	242.00	1.0/2.6

µ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-30

Chemical Analyses of Water Samples

Location: Cow Park-A

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	8.8.86	8.10	662	475.8	82.56	16.80	58.5	1.20	-	21.99	15.69	0.03				314.39	34.62	349.01	275.3	1.5/3.7
2	9.8.86	8.52	654	452.3	82.76	17.04	58.0	1.10	0.14	22.24	17.17	-				318.55	30.46	349.01	276.8	1.5/3.6
3	10.8.86	8.00	660	464.6	82.16	17.28	58.0	1.10	0.15	22.49	16.70	0.10				318.55	27.70	346.25	276.3	1.5/3.6
4	23.3.88	7.7	680	443.5	85.8	18.7	58.0	1.1	-	21.7	31.4	0.12	-	-	-	283.8	0.0	283.8	292	1.5/3.5

e/u/mhos/cm at 25°C    \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-31

Chemical Analyses of Water Samples

Location: NAGGO HEAD

Area: CAYMANAS - PROJECT 'B'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	25.9.86	8.65	661	452.70	68.14	26.40	47.0	3.36	0.03	14.00	2.94	-				277.0	41.55	318.55	261	1.2 /2.93
2	26.9.86	8.60	674	449.95	69.12	22.80	47.0	3.36	0.03	13.50	7.84	-				285.31	30.47	315.78	268	1.2/2.98
3	27.9.86	8.57	683	447.0	70.54	23.04	47.0	3.36	0.04	14.00	16.69	0.14				285.31	27.70	313.01	272	1.2/2.95

e/u/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)



St. Catherine Plains

Table-32

Chemical Analyses of Water Samples

Location: GUINEP PEN

Area: CAYMANAS - PROJECT 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total* (Hardness)	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	4.9.86	8.52	663	431.3	52.71	22.20	74	5.6	0.03	21.99	9.31	10.16				295.70	60.94	349.64	224.0	2.1/5.0
2	6.9.86	8.56	657	449.05	50.90	21.48	72	5.8	0.04	21.99	7.84	-				278.39	36.02	314.41	217.0	2.1/4.81

@µmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

55

St. Catherine Plains

Table-33

Chemical Analyses of Water Samples

Location: Watson Grove #3

Area: Caymanas Area - Project C

SL NO.	DATE	pH	e Sp. Conduc-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total* Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	16.4.86	7.7	670	On the spot measurements with portable pH meter and conductivity meter during development.																
2	30.4.86	8.2	625	398.25	87.37	22.56	31.25	1.30	--	29.91	11.76					271.5	33.24	304.74	312	0.8/1.9
3	2.5.86	7.90	650	394.4	93.38	18.96	31.50	1.30	0.04	28.39	16.67					304.7	--	304.7	312	0.8/1.9
4	3.5.86	8.02	635	398.6	93.14	18.84	31.25	1.30	--	29.20	11.27					306.68	--	306.68	311	0.8/1.9
5	14.5.86	8.08	622	386.0	89.4	20.9	35.0	1.7	--	28.9	15.7					245.1	66.5	311.6	310	0.9/2.1
6	12.12.86	8.12	542	348.0	61.12	18.72	28.0	2.40	0.48	32.57	25.96	0.19				229.14	8.33	237.47	231	0.8/1.7
7	3.6.87	8.2	516	406.4	90.0	17.9	29.0	1.0	0.06	27.7	18.6		0.18		259.2	287.0	11.0	298.0	299	0.7/1.8
8	30.7.87	7.9	506	282.4	36.1	17.3	27.0	1.1	0.02	30.2	0	0.55	0.23	-	182.74	92.7	14.7	107.4	164.0	0.9/1.6
9	9.12.87	7.67	639	401.5	90.2	20.9	30.0	1.2	0.05	26.0	13.7	0.06	0.20	-	-	272.6	19.5	292.1	312	0.7/1.8
10	9.2.88	7.8	630	407.2	93.4	16.6	31.7	1.1	0.28	32.5	19.6	0.08		-	-	298.2	0.0	298.2	302	0.8/1.8
11	2.6.88	8.17	634	442.1	91.2	18.1	28.0	4.2	0.02	31.0	21.6	-	-	-	-	268.1	39.2	307.3	303.0	0.7/1.7
12	1.7.88	8.4	647	464.6	91.0	18.2	27.1	3.62	0.05	25.5	7.8	0.09	0.04	-	-	240.7	-	240.7	302.0	0.7/1.6
13	9.8.88	7.4	644	-	-	-	26.0	-	-	28.6	-	-	-	-	-	318.1	-	318.1	-	-
14	11.10.88	7.38	644.8	410	89.0	18.4	25.3	1.1	0.04	24.0	21.26	-	0.126	0	6.76	289	-	289	298	0.64/1.55
15	23.11.88	-	661	-	-	-	25.0	-	-	32.9	-	-	-	-	-	304.7	5.2	309.9	-	-

e/p/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analyses by Jamaica Bauxite Institute, Kingston)

\* Analysis by National Water Commission, Kingston

50

St. Catherine Plains

Table-34

Chemical Analyses of Water Samples

Location: Riversdale #1

Area: Caymanas Area - Project 'C'

SL NO.	DATE	pH	e Sp. Conduc-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR		
																HCO <sub>3</sub>	CO <sub>3</sub>	Total			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total* Hardness	20	21
1	20.8.86	7.95	717	444	96.59	26.16	25.5	0.70	0.06	47.98	11.77	-	-	-	-	315.78	0	315.78	350	0.6/1.5	
2	21.8.86	8.15	708	444.7	95.59	26.64	25.0	0.70	0.34	49.98	12.26	-	-	-	-	315.77	0	315.77	349.5	0.6/1.4	
3	9.12.87	7.75	771	501.1	102.6	30.2	27.5	0.65	2.20	59.7	0.2	0.12	0.3	-	-	296.4	24.4	320.8	382	0.6/1.5	
4	8.3.88	7.2	750	508	99.8	30.0	30.6	0.6	0.08	63.5	18.6	0.08	0.09	-	-	232.3	28.7	261.0	374	0.7/1.7	
5	21.7.88	7.2	698	392.9	88.2	32.1	23.4	2.7	0.22	43.9	11.8	0.06	0.21	-	-	308.7	15.1	323.8	352	0.54/1.3	
6	9.8.88	7.2	860	-	-	-	33.5	-	-	84.1	-	-	-	-	-	342.9	-	342.9	-	-	
7	5.9.88	7.7	975	613	114.6	30.2	43.5	4.2	1.8	106.1	0.0	-	-	-	-	345.0	15.6	360.6	412	0.9/2.38	
8	4.11.88	-	1020	-	-	-	38.0	-	-	125.1	-	-	-	-	-	354.2	0.0	354.2	-	-	
9*	24.11.88 (10:30 a.m.)	7.4	1056	688.2	121.8	35.0	46.0	-	0.09	126.9	30.40	0.02	1.70	-	9.08	346.4	-	346.4	450.0	0.67/1.8	
10*	24.11.88 (4:00 p.m.)	-	742	-	-	-	25.0	-	-	51.9	-	-	-	-	4.65	-	-	-	-	-	
11*	25.11.88	-	741	-	-	-	25.0	-	-	53.4	-	-	-	-	4.65	-	-	-	-	-	

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

\* NH<sub>3</sub> = 0.00

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-35

Chemical Analyses of Water Samples

Location: Limetree

Area: Bernard Lodge - Project 'E'

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	9.4.87	7.65	838	561.5	107.2	20.2	42.0	1.1	0.01	80.7	26.5	0.52	0.14		564.8	295.8	0	295.8	351.0	1.0/2.4
2	10.4.87	7.62	813	560.2	105.4	19.7	40.0	1.05	0.007	75.7	26.5	0.42	0.14		570.3	297.19	0	297.19	345.0	0.9 /2.3

@/u/nhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-36

Chemical Analyses of Water Samples

Location: Government Park

Area: Bernard Lodge - Project E

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	6.5.87	7.0	1210	730.9	160.3	44.4	40.0	1.5	0.65	53.5	nil	—	0.16		40.0	385.0	8.0	393.0	585	0.72.0
2	7.5.87	7.2	1090	492.4	127.4	37.0	36.0	1.2	0.07	49.5	137.3	—	0.14		36.0	250.0	11.0	261.0	472	0.7/1.8
3	1.7.88	8.0	857	599.2	117.8	32.8	40.2	4.28	0.05	33.2	<0.2	0.14	-	-	-	355.6	-	355.6	429	0.84/2.16

g/l/mhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-37

Chemical Analyses of Water Samples

Location: Clifton

Area: Bernard Lodge - Project 'E'

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	23.7.87	7.7	789	471.6	96.1	23.5	44.0	1.0	0.04	32.2	31.4	0.63	-	-	-	388.5	0	388.5	338	1.0/2.6
2	24.7.87	7.8	779	345.7	95.0	31.4	46.0	0.9	0.12	31.8	27.4	0.55	-	-	-	385.7	0	385.7	334	1.0/2.7

e/u/mhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

60

St. Catherine Plains

Table-38

Chemical Analyses of Water Samples

Location: Congriev Park

Area: Bernard Lodge - Project E

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/L	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	15.4.87	7.66	840	496.6	60.52	30.96	56	0.83	0.010	32.66	12.76	0.23	0.22		77.52	379.06	19.39	398.5	280.0	1.4 /3.4
2	16.4.87	7.74	828	499.6	60.52	29.52	53	0.78	0.010	32.17	4.00	0.45	0.22		77.52	361.01	27.70	388.71	274.0	1.4 /3.4

e/u/mhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

61

St. Catherine Plains

Table-39

Chemical Analyses of Water Samples

Location: SALT POND #7

Area: BERNARD LODGE PROJECT 'E'

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	27- <sup>8</sup> / <sub>87</sub>	8.5	760	500	72.10	16.9	87.2	2.93	0.04	32.5	6.9	0.52	-	-	-	311.3	26.3	337.6	250	2.4 /4.9
2	28- <sup>8</sup> / <sub>87</sub>	8.3	630	466	45.50	17.5	79.2	1.98	0.07	33.7	27.0	0.41	-	-	-	286.2	14.4	300.6	189	2.5 /5.5

Sp. Conductance at 25°C as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

107



St. Catherine Plains

Table-40

Chemical Analyses of Water Samples

Location: Reids Pen #1

Area: Bernard Lodge - Project E

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total* Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	16.7.86	7.80	659	534.2	40.48	27.60	80.5	1.70	-	75.98	33.34	-	-	-	-	335.17	0	335.17	176.0	24/5.5
2	22.4.87	7.79	840	512.1	56.51	17.24	83.0	1.20	Trace	53.45	66.67	0.10	0.27	-	77.52	262.43	36.10	298.53	212.0	2.5/5.5
3	16.9.87	7.7	880	414.7	84.6	19.7	80.2	1.1	0.10	72.5	19.6	0.47	-	-	-	314.9	19.2	334.1	293.0	2.0/5.0
4	11.2.88	7.2	832	507.4	93.4	19.4	84.3	1.3	0.03	71.6	33.3	0.02	-	-	-	265.8	23.9	289.7	314	2.1/5.0
5	1.7.88	8.1	816	597.0	82.6	18.5	81.2	5.77	0.04	68.4	13.7	0.09	-	-	-	268.2	-	268.2	282	-
6	5.8.88	7.4	850	-	-	-	75.0	-	-	50.2	-	-	-	-	-	347.9	0.0	347.9	-	-
7	19 <u>8</u> 88	7.4	840	-	-	-	72.5	-	-	70.25	-	-	-	-	-	357.8	0.0	357.8	-	-
8	30 <u>9</u> 88	7.5	652	374.4	74.5	17.3	73.0	5.5	0.21	36.0	-	0.04	-	-	-	240.9	49.5	290.4	258.0	1.98/4.55
9	21 <u>11</u> 88		776	-	-	-	76.0	-	-	44.5	-	-	-	-	-	328.1	20.83	348.9	-	-

0/u/mhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

103

St. Catherine Plains

Table-41

Chemical Analyses of Water Samples

Location: Goshen-3A

Area: Bernard Lodge - Project 'E'

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR/ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	25.3.87	7.48	893	539.10	94.59	35.76	59	1.6	0.01	38.61	43.14	0.03	0.29	3.75	55.37	397.18	0	397.18	385	1.3/3.4
2	27.3.87	7.38	884	540.50	94.19	35.76	57	1.6	Trace	38.11	48.05	0.02	0.29	2.00	44.30	391.63	0	391.63	384	1.3/3.3
3	31.3.87	7.47	887	540.30	94.79	34.92	56	1.6	0.01	37.12	55.89	0.10	0.29	3.08	44.30	394.41	0	394.41	382	1.3/3.2

µmhos/cm at 25 C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-42

Chemical Analyses of Water Samples

Location: Clifton - B

Area: Bernard Lodge - Project E

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	16.5.87	7.2	802	406.9	88.2	25.9	49.0	0.5	0.04	46.0	2.9		0.25		49.0	179.0	19.0	198.0	328	12/2.6
2	17.5.87	7.2	807	429.2	88.6	28.1	47.0	0.5	0.04	45.0	nil		0.27		47.0	197.0	14.0	211.0	338	1.1/2.5
3	19.5.87	7.1	815	516.2	91.4	26.9	45.0	0.5	0.10	45.0	nil		0.28		45.0	249.0	19.0	268.0	340	1.1/2.5

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>  
 (Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-43

Chemical Analyses of Water Samples

Location: CLIFTON #5

Area: BERNARD LODGE - PROJECT 'E'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR /ADJ SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	26-1/88	7.6	720	447.0	109.4	17.5	37.0	1.0	0.08	31.4	25.5	0.10	-	-	-	331.3	0	331.3	346.0	0.9/2.2
2	27-1/88	7.5	720	432.0	110.6	17.5	36.0	1.0	0.03	30.6	30.4	0.11	-	-	-	338.8	0	338.8	349.0	0.8./2.1
3	29-1/88	7.6	720	438.0	110.2	17.8	36.0	1.0	-	32.5	30.4	0.13	-	-	-	331.3	0	331.3	349.0	0.8./2.1

@µmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

65

St. Catherine Plains

OBSERVATION WELL

Table-44

Chemical Analyses of Water Samples

Location: WATERFORD

OBS WELL

Area:

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	11/87	7.8	4000	2602.2	242.1	89.3	494.5	6.8	0.05	1144.6	174.5	0.29	-	-	-	151.3	34.2	185.5	976	
2(a)	23. <u>2</u> / <u>88</u>	8.0	3390	-	-	-	500.0	-	-	981.9	-	-	-	-	-	162.8	0.0	162.8	-	
(b)		8.0	3600	-	-	-	510.0	-	-	1065.7	-	-	-	-	-	156.8	0.0	156.8	-	
3	24 <u>3</u> / <u>88</u>	7.9	3290	-	-	-	-	-	-	958.2	-	-	-	-	-	-	-	-	-	
4	8 <u>6</u> / <u>88</u>	7.4	3370	2137.8	187.6	62.4	440.0	44.0	0.29	933.6	133.3	-	-	-	-	189.7	21.0	210.7	728.0	
5	5 <u>7</u> / <u>88</u>	7.4	3310	-	-	-	428.5	-	-	911.7	-	-	-	-	-	170.0	-	170.0	-	
6	21 <u>7</u> / <u>88</u>	7.2	3320	-	-	-	411.5	-	-	910.9	-	-	-	-	-	222.9	-	222.9	-	
7	5 <u>8</u> / <u>88</u>	7.5	3250	-	-	-	410.0	-	-	897.6	-	-	-	-	-	218.7	-	218.7	-	

e/μmhos/cm at 25°C    \* as CaCO<sub>3</sub>

(a) 40 ft. depth sample

(b) 60 ft. depth sample

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

OBSERVATION WELL Table 44 (Contd.)

Location: WATERFORD

OBS. WELL

Area:

SL NO.	DATE	pH	Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total * Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
8	19 <u>8</u> 88	7.3	3380	-	-	-	382	-	-	899.3	-	-	-	-	-	223.6	9.9	233.5	-	-
9	2 <u>9</u> 88	7.6	3350	2082.8	178.8	57.6	430.0	35.0	0.21	891.5	105.9	-	-	-	-	169.3	31.2	200.5	686	-
10	28 <u>9</u> 88	7.0	3470	-	-	70.8	455.0	38.0	-	976.5	-	-	-	-	-	184.9	0.0	184.9	-	-
11	18 <u>10</u> 88	-	3620	-	-	65.5	460.0	-	-	955.2	-	-	-	-	-	192.7	29.6	222.3	-	-
12	21 <u>11</u> 88	-	3490	-	-	-	445	-	-	946.9	-	-	-	-	-	199.2	20.8	220.0	-	-

①/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>  
 (Analysis by Jamaica Bauxite Institute, Kingston)

(a) 40 ft. depth sample  
 (b) 60 ft. depth sample

St. Catherine Plains

OBSERVATION WELL

Table-45

Chemical Analyses of Water Samples

Location: CUMBERLAND PEN a) Deep OBS WELL  
b) Shallow

Area:

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 a	11/87	8.3	1220	699.7	52.1	23.0	214.5	7.7	0.43	177.4	45.1	0.23	-	-	-	300.1	56.1	356.2	226	
b		7.8	1150	664.4	49.7	23.5	204.5	1.7	0.97	150.4	80.4	0.17	-	-	-	330.6	64.4	395.0	222	
2 a	23.2.88	8.4	800	-	-	-	162.5	-	-	41.4	-	-	-	-	-	308.9	0.0	308.9	-	-
b		8.5	814	-	-	-	190.0	-	-	39.0	-	-	-	-	-	296.9	19.2	316.1	-	-
3 a	24.3.88	8.3	775	-	-	-	-	-	-	37.8	-	-	-	-	-	-	-	-	-	-
b		8.4	798	-	-	-	-	-	-	38.6	-	-	-	-	-	-	-	-	-	-
4 a	8.6.88	7.7	827	545.4	36.1	13.9	150.0	23.0	0.78	35.5	15.7	-	-	-	-	370.5	30.1	400.6	148.0	-
5 a	5.7.88	7.9	827	-	-	-	138.5	-	-	35	-	-	-	-	-	296.9	14.4	311.3	-	-
b		8.1	829	-	-	-	181.5	-	-	27.6	-	-	-	-	-	295.7	23.9	319.6	-	-
6 a	21.7.88	7.4	805	-	-	-	138.5	-	-	33.9	-	-	-	-	-	384.0	-	384.0	-	-
b		7.7	836	-	-	-	141.2	-	-	30.3	-	-	-	-	-	408.1	6	414.1	-	-
7 a	5.8.88	7.7	825	-	-	-	140.0	-	-	31.2	-	-	-	-	-	397.6	0	397.6	-	-
b		7.9	823	-	-	-	170.0	-	-	28.4	-	-	-	-	-	407.5	0	407.5	-	-

e/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table 45 (Contd.)

Chemical Analyses of Water Samples

Location: CUMBERLAND PEN

a) Deep

b) Shallow

OBS. WELL

Area:

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total* Hardness	SAR/ADJ SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
8 a	19 <u>8</u> 88	7.5	810	-	-	-	167.5	-	-	35.5	-	-	-	-	-	392.6	29.8	422.4	-	-
b		7.8	832	-	-	-	167.5	-	-	31.6	-	-	-	-	-	282.7	39.8	322.5	-	-
9 a	2 <u>9</u> 88	8.1	827	477.2	24.8	14.9	147.5	19.0	0.29	35.9	9.8	-	-	-	-	372.4	41.7	414.1	124	-
b		8.1	736	448.8	19.2	8.2	153	7.0	2.25	27.4	27.4	-	-	-	-	343.7	36.5	380.2	82	-
10 a	28 <u>9</u> 88	7.2	691	-	-	15.4	130.0	11.8	-	30.1	-	-	-	-	-	338.5	26.0	364.5	-	-
b		7.3	748	-	-	3.2	175.0	9.6	-	27.9	-	-	-	-	-	325.5	72.9	398.4	-	-
11 a	18 <u>10</u> 88	-	773	-	-	13.9	137.5	-	-	35.5	-	-	-	-	-	365.9	20.8	386.7	-	-
b		-	858	-	-	7.0	177.5	-	-	35.5	-	-	-	-	-	394.5	0.0	394.5	-	-
12 a	21 <u>11</u> 88	-	724	-	-	-	120.6	-	-	32.2	-	-	-	-	-	321.6	20.8	342.4	-	-
b		-	563	-	-	-	110.0	-	-	23.5	-	-	-	-	-	244.8	26.0	270.8	-	-

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)



St. Catherine Plains

OBSERVATION WELL Table-46

Chemical Analyses of Water Samples

Location: NAGGO HEAD OBS. WELL

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	4.9.87	8.6	1190	761	12.80	8.4	227	6.15	0.07	141.5	53.0	0.69	-	-	-	361.6	23.9	385.5	67	
2	11/87	8.3	1150	668.2	14.4	16.3	254.5	6.3	1.52	121.3	82.4	0.24	-	-	-	317.2	65.8	383.0	104	
3	23 <u>2</u> / <u>88</u>	8.6	1100	-	-	-	278.5	-	-	123.2	-	-	-	-	-	292.1	16.8	308.9	-	
4	24 <u>3</u> / <u>88</u>	8.4	1070	-	-	-	-	-	-	119.5	-	-	-	-	-	-	-	-	-	
5	28 <u>4</u> / <u>88</u>	7.7	1120	-	-	-	-	-	-	122.5	-	-	-	-	-	342.6	33.1	375.7	-	
6	8 <u>6</u> / <u>88</u>	7.9	1100	711.00	24.0	0.0	250.0	33.0	0.57	114.4	41.2	-	-	-	-	355.4	42.2	397.6	60.0	
7	5 <u>7</u> / <u>88</u>	8.2	1120	-	-	-	255	-	-	114.1	-	-	-	-	-	292.1	19.2	311.3	-	
8	21 <u>7</u> / <u>88</u>	7.7	1090	-	-	-	245.0	-	-	115.5	-	-	-	-	-	384.0	-	384.0	-	
9	5 <u>8</u> / <u>88</u>	7.9	1110	-	-	-	245	-	-	105.9	-	-	-	-	-	397.6	-	397.6	-	

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-46 (Contd.)

Chemical Analyses of Water Samples

Location: Naggo Head Obs. Well

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
10	19 <u>8</u> 88	7.9	1130	-	-	-	228.7	-	-	117.0	-	-	-	-	-	417.5	0.0	417.5	-	-
11	29.88	8.2	1100	632.8	11.2	22.1	245	26.5	0.59	110.0	109.8	-	-	-	-	375.0	28.6	403.6	120	-
12	28 <u>9</u> 88	a) 7.6	1030	-	-	4.6	240	26.5	-	108.8	-	-	-	-	-	346.3	41.7	388.0	-	-
		b) 7.5	1090	-	-	7.0	225	27.0	-	119.3	-	-	-	-	-	380.2	26.0	406.2	-	-
13	18 <u>10</u> 88	-	1150	-	-	7.9	256.5	-	-	114.2	-	-	-	-	-	388	29.6	417.6	-	-
14	21 <u>11</u> 88	-	1150	-	-	-	245	-	-	150.6	-	-	-	-	-	385.4	20.83	406.23	-	-

a) from a depth of 10 ft.  
b) from a depth of 80 ft.

e/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

OBSERVATION WELL Table-47

Location: REIDS PEN OBS WELL

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total* Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	31 <u>7</u> 87	8.2	2390	1414.2	-	-	480.0	12.0	-	455.5	114.7	-	-	-	-	246.4	65.9	312.3	-	
2	11/87	8.0	2860	1660.6	59.3	35.5	509.5	13.5	0.22	358.6	225.5	0.15	-	-	-	346.4	68.3	414.7	286	
3	23 <u>2</u> 88	8.3	2670	-	-	-	575.0	-	-	560.0	-	-	-	-	-	344.8	0.0	344.8	-	
4	24 <u>3</u> 88	8.3	3500	-	-	-	-	-	-	524.5	-	-	-	-	-	-	-	-	-	
5	8.6.88	7.8	2350	1431.6	46.5	18.2	440.0	51.0	0.47	438.7	190.1	-	-	-	-	376.5	36.1	412.6	192.5	
6	1.7.88	8.4	2330	1465.0	39.3	22.9	469.0	43.80	-	412.8	136.3	0.28	-	-	-	304.1	18.8	322.9	192.0	
7	21 <u>7</u> 88	7.5	2310	-	-	-	440.0	-	-	418.5	-	-	-	-	-	385.5	30.1	415.6		
8	5.8.88	7.7	2310	-	-	-	450.0	-	-	409.0	-	-	-	-	-	427.4	0	427.4	-	
9	19 <u>8</u> 88	7.6	2300	-	-	-	430	-	-	418.7	-	-	-	-	-	427.4	0	427.4	-	
10	12 <u>9</u> 88	8.0	2250	1333.4	37.7	21.6	430	42.0	0.16	407.2	149.0	-	-	-	-	382.8	36.5	419.3	184	
11	28 <u>9</u> 88	7.5	2860	-	-	26.9	580	46	-	559.5	-	-	-	-	-	453.1	0	453.1	-	

e/p/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-47 (Contd.)

Chemical Analyses of Water Samples

Location: REIDS PEN OBS. WELL

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			Total * Hardness	SAR
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
12	21 <u>11</u> 88	-	2250	-	-	-	400.0	-	-	710.0	-	-	-	-	-	369.8	20.83	390.63	-	-

e/μmhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

## St. Catherine Plains

Table-48

## Chemical Analyses of Water Samples

Location: CUMBERLAND PEN PUMPING WELL

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total		Total* Hardness
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	14 $\frac{5}{86}$	8.05	580	21.29	76.75	23.16	32.5	-	0.19	21.29	21.57	-	-	-	-	292.23	-	292.25	298.0	-
2	3 $\frac{9}{87}$	8.2	510	390	65.3	20.2	30.8	0.63	-	18.7	0.00	-	-	-	-	258.6	16.8	275.4	-	-
3	11 $\frac{11}{87}$	7.6	580	355.6	71.7	16.3	35	0.90	-	15.8	3.9	-	-	-	-	241.9	33.5	275.4	-	-
4	1/88	7.9	560	403.4	79.3	20.6	37	0.80	-	24.3	33.3	-	-	-	-	286.2	-	286.2	-	-
5	5.8.88	7.5	536	-	-	-	33.5	-	-	17.8	-	-	-	-	-	298.2	-	298.2	-	-
6	19 $\frac{8}{88}$	7.5	558	-	-	-	33.5	-	-	20.5	-	-	-	-	-	298.2	9.9	308.1	-	-
7	2.9.88	7.9	560	333.2	60.9	15.4	36.0	3.8	0.3	20.8	0.0	-	-	-	-	261.7	36.5	298.2	216	-

e/μ/mhos/cm at 25°C \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-49

Chemical Analyses of Water Samples

Location: PORTMORE (NWC WELL) NO. 2

SL NO.	DATE	pH	e Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO <sub>4</sub>	B	F	PO <sub>4</sub>	NO <sub>3</sub>	* Alkalinity			SAR	
																HCO <sub>3</sub>	CO <sub>3</sub>	Total Hardness		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	15 <u>9</u> 86	7.95	562	435.9	57.31	4.08	58	3.7	0.06	16.99	109.82	-	-	-	-	349.02	-	349.02	158.5	
2	3.9.87	8.8	680	452.0	41.7	19.2	74.2	6.8	-	45.9	49.0	-	-	-	-	213.1	16.8	229.9	-	
3	14 <u>10</u> 87	7.9	463	238.8	76.6	15.6	8.8	0.6	-	15.8	0	-	-	-	-	184.4	33.5	217.9	-	
4	11 <u>11</u> 87	8.0	450	246.2	70.1	10.8	9.4	0.8	-	14.0	0.2	-	-	-	-	177.2	33.5	210.7	-	
5	21.1.88	8.0	720	563.8	64.5	28.6	62.5	4.4	-	33.5	35.2	-	-	-	0.31	364.5	6.0	370.5	-	
6	5.8.88	7.6	742	-	-	-	62.5	-	-	33.3	-	-	-	-	-	372.7	-	372.7	-	
7	19 <u>8</u> 88	7.4	731	-	-	58.5	58.5	-	-	33.6	-	-	-	-	-	372.6	0.0	372.6	-	
8	2.9.88	7.7	743	450.4	65.7	28.8	66.0	7.2	0.03	33.2	23.5	0.03	-	-	-	359.4	28.6	388.0	-	
9	21 <u>10</u> 88	-	-	-	-	27.8	56.0	-	-	34.7	-	-	-	-	-	330.7	52.08	382.78	-	

e/μmhos/cm at 25°C    \* as CaCO<sub>3</sub>

(Analysis by Jamaica Bauxite Institute, Kingston)

16

ST. CATHERINE PLAINS  
CHEMICAL CHARACTERISTICS OF WELL WATERS

TABLE-50

1

PROJECT 'A'

SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	C1. RANGE OF CONC (meq/l)			DESCRIPTION
					Co3+HCo3	Sodium	Chloride	
1	Half-Way-Tree #2 (Old Well)	1963 Nov.-78	7	A	0.064 0.140	0.65 1.00	0.25 0.56	The water was distinctly of 'A' type. The sodium and chloride contents fluctuated slightly. The very high chloride content of 8.57 meq/l on 12/11/75 is very abnormal for well waters in the area.
2	Half-Way-Tree #2 (New Well)	Dec.-85 March-88	12	A	0.072 0.129	0.78 1.26	0.39 0.67	The sodium and chloride contents fluctuated slightly. There was a slight overall increase in the sodium content over the years, the highest recorded being 1.26 meq/l in March '88 but no such increase is seen in the chloride content. The sodium content did not exceed either the magnesium or the calcium contents at any time. The water was distinctly of 'A' type. The 'B' value did not exceed that recorded on 24/1/74. The pumping water levels were often below sea level.
3	Half-Way-Tree #4	1963 Oct.-82	25	A/B	0.040 0.157	0.52 1.15	0.17 1.13	The water was distinctly of 'A' type except once on 28/5/73 when it was of 'B' type. Both the sodium and chloride contents do not show any progressive increase. The sodium content never exceeded either the magnesium or the calcium contents.
		Oct.-85 March-88	8	A/B	0.074 0.175	0.74 1.10	0.49 0.75	The water was of 'A' type except once on 15/10/85 when it was of 'B' type due to high sodium content of 1.83 meq/l. Polyphosphate used in the well development appears to have caused this high sodium level, as such a high level was not recorded subsequently. The sodium content did not exceed the calcium or magnesium contents and the highest recorded in March '88 was 0.04 meq/l less than the highest recorded on 25/4/80 for the historical data. The chloride content did not exceed the highest recorded on 21/9/74 for the historical data. The pumping water levels were sometimes below the sea level.
4	Half-Way-Tree #5	1963 - Aug.-82	2	A	0.059 0.183	0.70 1.04	0.43 0.52	The high 'B' value in August '82 was due to the low bicarbonate content.
		Sept.-85 Feb.-88	6	A/B	0.071 0.122	0.89 1.04	0.39 0.66	The water was of 'A' type; only once on 16/7/86 it was marginally of 'B' type. The sodium content did not exceed the calcium or magnesium contents. The sodium and chloride contents were within the general range of concentration in waters from HWT #2 and #4. The pumping water levels were usually above sea level but sometimes below it to the extent of about 3 ft.
5	Half-Way-Tree #6	May-73 Aug.-82	3	A/B	0.060 0.198	1.10 1.59	0.37 1.10	The sodium content was more than the magnesium content in Nov. 75.
		Feb.-86 Nov.-87	5	A/B	0.089 0.102	1.39 1.50	0.51 0.58	The sodium content was more than the magnesium content. The chloride content of less than 0.6 meq/l was within the general range of concentration for waters in the area. Both the sodium and chloride contents were less than those recorded in Aug. '82. The pumping water levels were generally above sea level but sometimes below the sea level the maximum being about 8 ft.

A = Calcium Bicarbonate  
B = Calcium-Magnesium Bicarbonate

C = Sodium-Bicarbonate  
D = Sodium Chloride

E = Cl/Co3+HCo3

SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	C1. RANGE OF CONC (meq/l)			DESCRIPTION
					Co3+HCo3	Sodium	Chloride	
6	Cookson #3	1963 Jan-74	6	A/B	0.054 0.150	0.78 1.35	0.25 0.62	The water was of 'A' type except once on 24/1/74 when it was of 'B' type. On the same day the value of 'z' was high due to low bicarbonate content and not due to high chloride content. The sodium content was less than that of calcium and magnesium.
	Cookson #3	July-85 Mar-87	5	A/B	0.097 0.110	1.40 1.95	0.62 0.72	The water was of 'A' type except once on 16/7/86 when it was of 'B' type. The sodium content fluctuated much and sometimes it was slightly more than that of magnesium (7/11/85 and 16/7/86). There was a general overall increase in the sodium content with reference to that in 1963. There was also a general overall increase in the chloride content but it was within the general range of concentration for waters in the area. The pumping water levels were above sea level.
7	Cookson #4	Oct.-86 Mar-88	6	A/B	0.097 0.150	1.57 2.17	0.61 0.72	There was a slight but progressive increase in the sodium and chloride contents. The former was more than the magnesium content from Feby. '87. The chloride content was within the general range of concentration in well waters in the area. The pumping water levels were below sea level sometimes to the extent of 12-14 ft.
8	Newlands #2	Feb.-86 Nov.-88	11	A/B	0.071 0.146	0.56 2.65	0.35 0.60	The sodium content was less than the magnesium content except on 27/2/86, 28/9/88 and 18/10/88. The chloride content was within the general range of concentration in well waters in the area. The sample on 27/2/86 was collected from pumping well. The well is not in use and therefore other samples were collected by a sampler from the depth of 50 feet.
9	Newlands #2A	April 87 March 88	4	B	0.094 0.147	1.52 2.00	0.60 0.74	Three samples were collected in April '87 during pumping test just after the construction of the well and one was collected in March '88, when the well was in use. Between April '87 and March 88, there was a slight increase both in the sodium and chloride contents. However, the sodium content was not more than the magnesium content and chloride content was within the general range of concentration in well waters in the area. The pumping water levels were around 10 ft. below sea level
10	Newlands #3	Oct.-86 Mar. 88	7	A/B	0.092 0.122	1.61 1.91	0.50 0.56	The sodium content shows a slight but steady increase from August '87 and it was more than the magnesium content all through. The chloride content was more or less uniform and well within the general range of concentration in well waters in the area. The pumping water levels were generally below sea level.
PROJECT-B								
11	North Syndicate (Old Well)	1963 - Nov.-75	4	A	0.066 0.086	0.56 0.94	0.47 0.51	The sodium content was low and did not exceed either the calcium or the magnesium contents. The chloride content was also low.
12	North Syndicate #2	Nov.-86	4	A	0.083 0.091	0.74 1.59	0.53 0.56	The chloride content was low. The sodium content increased from 0.74 meq/l to 1.59 meq/l in 2 days but it did not exceed either the calcium or the magnesium contents. The pumping water levels were about 12 ft. below sea level but are likely to be just a few feet below sea level when the well will be put into regular use at the recommended rate of abstraction.



SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	C1. RANGE OF CONC (mcg/l)			DESCRIPTION
					Co3+HCo3	Sodium	Chloride	
13	South Syndicate (Old Well)	1963 - Jan.-75	5	A	0.053 0.085	0.56 0.83	0.28 0.51	The quality of water appears to be like the one from North Syndicate #2 old well.
14	South Syndicate #2	Oct.-86	2	A/B	0.100 0.120	1.54 1.96	0.65 0.76	The sodium content considerably increased and the chloride content slightly increased with respect to those found in the water from South Syndicate (old well) before 1975. The sodium content also exceeded the magnesium content. But both these declined from 9th to 11th October, 1986. The pumping water levels were near about sea level, but are likely to be above the sea level, when the well will be put into regular use at the recommended rate of abstraction.
15	Cow Park-A	Aug.-86 Mar.-88	4	A	0.089 0.107	2.52 2.54	0.61 0.63	Three samples were collected in August '86 and one in March '88. The chloride and sodium contents did not show any appreciable variations between these two periods. The sodium content was higher than that found in the waters of North Syndicate and South Syndicate wells. It was also more than the magnesium content. The chloride content, however, was low and in line with that found in the waters in the area. The pumping water levels were a few feet below sea level but when the well will be put into regular use at the recommended rate of discharge, the pumping water levels are likely to be near about the sea level.
16	Naggo Road	Sep.-86	3	B	0.060 0.062	2.04	0.38 0.39	The sodium content was more than that found in the waters from North Syndicate and South Syndicate wells and it also exceeded the magnesium content in the last two samples. The chloride content was very low. The pumping water levels were around 6 ft. below sea level and are likely to be the same when the well is put into regular use at the recommended rate of discharge.
17	Gulnep Pen	Sep.-86	2	B	0.087 0.098	3.13 3.22	0.62	The chloride content was low but the sodium content was the highest recorded in the area. The latter exceeded both the calcium and magnesium contents which was not the case with any of the well waters in the area. It however showed a declining trend from 4th to 6th September '86. The pumping water levels were about 3 ft. below sea level but they are likely to be just above sea level when the well is put into regular use at the recommended rate of discharge.
18	Cedar Grove #2 (Old Well)	May-73 Jan.-74	2	A/B	0.119 0.187	1.01 2.09	0.70	The chloride content was not high but the sodium content was more than that found in the waters from other wells in the area during the same period. The sodium content did not exceed either the calcium or the magnesium contents.  (Water samples were collected from the new wells during the testing immediately after their construction)
PROJECT-C								
19	Watson Grove #2 (Old Well)	Feb.-72 Oct.-82	16	A	0.047 0.215	0.61 1.09	0.32 1.54	The sodium and chloride contents fluctuated moderately, and the former did not exceed either the calcium or the magnesium contents.

SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	C1. RANGE OF CONC (meq/l)			DESCRIPTION
					Co3+HCo3	Sodium	Chloride	
20	Watson Grove #3	April-86 Nov.-88	13	A/B	0.117 0.400	1.08 1.52	0.65 0.93	There was an overall increase in the sodium content when compared with that found in Watson Grove #2 well water. There also appears to be a slight overall increase in the chloride content but it did not exceed the maximum recorded for Watson Grove #2 well water in October 1982. The calcium and bicarbonate contents were distinctly low in the water on 30th July 1987, due to which the 'E' value was the highest and the water was of 'B' type on that date. The pumping water levels were mostly above sea level.
21	Riversdale #1	Aug-86 Nov-88	11	A	0.191 0.546	1.02 2.00	1.24 3.78	The chloride content was distinctly higher than that found in the water from Watson Grove #3 well. The sodium content did not exceed the magnesium content but the chloride content exceeded the sodium content all through. The chloride content of 2.37 to 3.78 meq/l during Aug. to Nov. 88 is unusually high. However it declined to 1.46 meq/l on 25/11/88. The pumping water levels were mostly above sea level.
PROJECT-B (Old Wells)								
22	Limetree #1	1963 July-78 April-87	7 2	A A	0.080 0.166 0.359 0.386	0.48 1.85 1.74 1.83	0.53 1.66 2.13 2.28	The sodium and chloride contents do not show any appreciable increase upto 1974 but between 1974 and 1978 there was a considerable increase in the concentration of these constituents. The sodium content was not more than that in July 1978, but the chloride content increased from 1.66 meq/l in July 1978 to 2.28 meq/l. The chloride content is considered to be high when compared with that found in the waters from other wells in the area for the same period. It exceeded the sodium content and the latter slightly exceeded the magnesium content.
23	Government Park	1963 Jan-75 May-87 July-88	6 3	A/B A	0.072 0.183 0.161 0.268	1.00 2.04 1.57 1.75	0.42 1.04 0.94 1.51	The sodium and chloride contents show moderate fluctuations but there was no continuous increase from 1963 to 1975. There was an increase in the sodium and chloride contents from 1975 to 1987. The chloride content decreased from 87 to 88 while the sodium content increased. However both the sodium and chloride contents in July 88 were less than the highest recorded before 1975. The high fluctuations observed in the concentrations of anions and cations point to the unstable composition of the well water. The pumping water levels were about 25 ft. above sea level.
24	Clifton	May-73 Nov-75 July-87	2 2	A A	0.087 0.116 0.116 0.117	0.56 1.80 1.91 2.03	0.65 0.70 0.90 0.91	The sodium content shows a high increase from 1973 to 1975 while the chloride content shows a slight increase. The former however did not exceed the magnesium content. Both the sodium and chloride contents show a slight increase from 1975 to 1987. The pumping water levels were about 26 ft. above sea level.
25	Goshen #2	1963 Nov-75	7	A/B	0.064 0.222	1.57 0.93	0.42 0.93	There was an increase in the sodium and chloride contents from 1963 to 1975 and the former exceeded the magnesium content only once. The fluctuations in the sodium content were more than those in the chloride content.
26	Congrieve Park #4	May-72 Aug-82	2	A	0.089 0.106	1.57 1.78	0.68 0.81	The sodium and chloride contents were within the general range of concentration in well waters in the area during this period.

SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	C1. RANGE OF CONC (meq/l)			DESCRIPTION
					Co3+HCo3	Sodium	Chloride	
	Congrieve Park #4	April-87	2	B	0.110 0.117	2.30 2.44	0.91 0.92	Both the sodium and chloride contents show a rise with reference to the concentrations in 1982. Though the rise in sodium content was high being 0.9 meq/l, the concentration of 2.44 meq/l was not more than that found in Goshen #2 well water in 1973. The pumping water levels were about 2 ft. below sea level.
27	Salt Pond #7	1963 Oct-72 Aug-87	4 2	A/B B	0.132 0.160 0.136 0.158	1.26 3.30 3.44 3.79	0.45 1.01 0.92 0.95	The sodium content highly fluctuated and it was more than the calcium and magnesium contents in 1963 and the magnesium content in October 1972. The chloride content was in the general range for well waters in the area for the corresponding period. The sodium content was more than the highest recorded (in 1963) and also more than that found in the well waters in the area for the corresponding period. It exceeded the calcium and magnesium contents. The pumping water levels were about 5 ft. above sea level.
28	Reids Pen #1	May-72 Jan-81 July-86 Nov.-88	6 9	- B	0.307 0.202 0.360	0.83 3.15 3.67	0.89 1.00 2.14	Both the sodium and chloride contents show high fluctuations. The sodium content fluctuated slightly. It exceeded the magnesium content all through and twice exceeded the calcium content. The chloride content fluctuated moderately. Both the sodium and chloride levels were higher than the general range of concentration in well waters in the area during this period. The overall high fluctuations in the concentrations of the ions indicate a somewhat unstable composition of the well waters. The pumping water levels were generally about 5-8 ft. below sea level.
29	Reids Pen #2	Sep-72 Sep-82	9	A/B	0.093 0.210	2.35 3.26	0.70 1.13	Both the sodium and chloride contents show moderate fluctuations. The former exceeded the magnesium content all through. The moderate to high fluctuations in the concentrations of the ions inciated a somewhat unstable compositin of the well water. The sodium content of 6.52 meq/l on 14/10/81 is unusually high for water in the area. (The wells were tested for their yield and water quality in the year 1987 and water samples were collected from the wells at that time)
	New Wells							
30	Goshen #3A	Mar-87	3	B	0.133 0.138	2.44 2.57	1.05 1.09	The sodium content did not exceed the magnesium content and it was not more than the highest recorded for Goshen #2 well (which is about 200 ft. away) for the period 1963 to 1975. The chloride content, however, was slightly more than the highest recorded for Goshen #2 well. The pumping water levels were about 6 ft. above sea level.
31	Clifton-B	May-87	3	A	0.236 0.328	1.96 2.13	1.27 1.30	The sodium content declined from the first to the last day. It was less than the magnesium content in the last two samples. The pumping water levels were about 5 ft. above sea level.
32	Clifton-5	Jan-88	3	A	0.129 0.139	1.57 1.61	0.86 0.92	The sodium content slightly exceeded the magnesium content all through. The pumping water levels were about 7 ft. below sea level but when the well is put into use at the recommended rate of abstraction, they are likely to be about 7 ft. above sea level. (Water samples from the 3 new wells were collected during the pumping tests conducted immediately after the construction of the wells)

SL. NO.	WELL NAME	PERIOD	NO. OF ANALYSES	TYPE OF WATER	RANGE OF CONC (meq/l)			DESCRIPTION
					Ca+Mg+Co3	Sodium	Chloride	
WELLS OUTSIDE THE PROJECT								
A. Observation Wells								
33	Waterford	Nov-87	12	D	5.76	16.62	25.15	This observation well is close to the sea and the water was sodium chloride type. There was no increase either in the sodium or the chloride contents from Nov. 87 to Sept. 88.
		Nov-88			9.57	22.19	32.29	
34	Cumberland Pen (Shallow)	Nov-87	11	C	0.174	8.89	0.66	The water was of sodium bicarbonate type. The sodium and bicarbonate contents fluctuated to the extent of about 4 meq/l. The chloride content decreased from 4.24 meq/l in Nov. 87 to 1.1 meq/l in Feb. 87 and thereafter remained less than that.
		Nov.-88			0.536	4.78	4.24	
	Cumberland Pen (Deep)	Nov-87	12	C	0.110	5.25	0.85	The water was of sodium bicarbonate type. There was a decline in the sodium and chloride contents from Nov. 87 to Feb. 88. Thereafter the chloride content remained more or less steady being around 1 meq/l but the sodium content fluctuated to the extent of about 2 meq/l.
		Nov-88			0.702	9.33	5.00	
It is observed that the sodium and sulphate contents were more in the water from the shallow aquifer than in that from the deep aquifer while the calcium, magnesium and chloride contents were more in the water from the deep aquifer than in that from the shallow aquifer.								
35	Naggo Head	Sept-87	14	C	0.376	9.57	2.99	The water was of sodium bicarbonate type but the sodium and chloride contents were higher than those found in the waters of Cumberland Pen piezometers. The chloride content was more or less steady but the sodium and bicarbonate contents fluctuated to the extent of about 2 meq/l. On 28/9/88 two samples were collected one from the depth of 10 ft. and the other from the depth of 80 ft. It is observed that the sodium content was more in the samples from the upper zone while the magnesium and chloride contents were more in the sample from the lower zone.
		Nov-88			0.563	12.11	4.25	
36	Reidspen	July-87	12	D	1.22	18.70	10.12	The water was of sodium chloride type. The sodium and chloride contents fluctuated to the extent of about 6 meq/l and 10 meq/l respectively. The bicarbonate content fluctuated to the extent of 4 meq/l. There was an increase in the sodium and chloride contents to the extent of 7 and 4 meq/l. respectively, from 2/9/88 to 28/9/88 after heavy rains in mid September '88.
		Nov-88			2.57	25.23	20.03	
WELLS OUTSIDE THE PROJECT AREAS								
37	Cumberland Pen	May-72	12	A	0.080	0.91	0.44	There was a slight but steady increase in the sodium content from 1972 to 1988 to the extent of 0.6 meq/l. It shows a tendency to exceed the magnesium content from Nov. 87. The chloride content fluctuated slightly to the extent of about 0.14 meq/l.
		Sept.-88			0.118	1.61	0.68	
38	Portmore #2 (NWC)	Sept.-86	9	A/B	0.069	0.38	0.39	The type of water varied from calcium bicarbonate to calcium magnesium bicarbonate with high fluctuations in the sodium content. Once on 7/9/87 the sodium content reached 48.1 percent of the cations, far exceeding the calcium content. The chloride content also fluctuated but less than 1 meq/l and from Jan. '88 it remained the same.
		Oct.-88			0.281	3.23	1.29	
The overall high fluctuations in the concentrations of other anions and cations indicate the unstable composition of the well water.								

Table-51

PUMPING WATER LEVELS IN WELLS  
ON THE DATES OF WATER SAMPLING

SL NO.	DATE	PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)
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HALF-WAY-TREE #2

1	28. 2.86	- 24.0
2	14. 5.86	- 14.5
3	16. 7.86	- 20.7
4	9. 2.87	- 19.8
5	12. 8.87	- 2.4
6	27.11.87	- 5.0
7	8. 2.88	- 4.6
8	8. 3.88	- 6.3

HALF-WAY-TREE #4

1	28. 5.73	+ 18.4
2	4/74	+ 23.0
3	8/74	+ 23.6
4	21. 9.74	+ 23.4
5	14.11.74	+ 23.6
6	5. 3.75	+ 16.7
7	12.11.75	+ 16.1
8	16. 6.75	+ 19.7
9	28.11.78	+ 9.5

Table-51

SL NO.	DATE	PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)
<u>HALF-WAY-TREE #4 (CONT'D)</u>		
10	8.10.85	+ 2.9
11	15.10.85	+ 2.9
12	28. 2.86	- 10.0
13	9. 2.87	- 24.9
14	12. 8.87	- 6.3
15	3. 9.87	- 6.2
16	15. 1.88	- 16.4
17	8. 3.88	- 3.5
<u>HALF-WAY-TREE #5</u>		
1	9. 9.85	+ 6.1
2	28. 2.86	- 2.4
3	16. 7.86	- 0.8
4	6.11.86	+ 4.9
5	9. 2.87	- 1.8
6	8. 2.88	+ 3.8
<u>HALF-WAY-TREE #6</u>		
1	28. 2.86	- 3.4
2	16. 7.86	+ 3.2
3	6. 3.87	+ 1.9
4	27.11.87	+ 12.4

Table-51

SL NO.	DATE	PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)
<u>COOKSON #3</u>		
1	16. 7.86	+ 7.3
2	9. 2.87	+ 8.0
<u>COOKSON #4</u>		
1	29.10.86	- 14.0
2	9. 2.87	- 12.1
3	6. 3.87	- 7.0
4	12. 8.87	- 12.5
5	8. 2.88	- 7.1
6	8. 3.88	- 12.1
<u>NEWLANDS #2A</u>		
1	22. 4.87	- 9.8
2	23. 4.87	- 11.1
3	24. 4.87	- 12.3
4	8. 3.88	- 10.0
<u>NEWLANDS #3</u>		
1	24.10.86	- 10.4
2	9. 2.87	- 7.6
3	12. 8.87	- 11.5
4	27.11.87	- 21.7
5	8. 2.88	- 36.5
6	8. 3.88	- 17.0

Table 51

SL NO.	DATE	PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)
<u>NORTH SYNDICATE #2</u>		
1	20.11.86	- 13.0
2	24.11.86	- 11.0
3	26.11.86	- 12.0
4	27.11.86	- 12.0
<u>SOUTH SYNDICATE #2</u>		
1	9.10.86	+ 2.0
2	11.10.86	0.0
<u>NAGGO HEAD</u>		
1	27. 9.86	- 6.0
<u>GUINEP PEN</u>		
1	6. 9.86	- 3.0
<u>COW PARK-A</u>		
1	10. 8.86	- 4.0
2	23. 3.88	- 2.0
<u>WATSON GROVE #3</u>		
1	30. 4.86	- 6.0
2	2. 5.86	- 6.2
3	12.12.86	+ 11.0
4	30. 7.87	+ 4.0
5	9.12.87	+ 14.3
6	9. 2.88	+ 13.9
7	2. 6.88	+ 9.6



Table-51

<u>SL NO.</u>	<u>DATE</u>	<u>PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)</u>
<u>WATSON GROVE #3 (CONT'D.)</u>		
8	1. 7.88	+ 12.4
9	9. 8.88	+ 4.2
10	11.10.88	+ 12.0
11	23.11.88	+ 2.5
<u>RIVERSDALE #1</u>		
1	21. 8.86	- 8.0
2	9.12.87	- 3.5
3	8. 3.86	+ 13.6
4	9. 8.88	+ 2.4
5	5. 9.88	+ 11.5
6	4.11.88	+ 5.5
7	24.11.88	- 7.5
8	25.11.88	+ 1.45
<u>GOVERNMENT PARK</u>		
1	6. 5.87	+ 24.1
2	7. 5.87	+ 22.5
3	1. 7.88	+ 16.2
<u>CLIFTON #3A</u>		
1	24. 7.87	+ 16.0
<u>CONGRIEVE PARK #4</u>		
1	16. 4.87	- 4.0

47

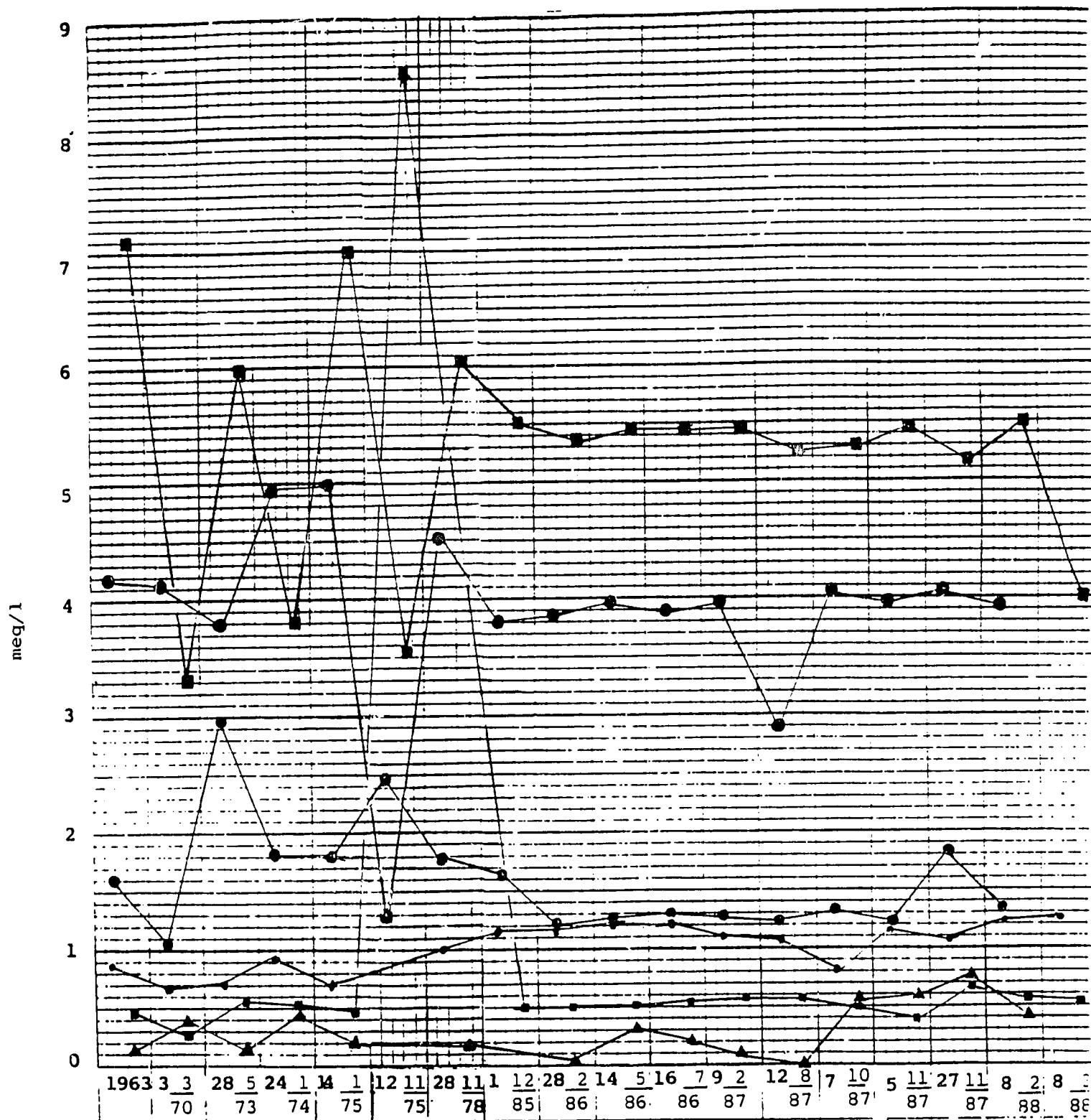
Table-5.

SL NO.	DATE	PUMPING WATER LEVEL ABOVE (+)/BELOW (-) SEA LEVEL (FEET)
<u>SALT POND #7</u>		
1	27. 7.87	+ 5.82
2	28. 7.87	+ 5.25
<u>REIDS PEN #1</u>		
1	16. 9.87	- 1.3
2	11. 2.88	- 5.7
3	1. 7.88	- 8.5
4	5. 8.88	- 5.6
5	19. 8.88	- 1.0
6	30. 9.88	Overflowing
7	21.11.88	Overflowing
<u>GOSHEN #3A</u>		
1	31. 3.87	+ 7.0
<u>CLIFTON-B</u>		
1	19. 5.87	+ 6.0
<u>CLIFTON #5</u>		
1	29. 1.88	- 8.0
<u>CUMBERLAND PEN</u>		
1	1/88	+ 8.3
2	5. 8.88	+ 3.51
3	19. 8.88	+ 1.95

GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER

AREA: BERNARD LODGE - PROJECT A

WELL NAME: HALF WAY TREE # 2

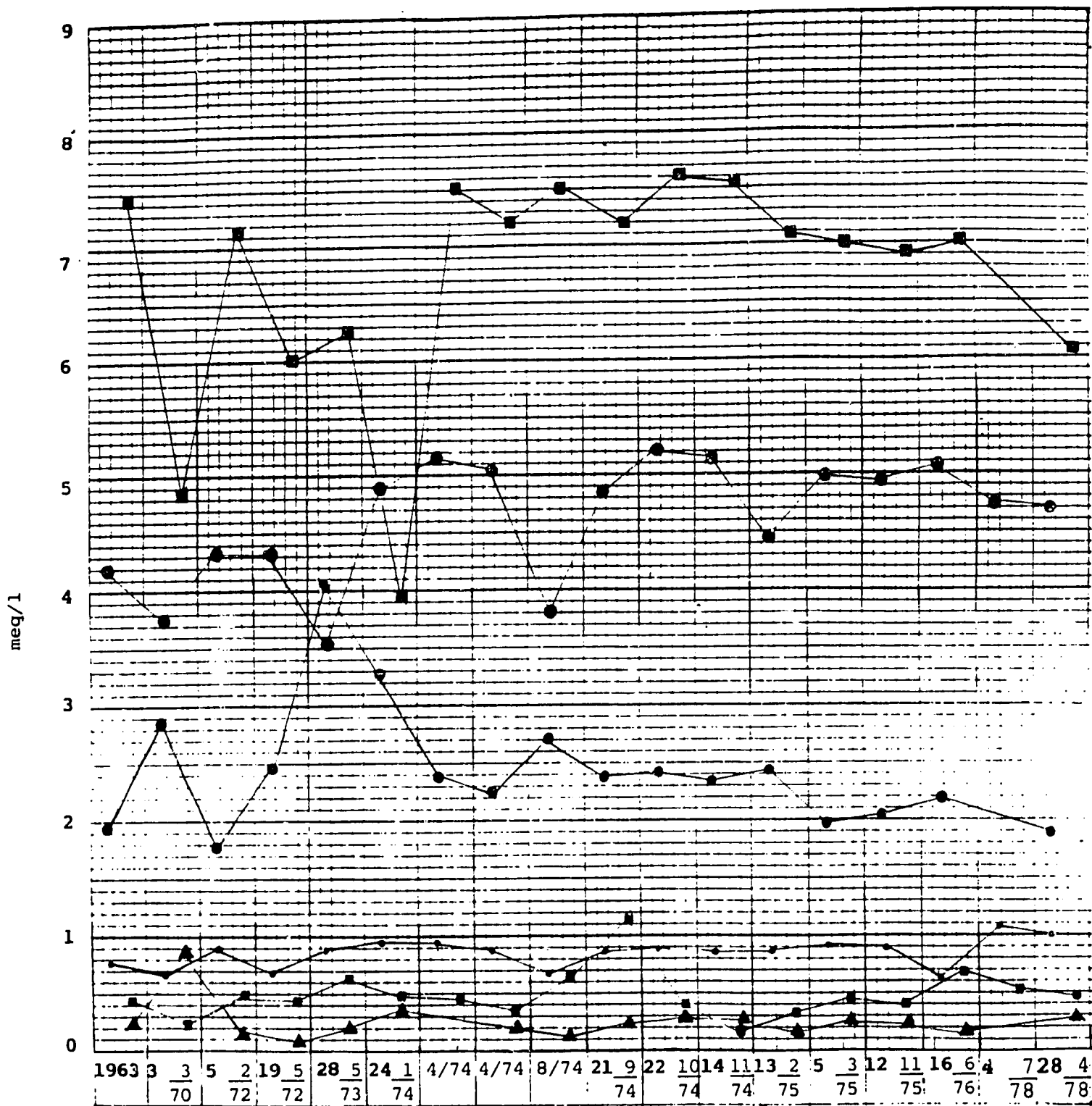


- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: HALF-WAY-TREE #4



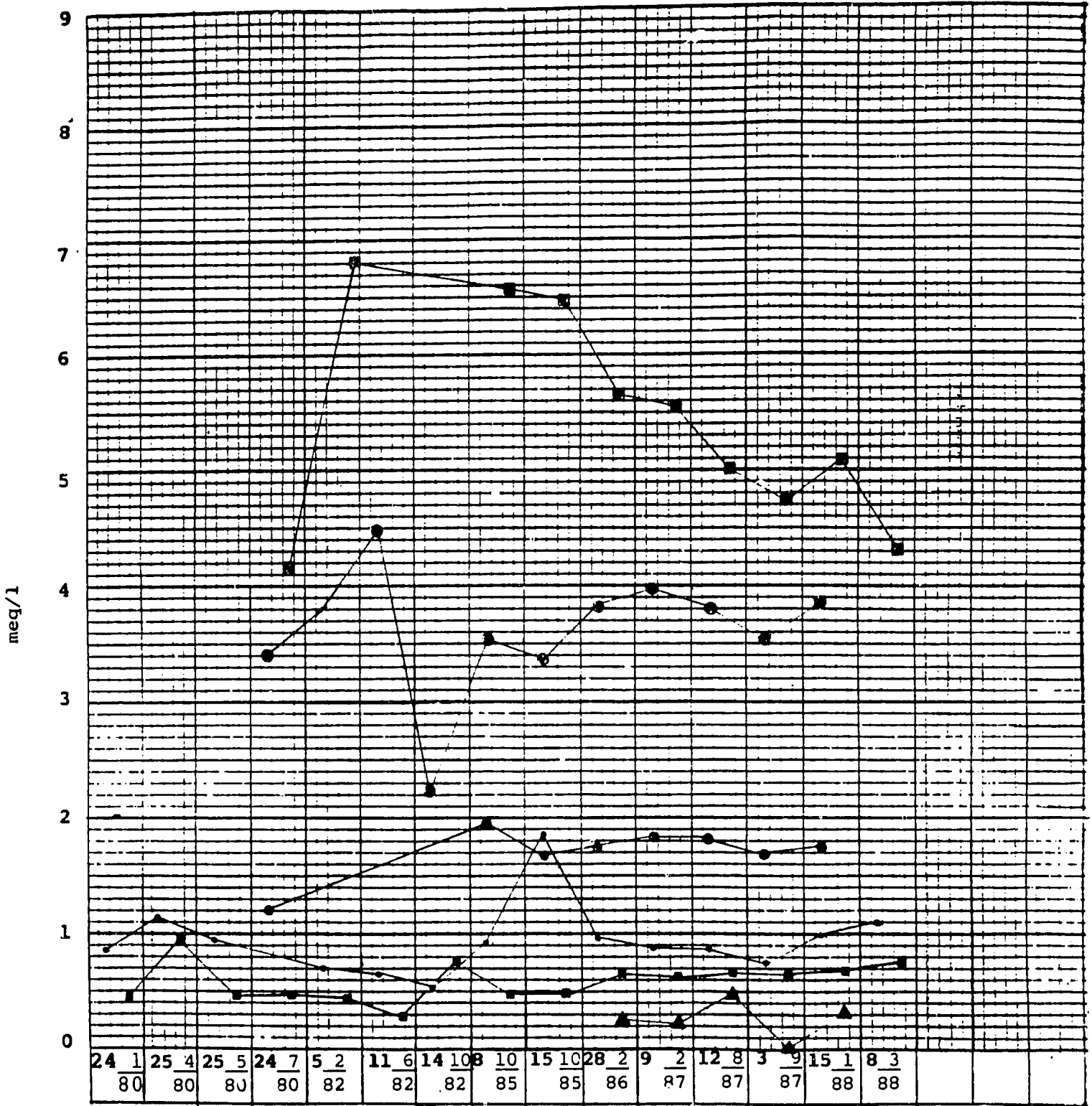
Date

- calcium
- chloride
- magnesium
- ▲ sulphate
- sodium
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: HALF WAY TREE #4



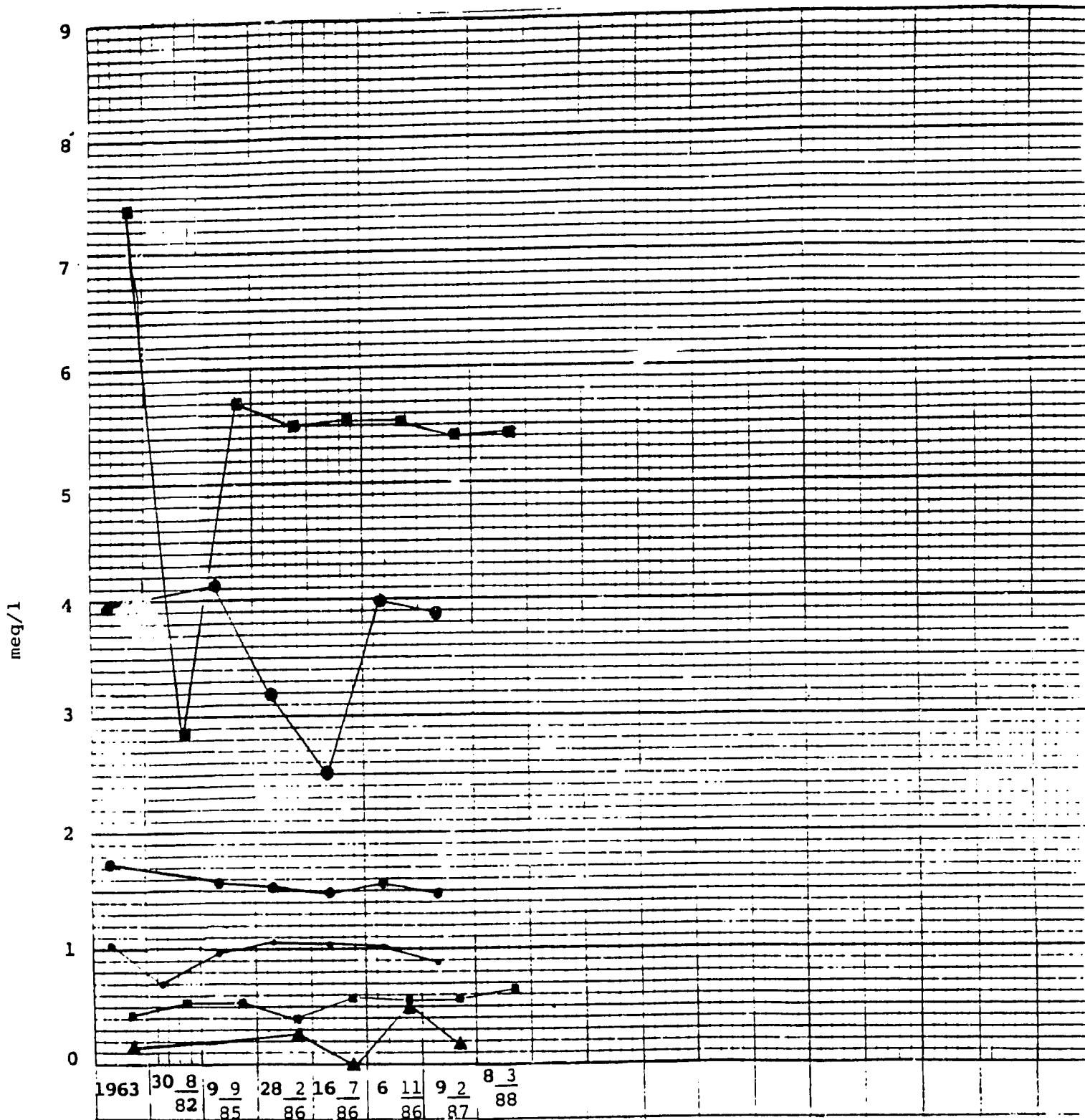
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: HALF-WAY-TREE #5



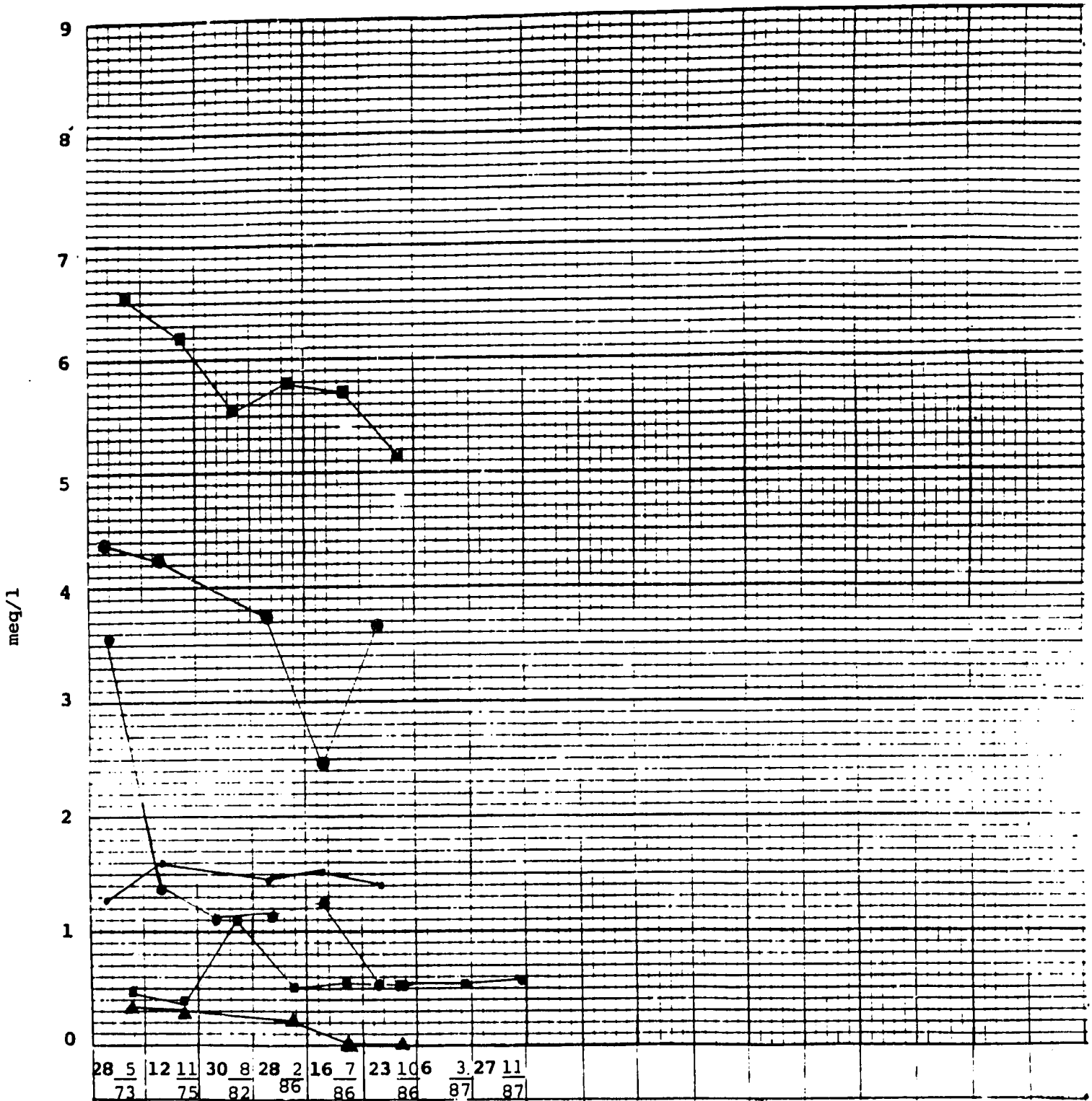
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: HALF-WAY-TREE #6



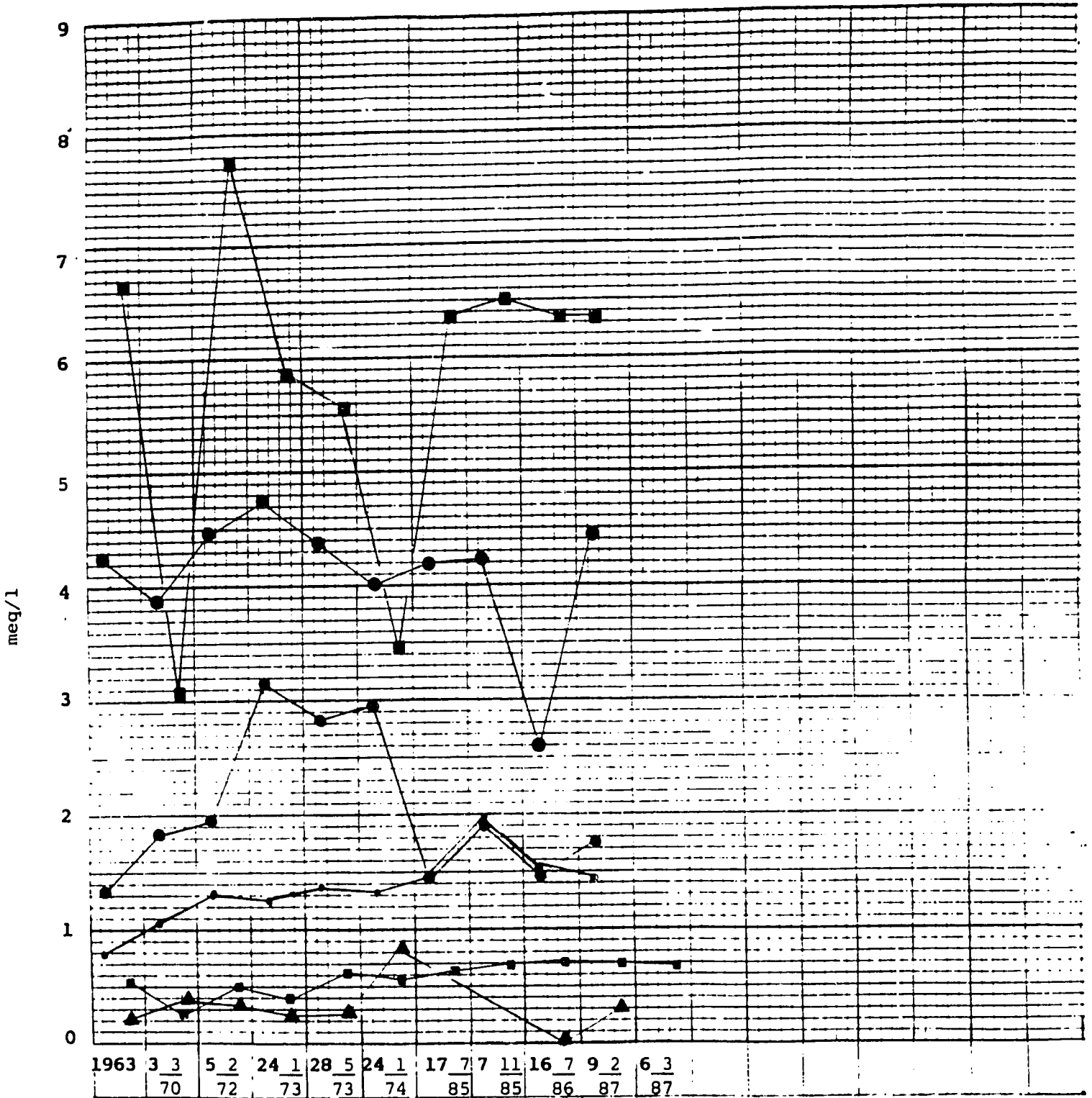
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: COOKSON #3



Date

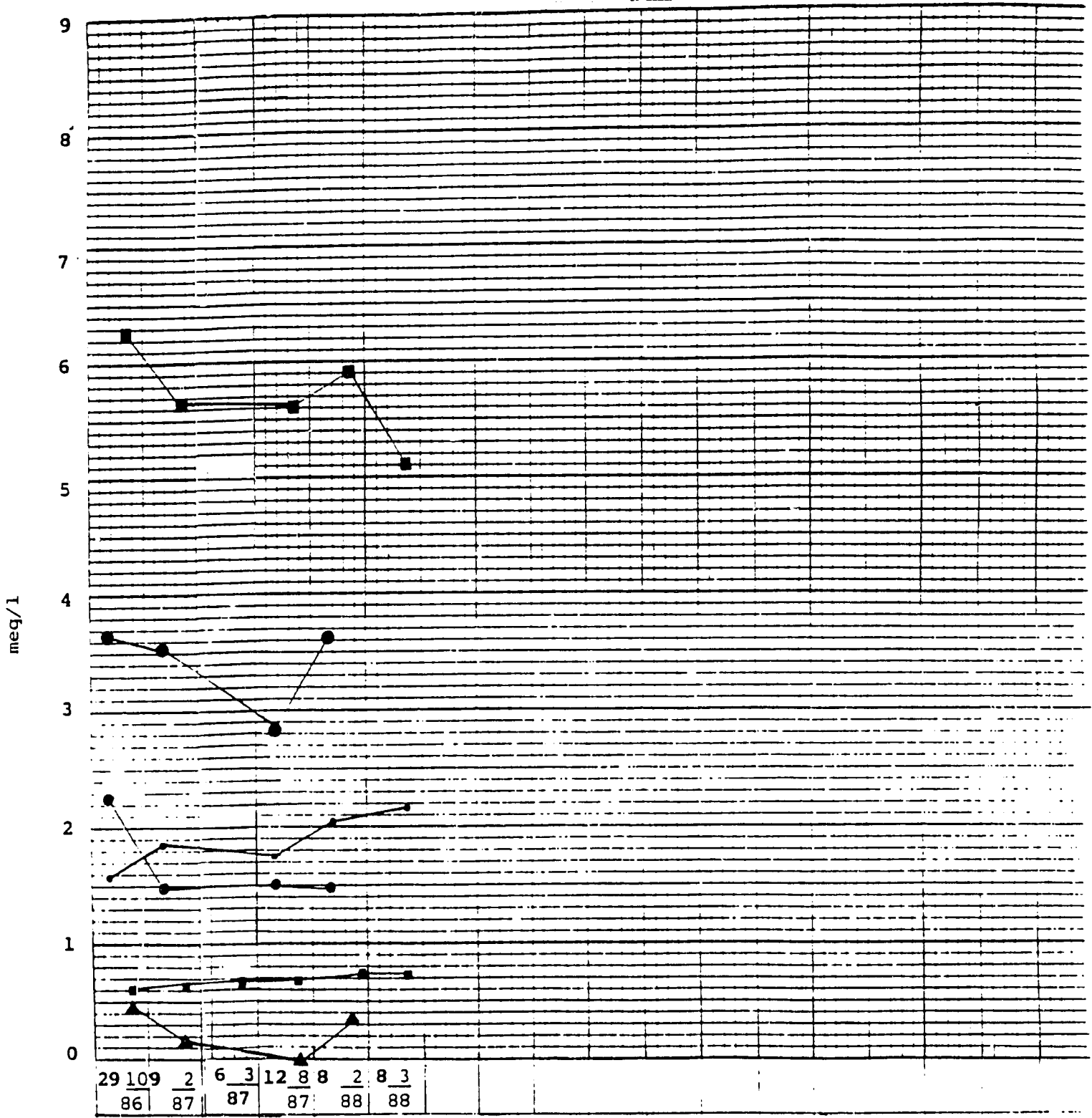
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate



**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: COOKSON #4



Date

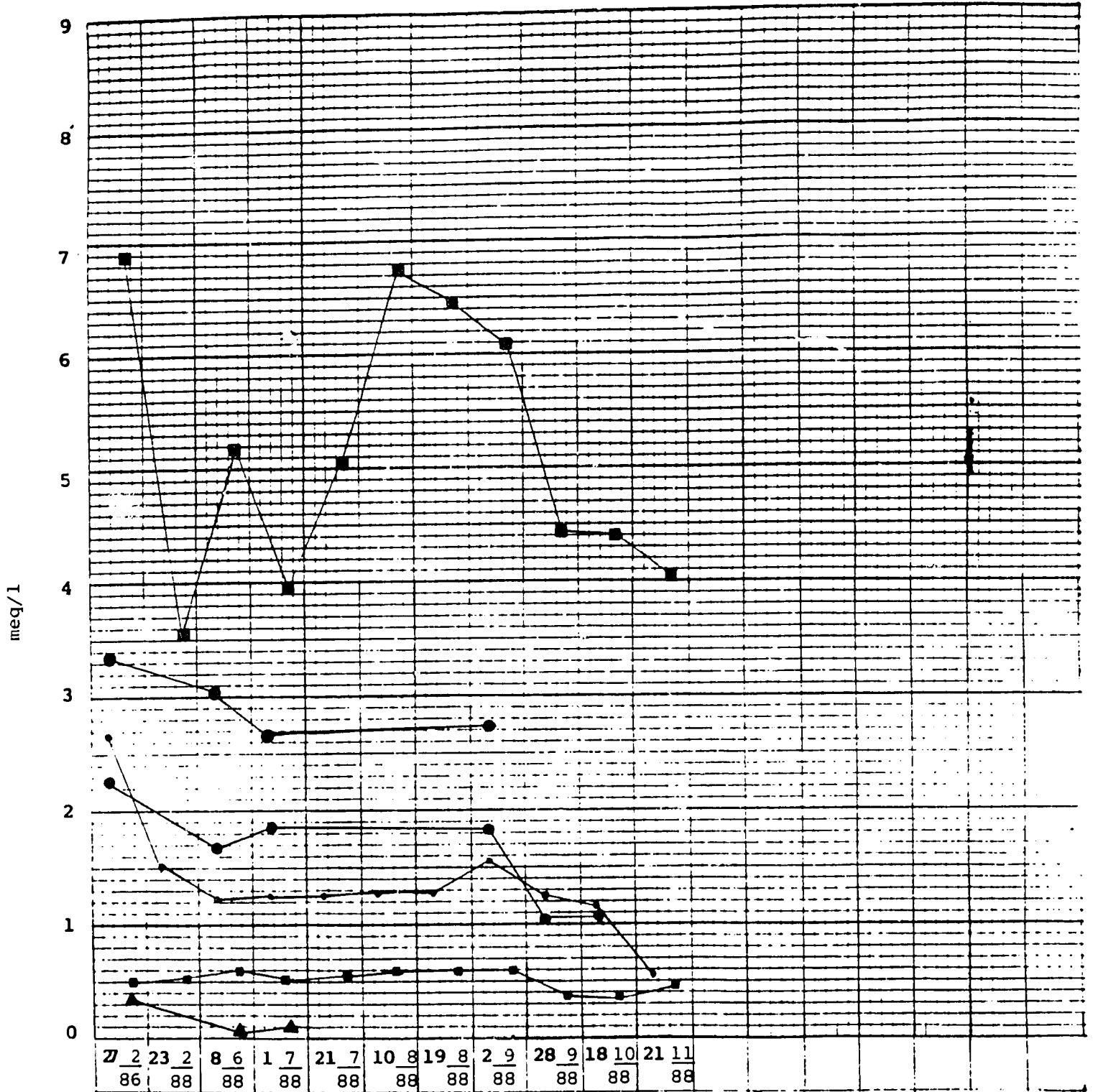
● calcium  
 ● magnesium  
 ● sodium

■ chloride  
 ▲ sulphate  
 ■ bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: NEWLANDS #2



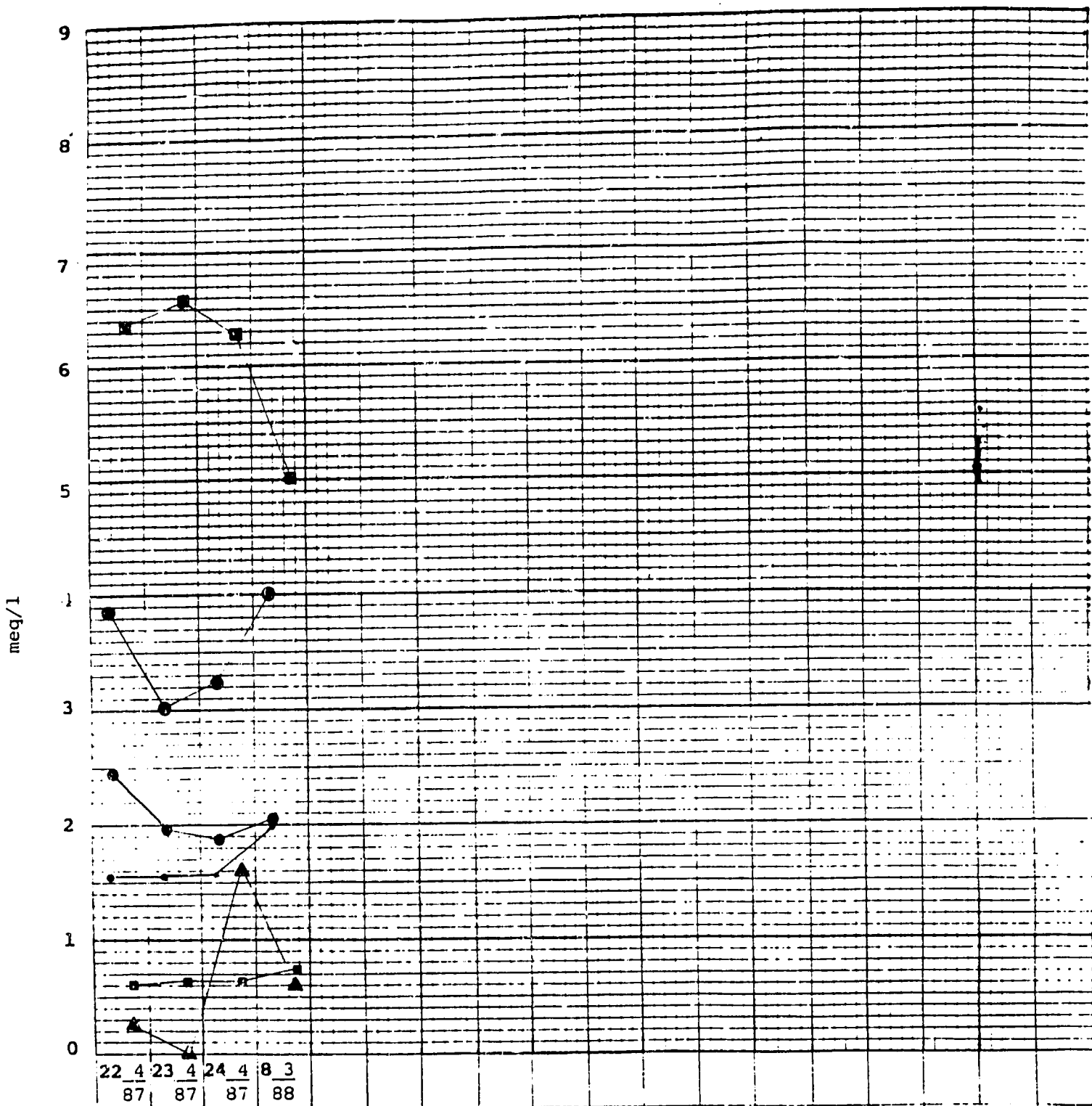
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT A

WELL NAME: NEWLANDS #2A



Date

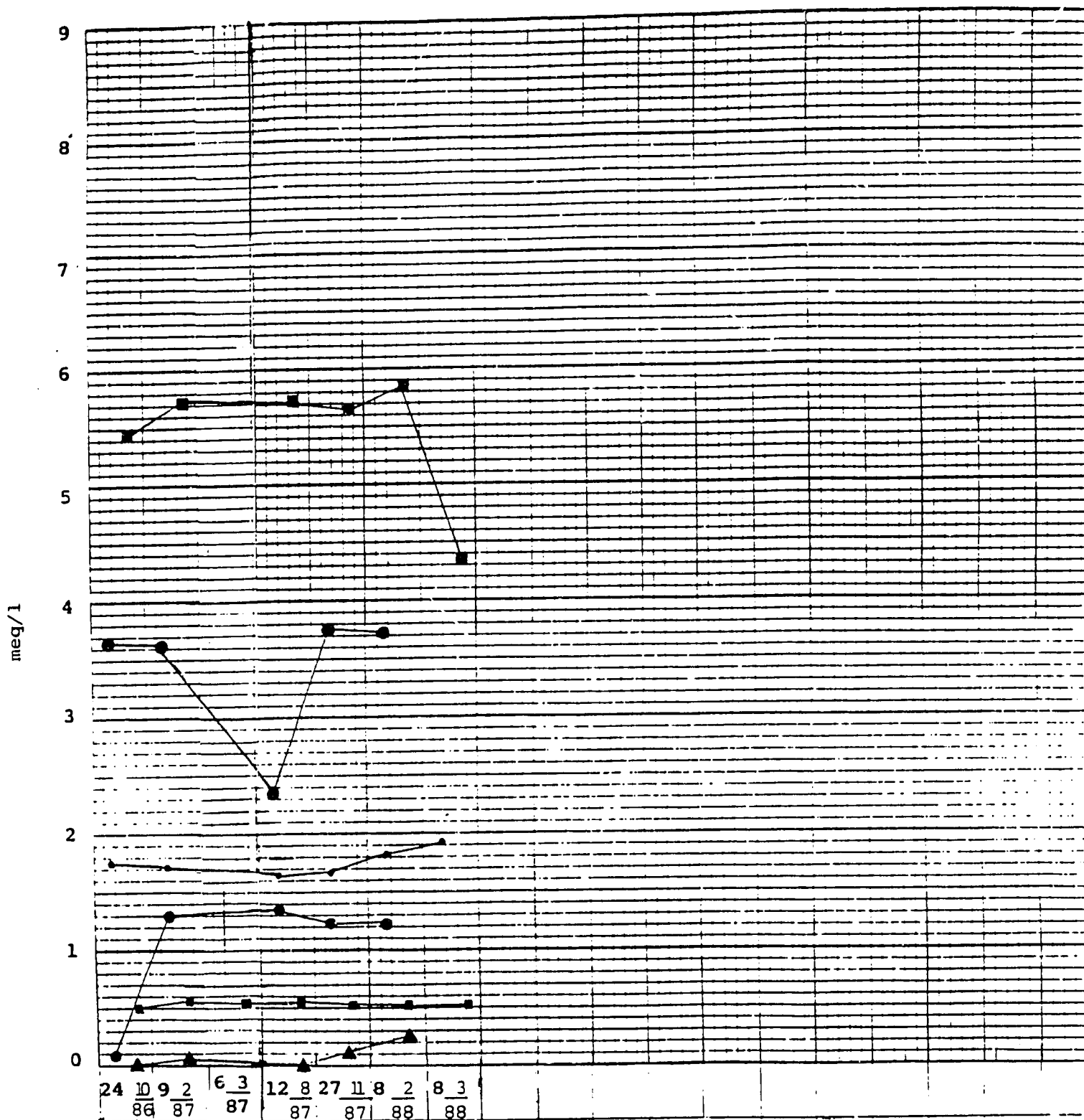
- calcium
- magnesium
- sodium

- chloride
- ▲ sulphate
- bicarbonate and carbonate

GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER

AREA: BERNARD LODGE - PROJECT A

WELL NAME: NEWLANDS #3



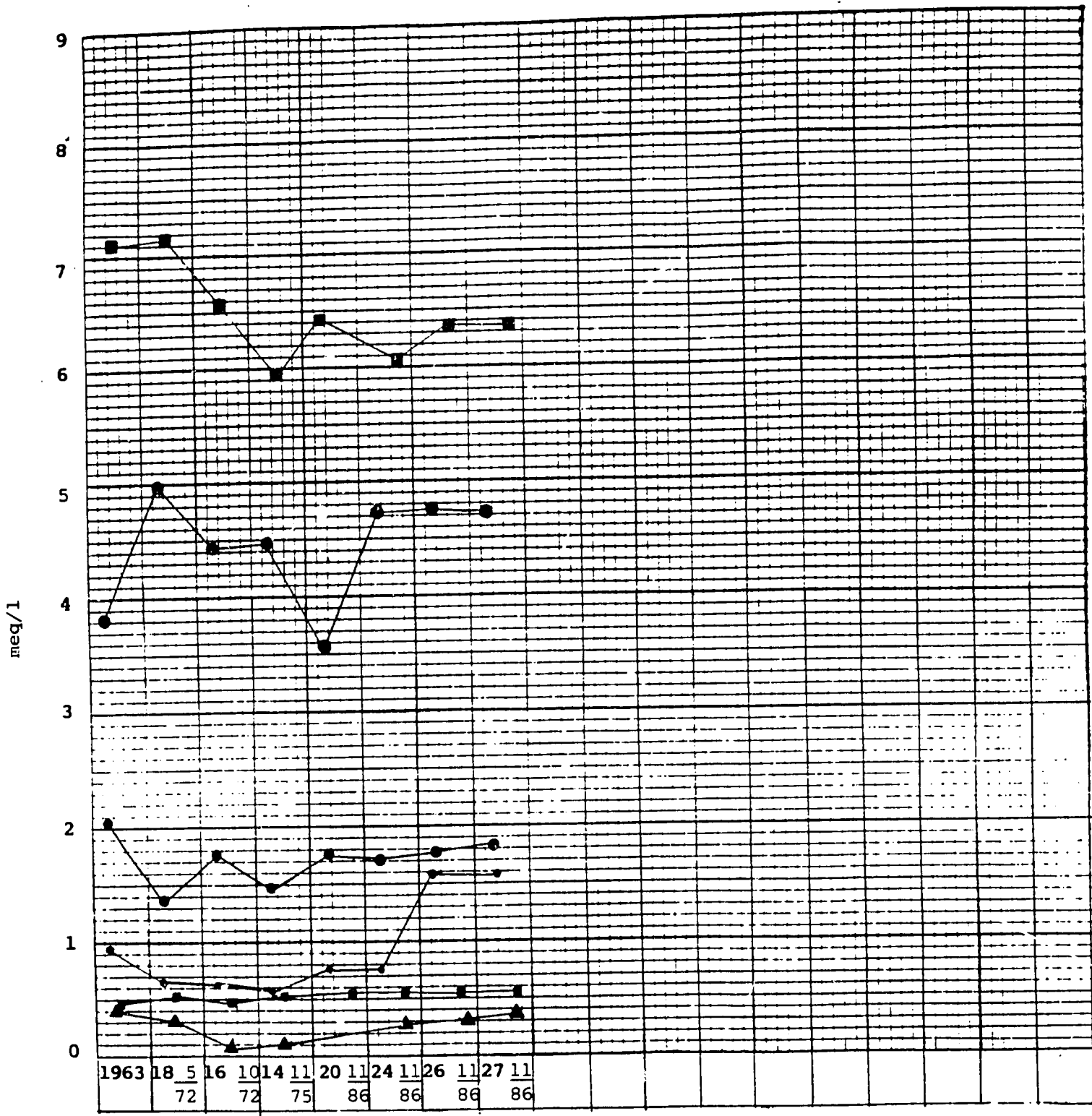
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: **CEYMANAS - PROJECT B**

WELL NAME: **NORTH SYNDICATE  
NORTH SYNDICATE #2**



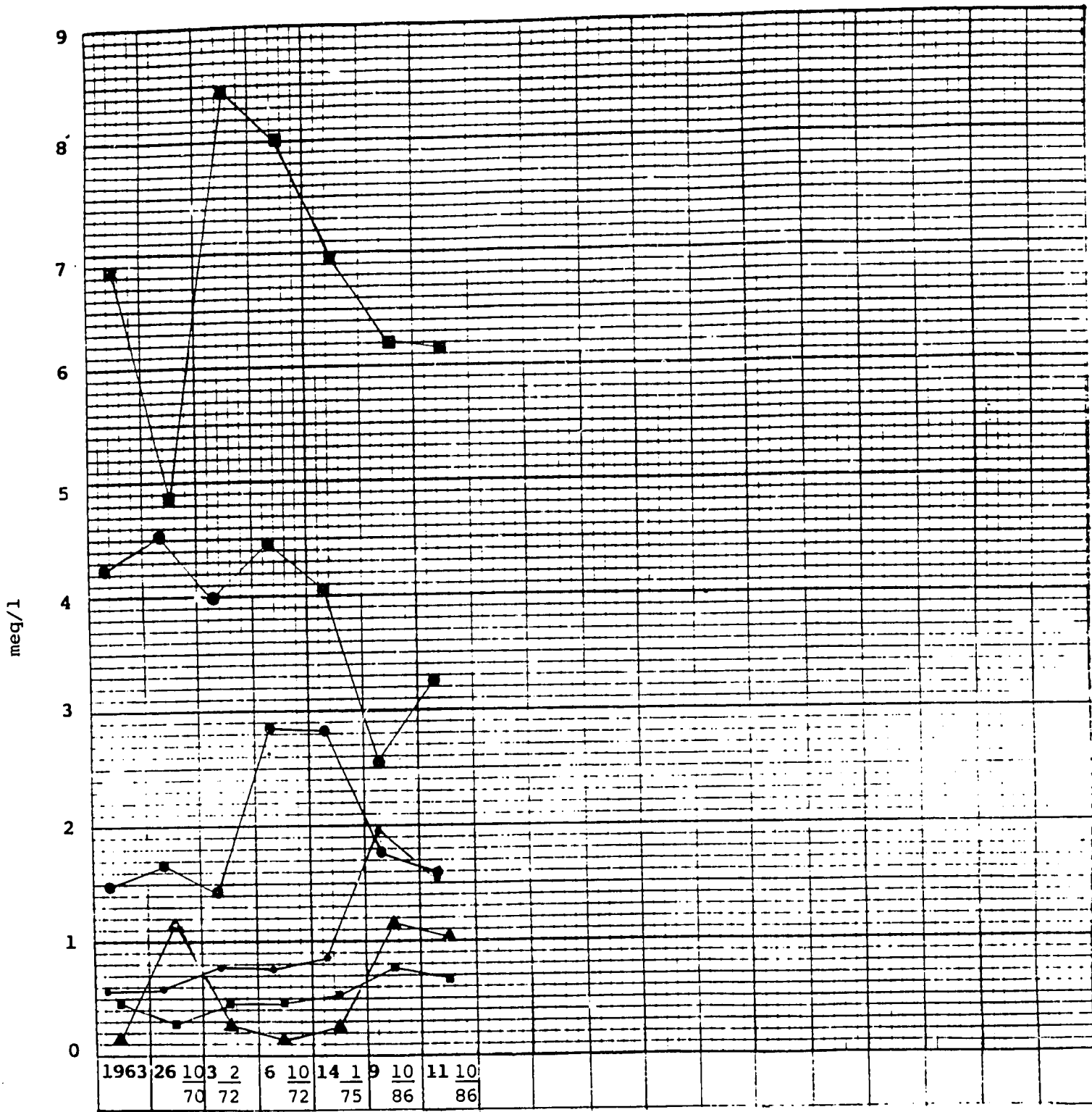
Date

- calcium
- chloride
- magnesium
- ▲ sulphate
- sodium
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: CAYMANAS - PROJECT B

WELL NAME: SOUTH SYNDICATE  
SOUTH SYNDICATE #2



Date

- calcium
- chloride
- magnesium
- ▲ sulphate
- sodium
- bicarbonate and carbonate

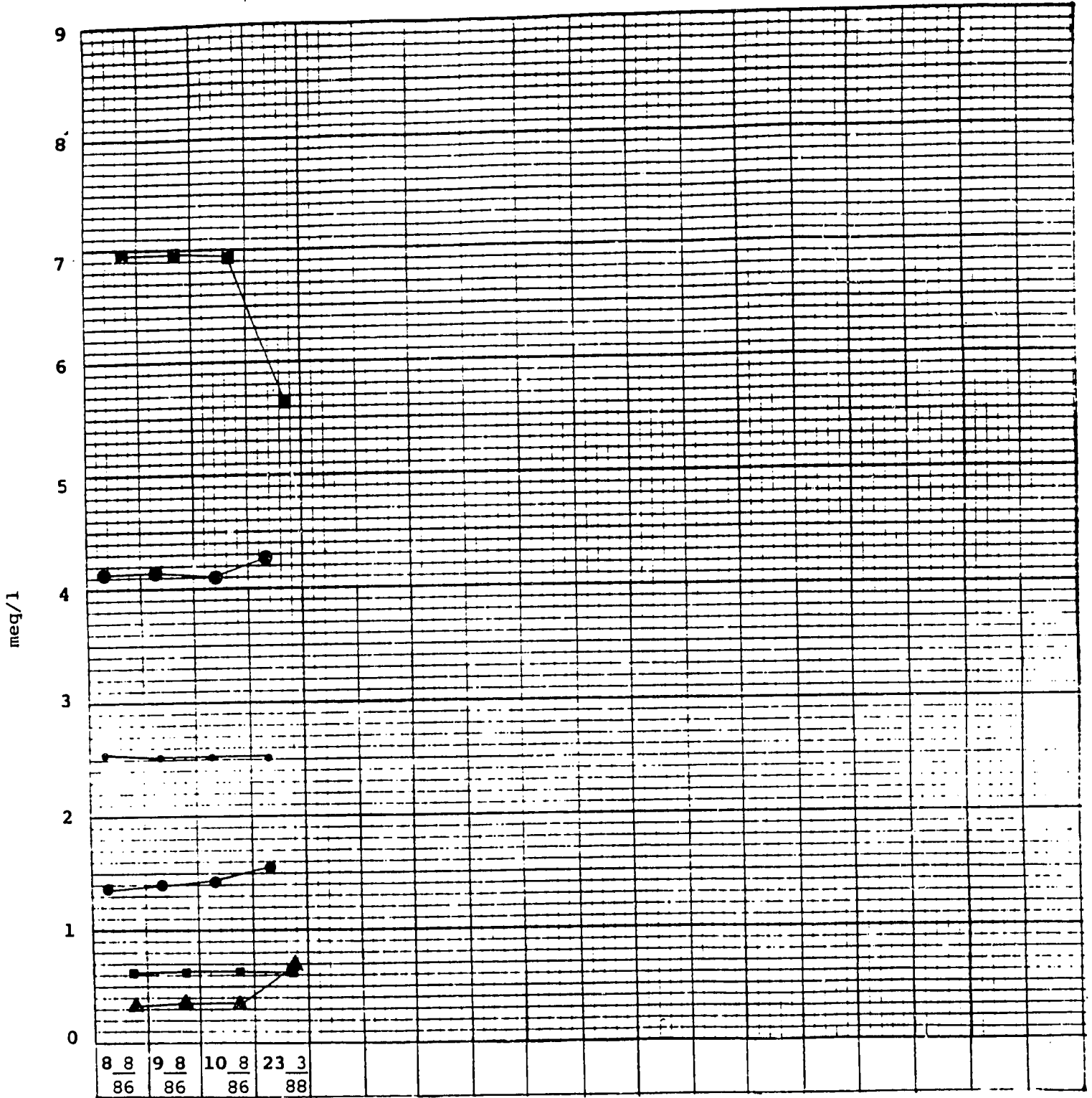
**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

12

AREA: CAYMANAS

- PROJECT B

WELL NAME: COWPARK A



Date

● calcium  
● magnesium  
● sodium

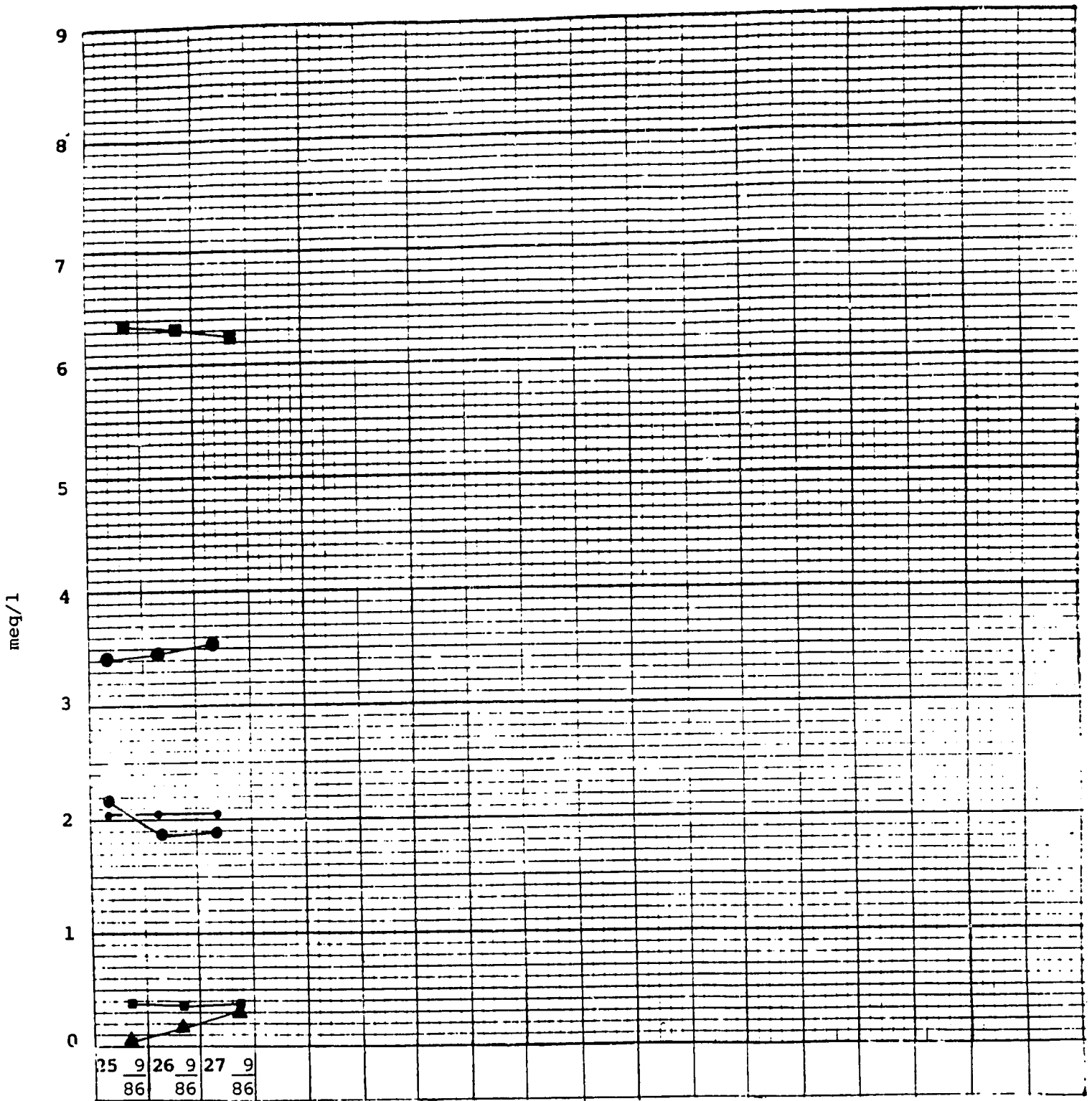
● chloride  
▲ sulphate  
■ bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND  
CATIONS IN WELL WATER**

13

AREA: CAYMANAS - PROJECT B

WELL NAME: NAGGO HEAD



Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate



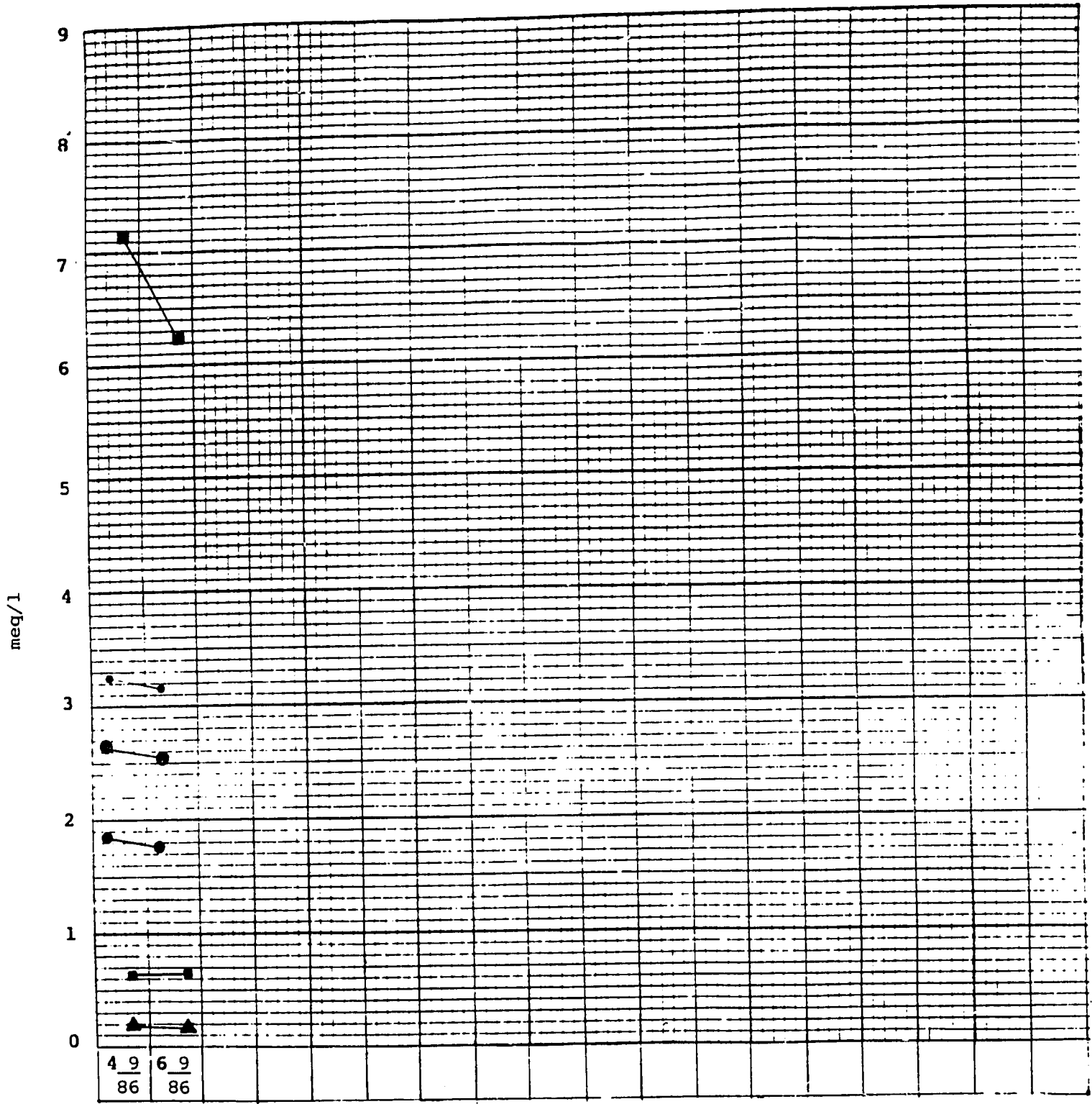
**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

14

AREA: CAYMANAS

PROJECT B

WELL NAME: GUINEP PEN



Date

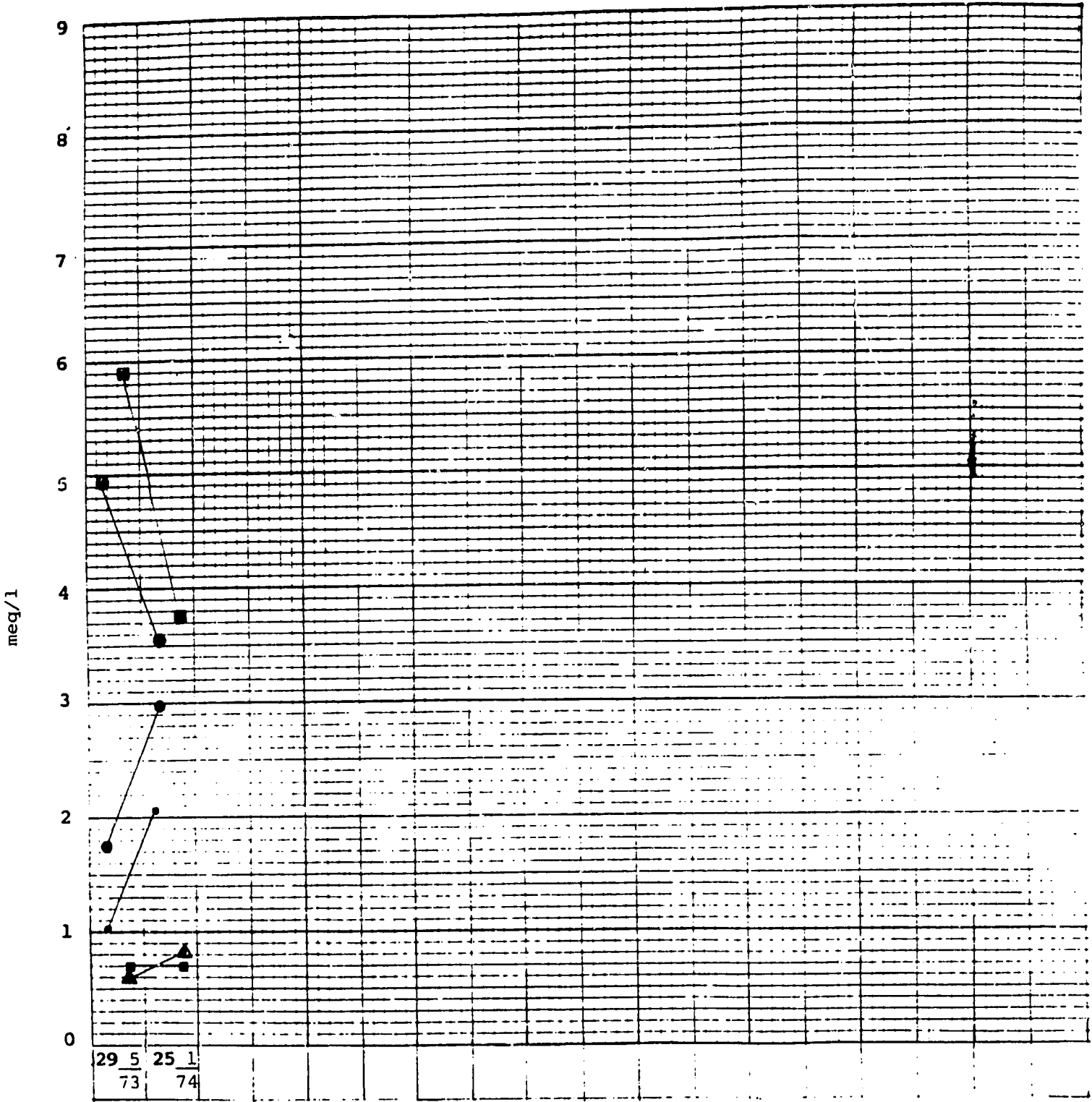
- calcium
- magnesium
- sodium

- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: CAYMANAS - PROJECT B

WELL NAME: CEDAR GROVE #2



Date

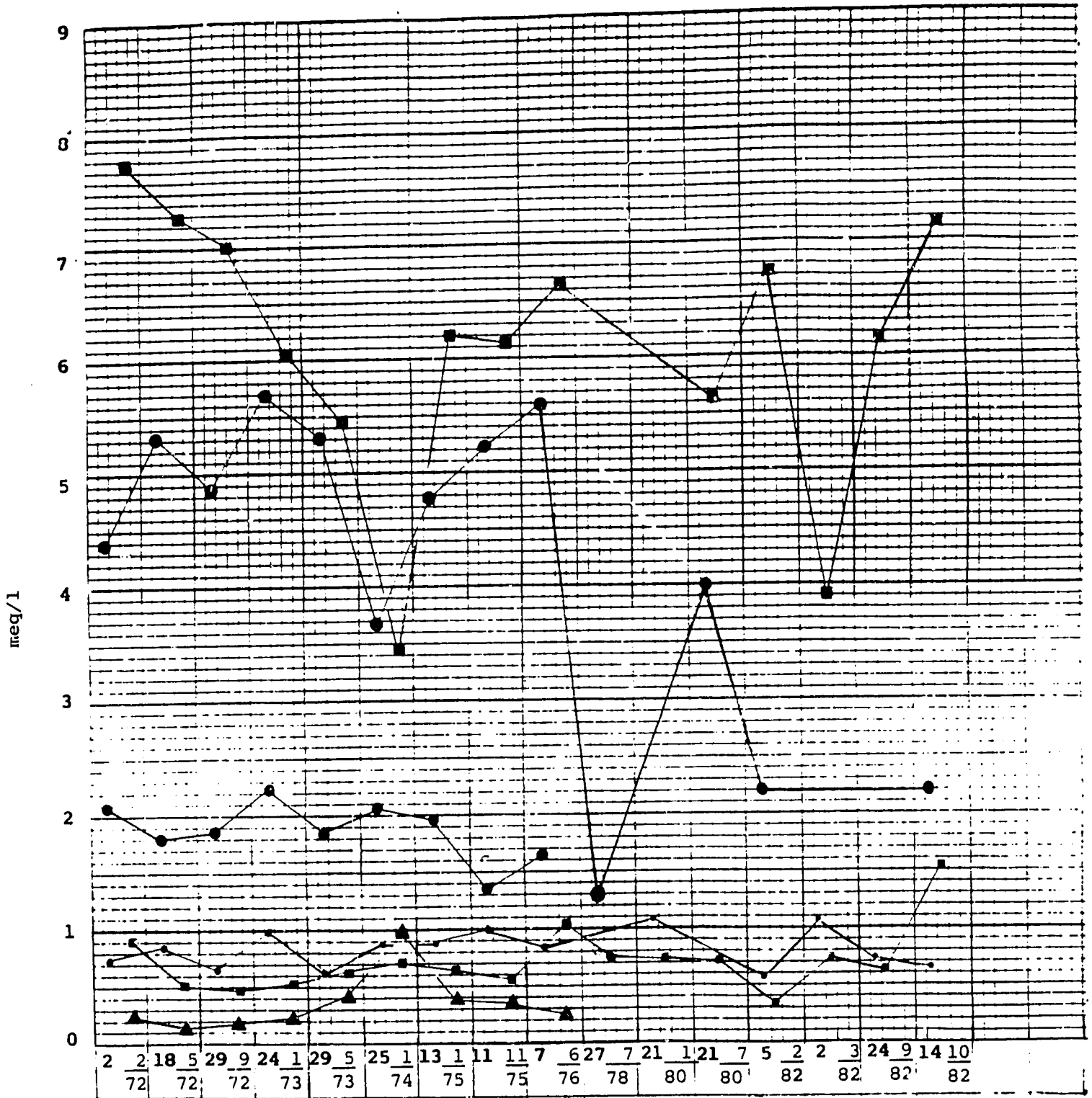
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

16

AREA: CAYMANAS, - PROJECT 'C'

WELL NAME: WATSON GROVE #2



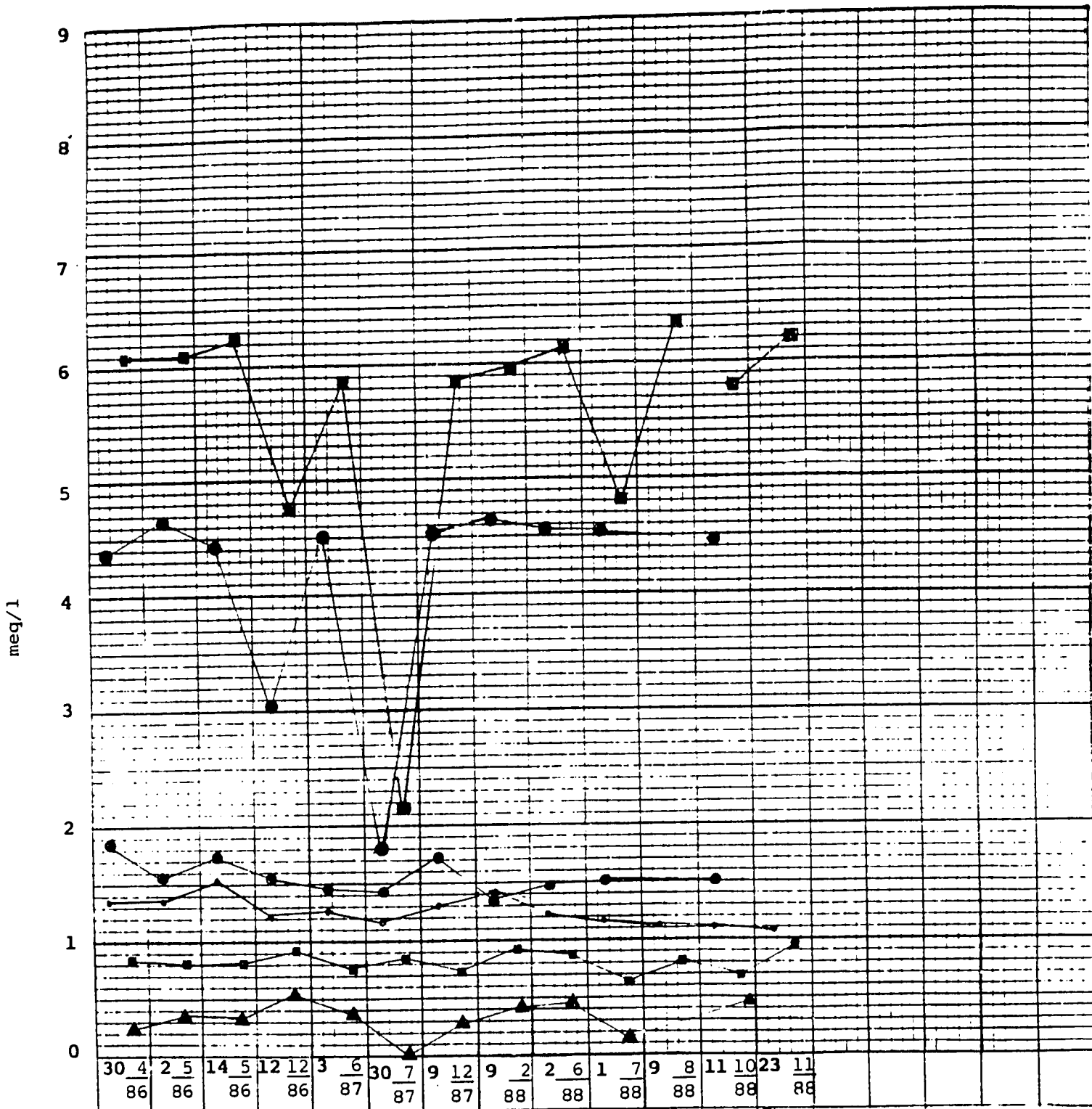
Date

- calcium
- chloride
- magnesium
- ▲ sulphate
- sodium
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: **CAYMANAS- PROJECT C**

WELL NAME: **WATSON GROVE #3**



Date

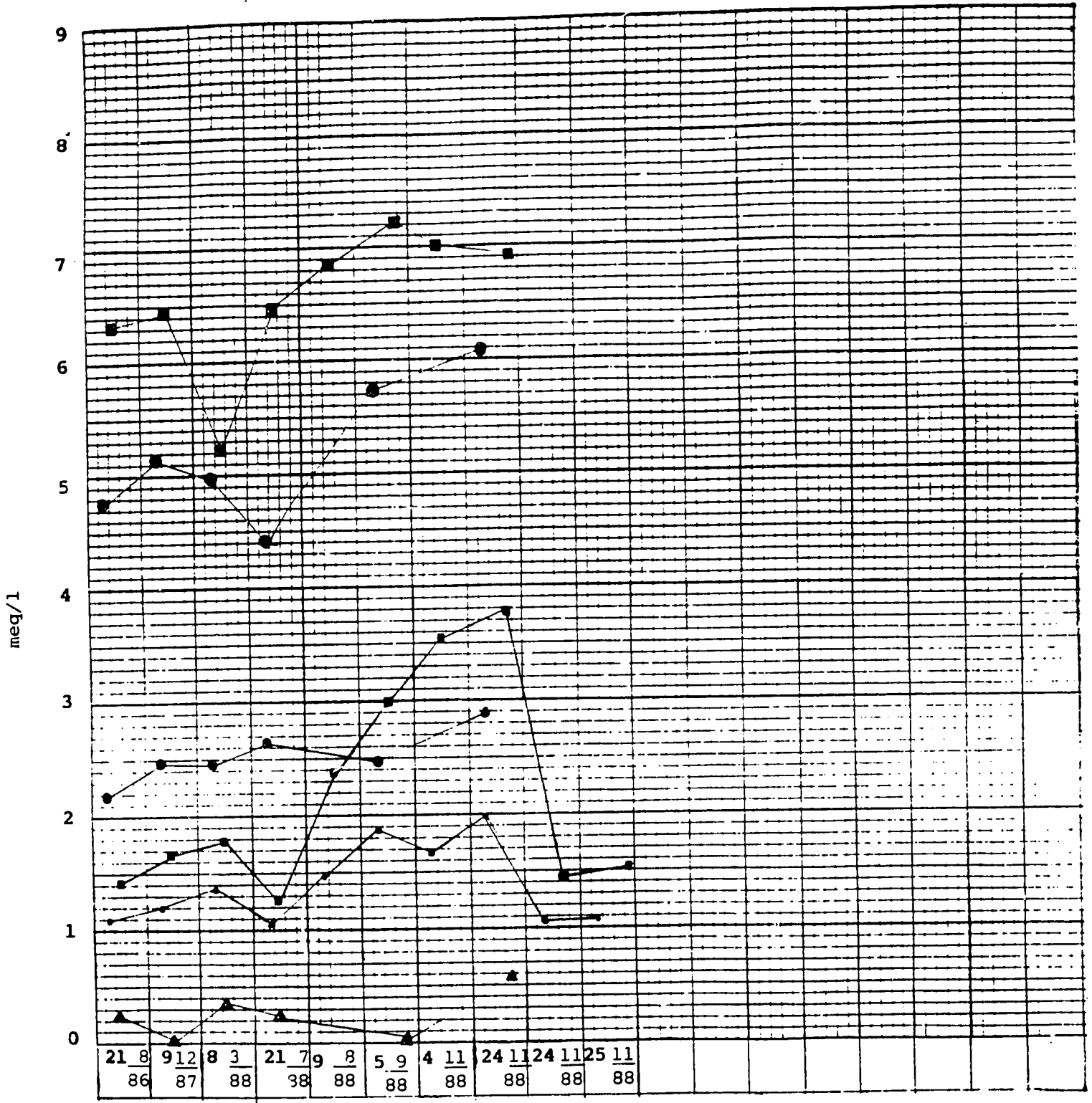
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

18

AREA: CAYMANAS - PROJECT 'C'

WELL NAME: RIVERSDALE #1



Date

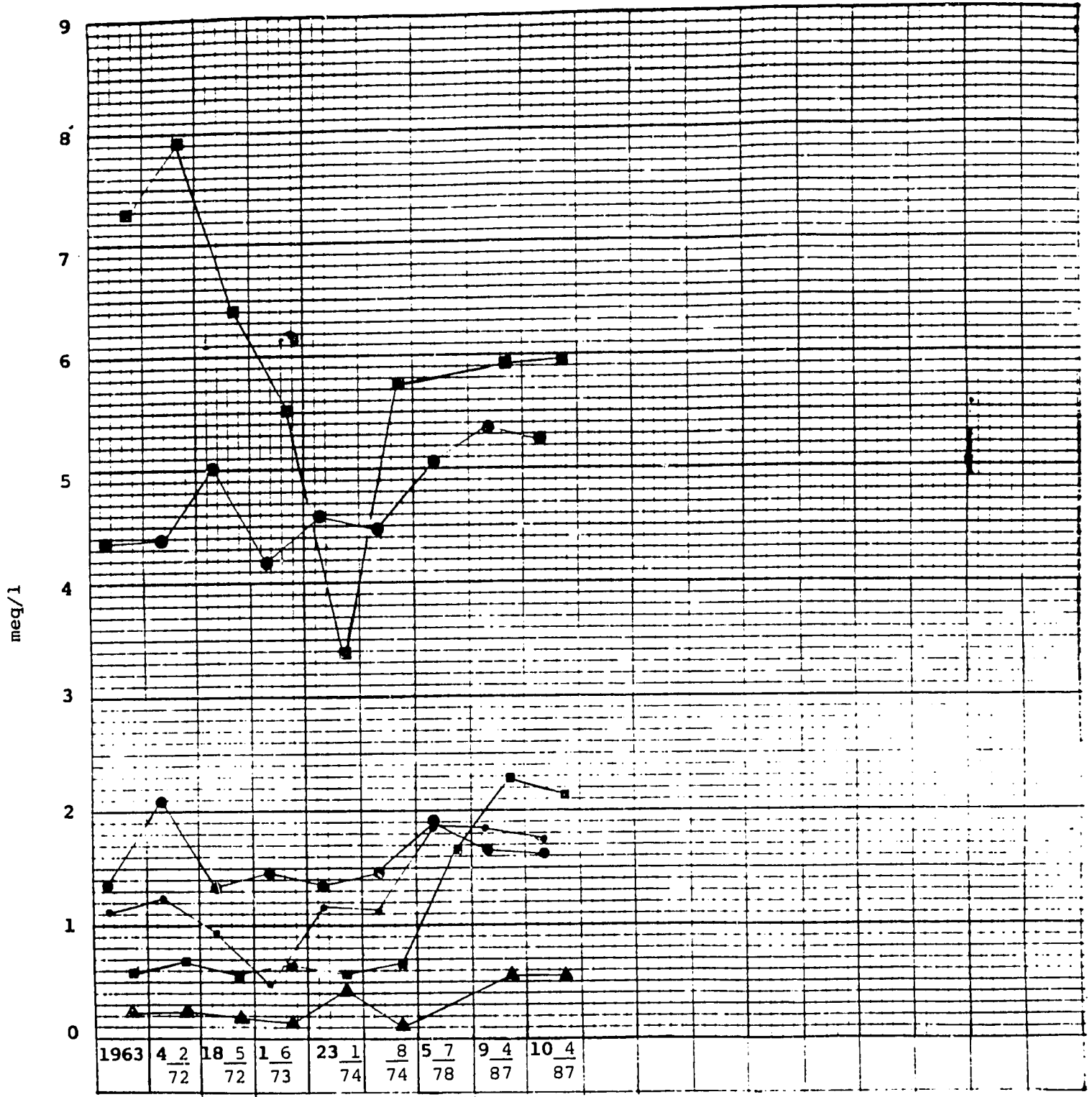
- calcium
- magnesium
- ◆ sodium
- ▲ chloride
- ▼ sulphate
- \* bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

19

AREA: BERNARD LODGE - PROJECT E

WELL NAME: LIMETREE #1



Date

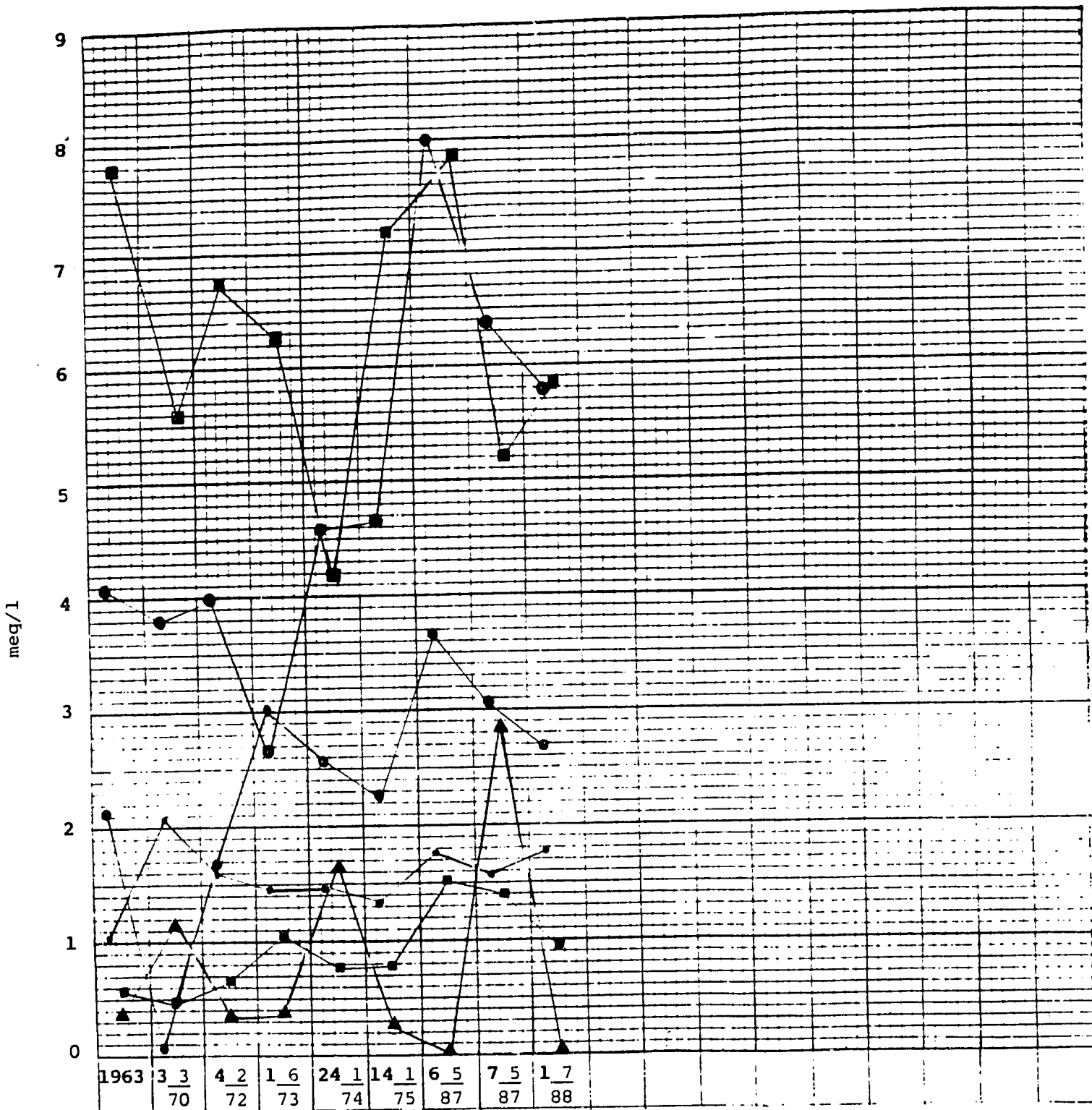
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

20

AREA: BERNARD LODGE - PROJECT E

WELL NAME: GOVERNMENT PARK



Date

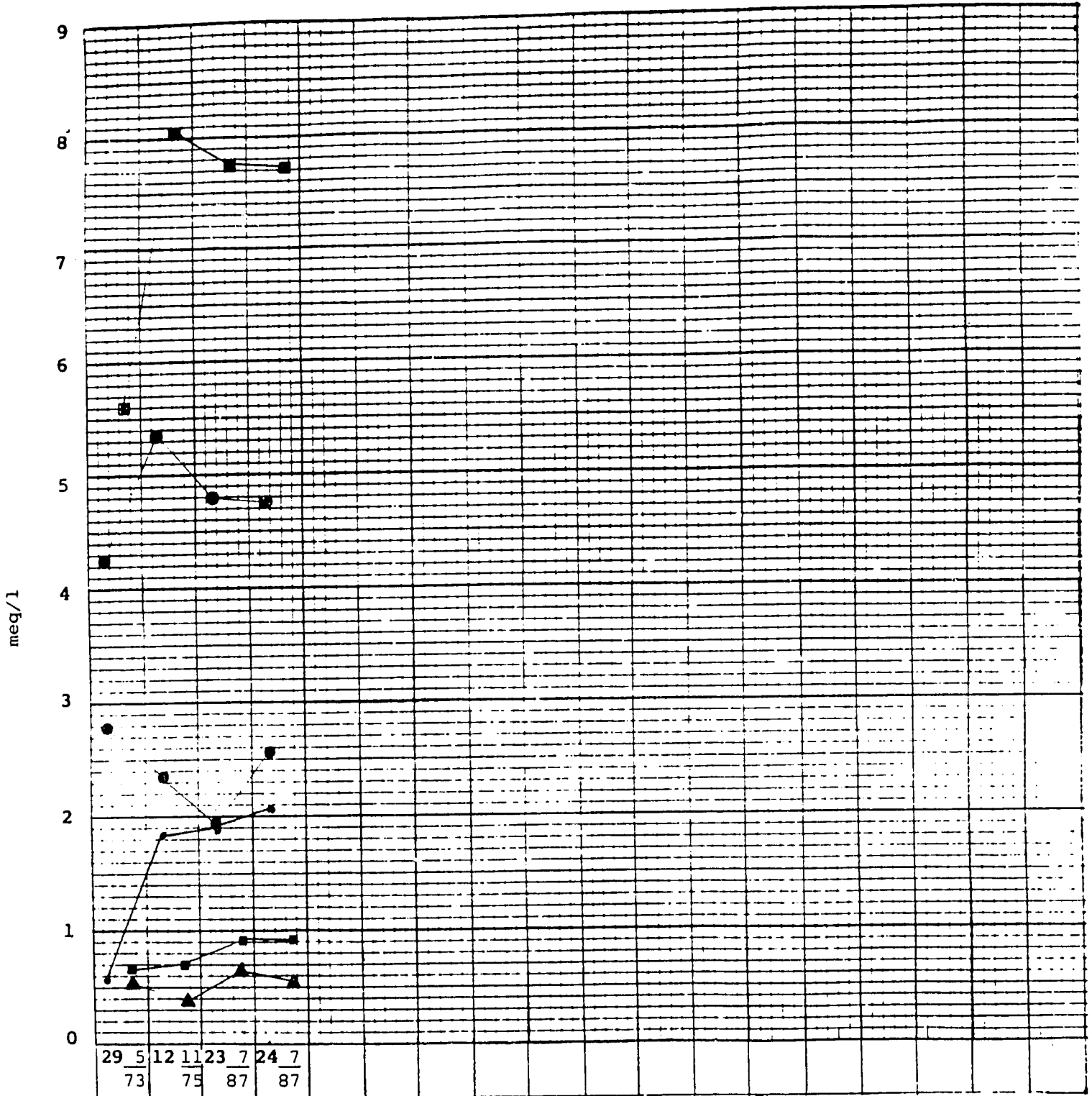
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND  
CATIONS IN WELL WATER**

21

AREA: BERNARD LODGE - PROJECT E

WELL NAME: CLIPTON #3



Date

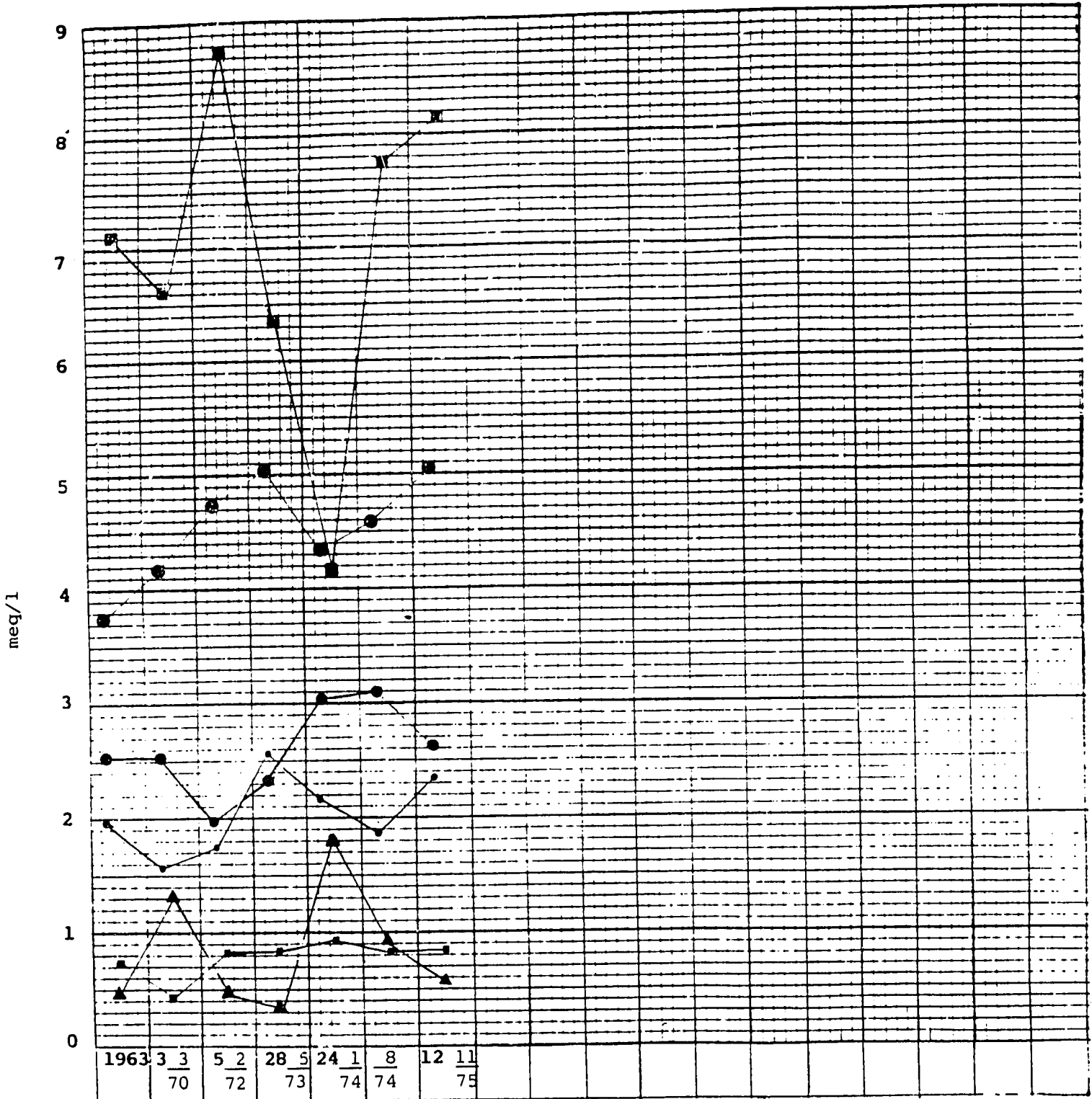
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate



**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT E

WELL NAME: GOSHEN #2



Date

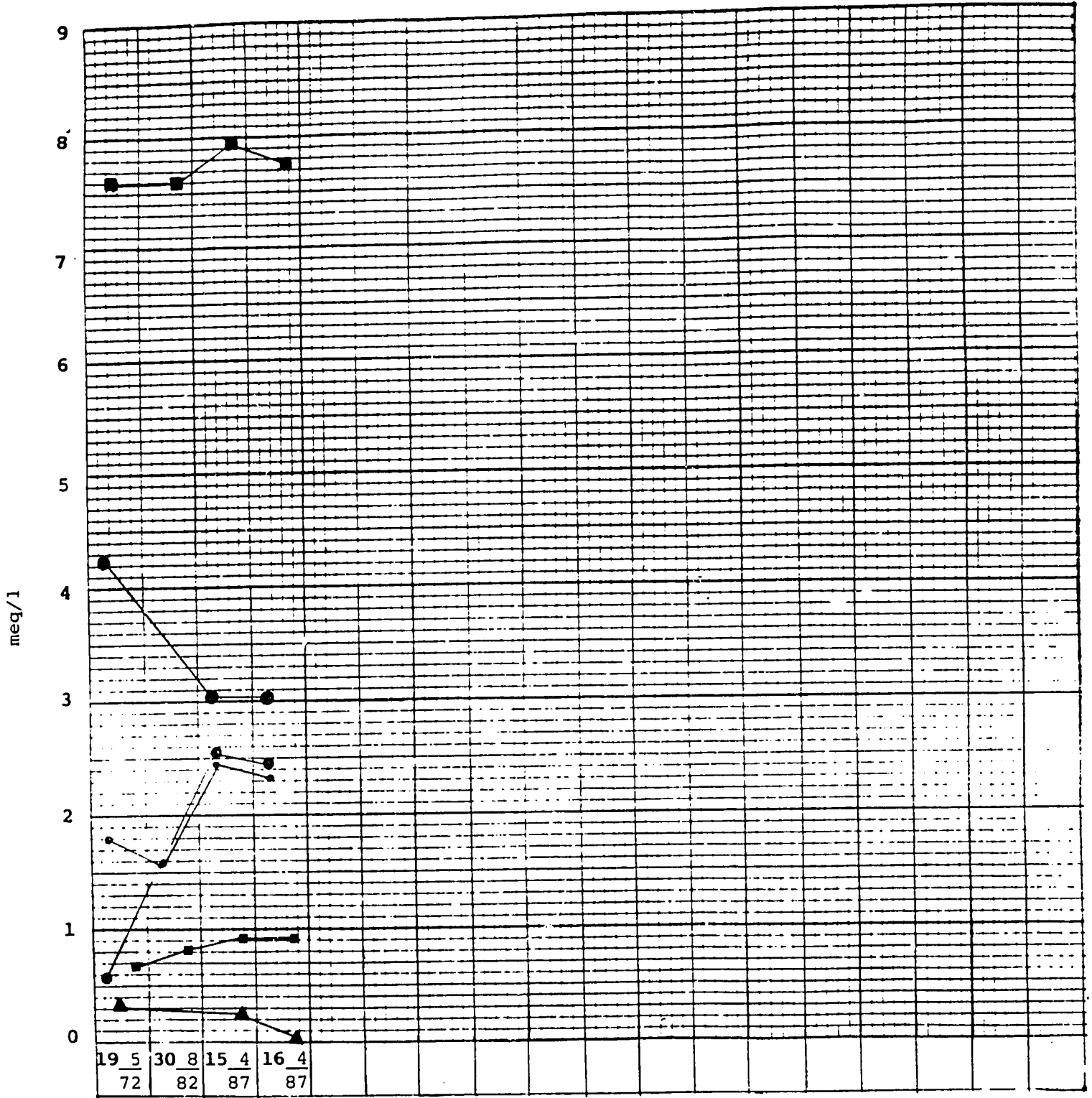
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

23

AREA: BERNARD LODGE - PROJECT E

WELL NAME: CONGRIEVE PARK #4



Date

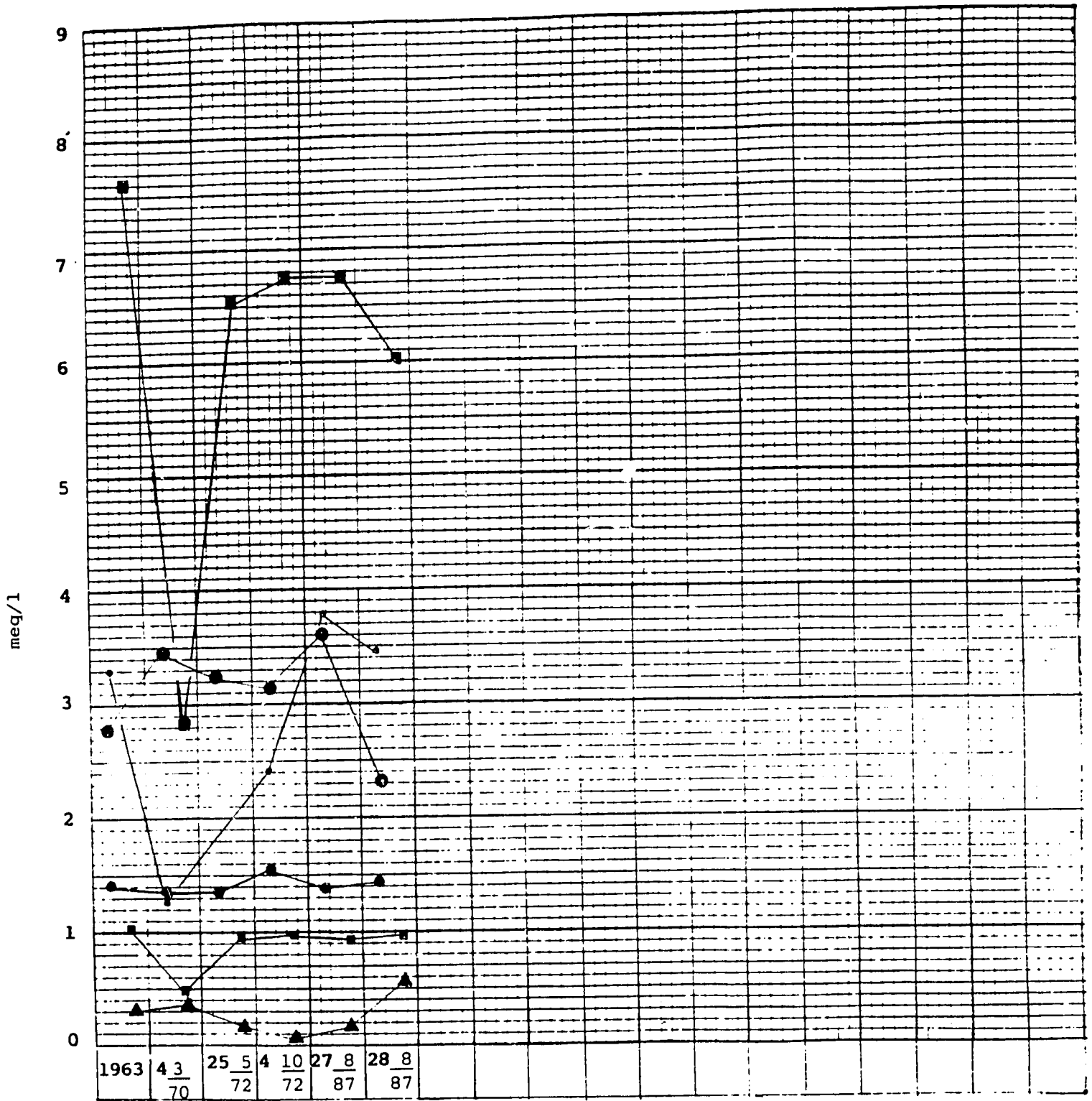
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

24

AREA: BERNARD LODGE - PROJECT E

WELL NAME: SALT POND #7



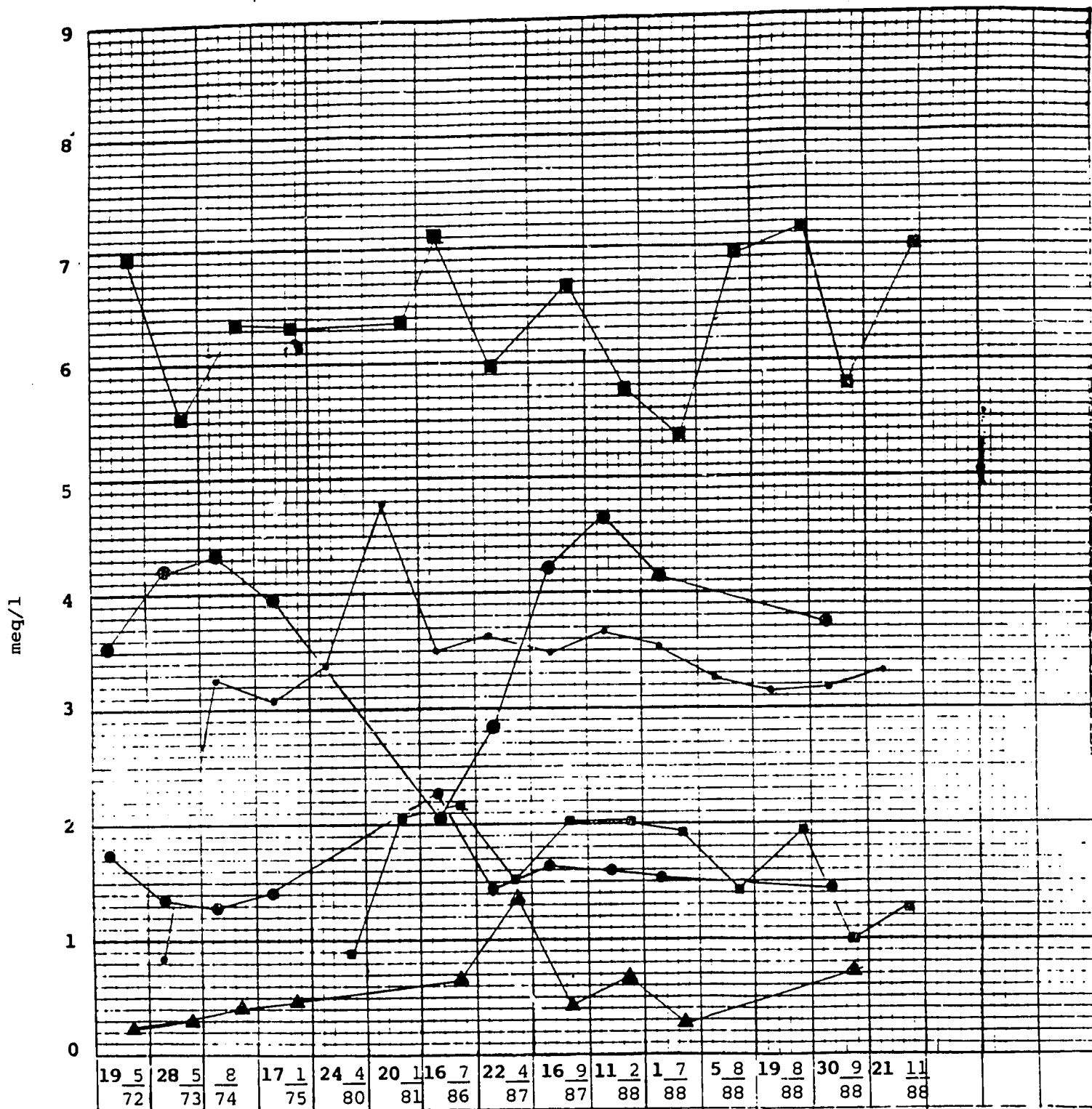
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE - PROJECT B

WELL NAME: REIDS PEN #1



Date

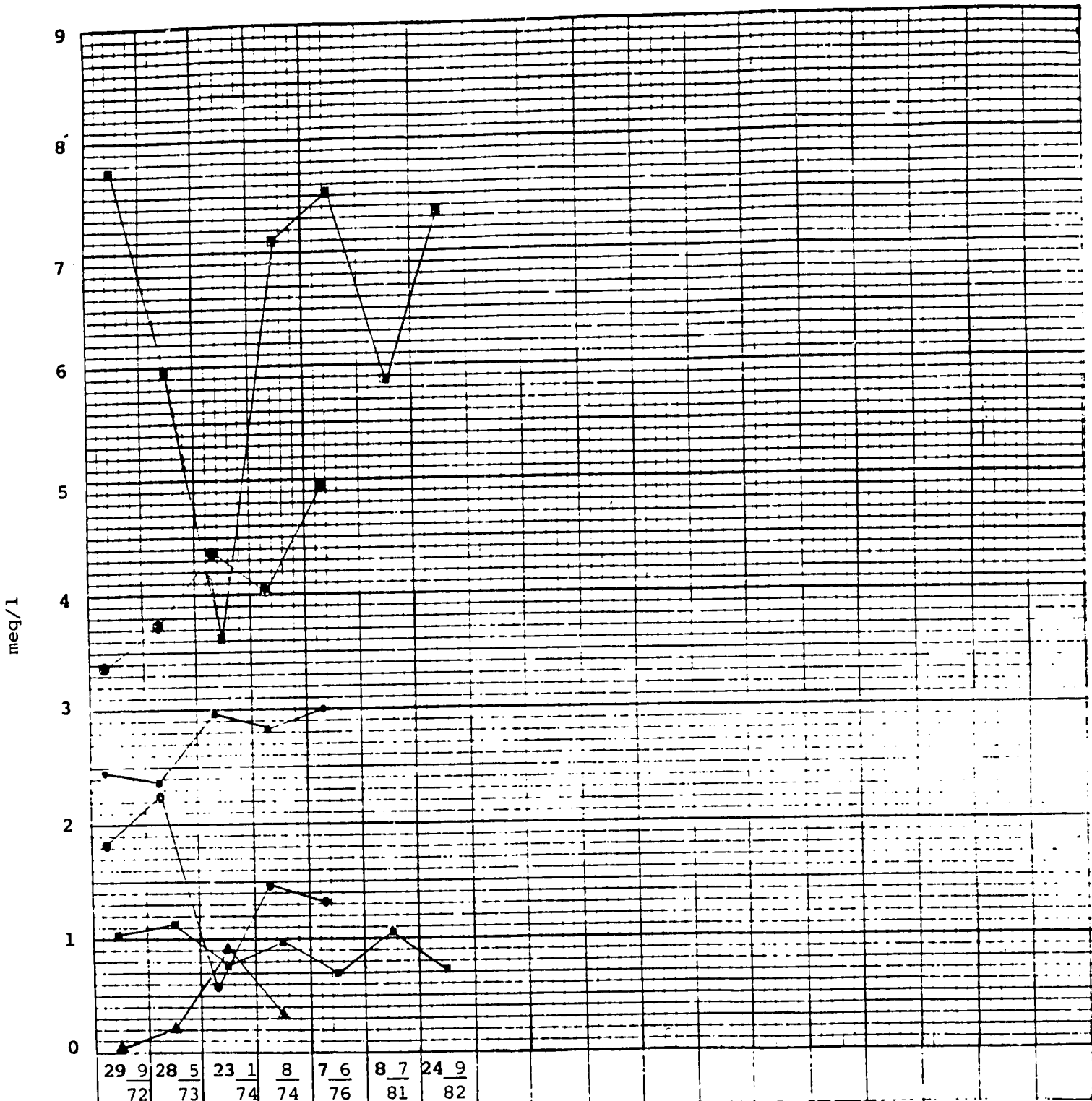
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

26

AREA: BERNARD LODGE - PROJECT E

WELL NAME: REIDS PEN #2



Date

● calcium  
● magnesium  
● sodium

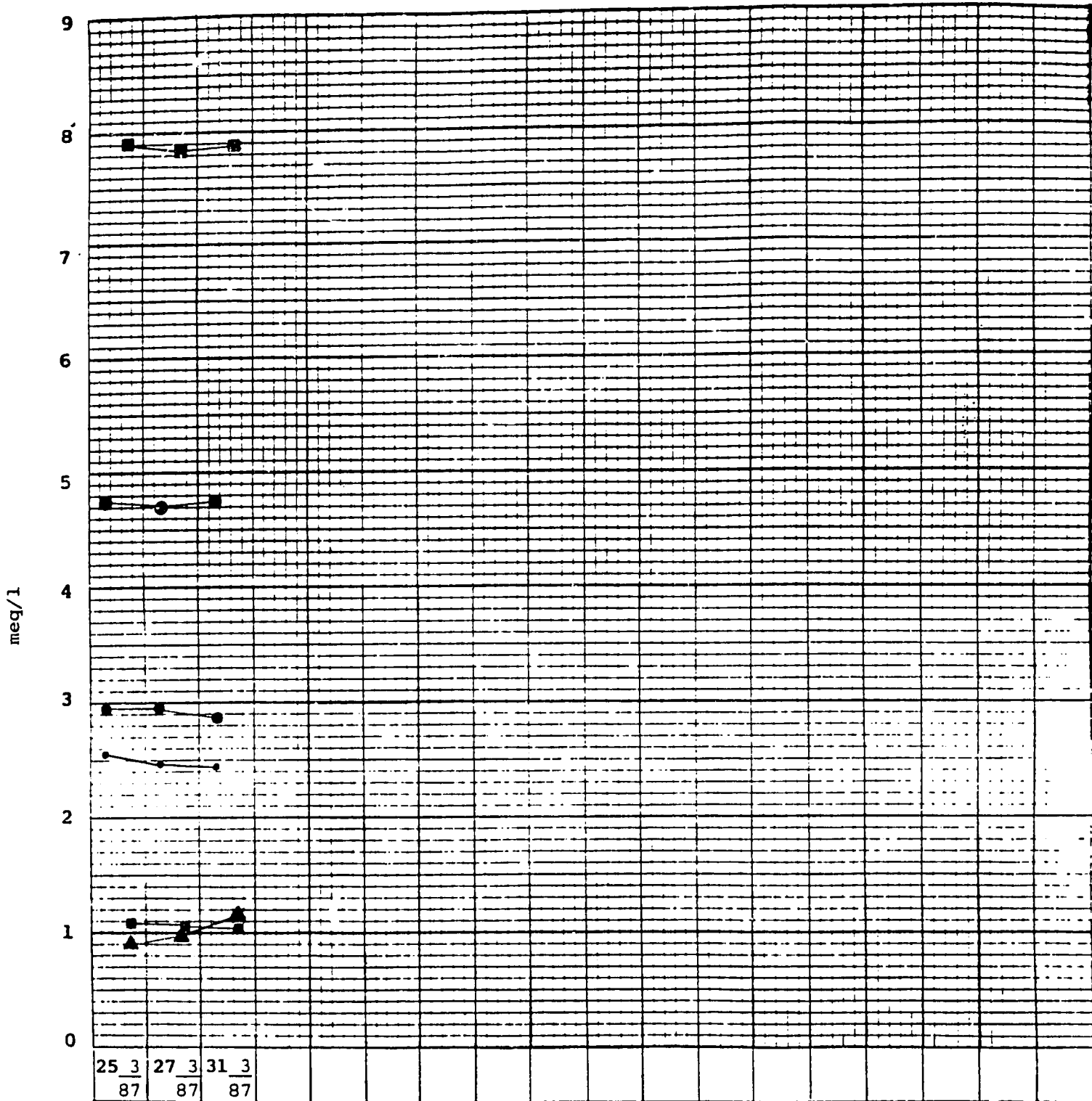
● chloride  
▲ sulphate  
■ bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND  
CATIONS IN WELL WATER**

. 27

AREA: BERNARD LODGE - PROJECT B

WELL NAME: GOSHEN #3A



Date

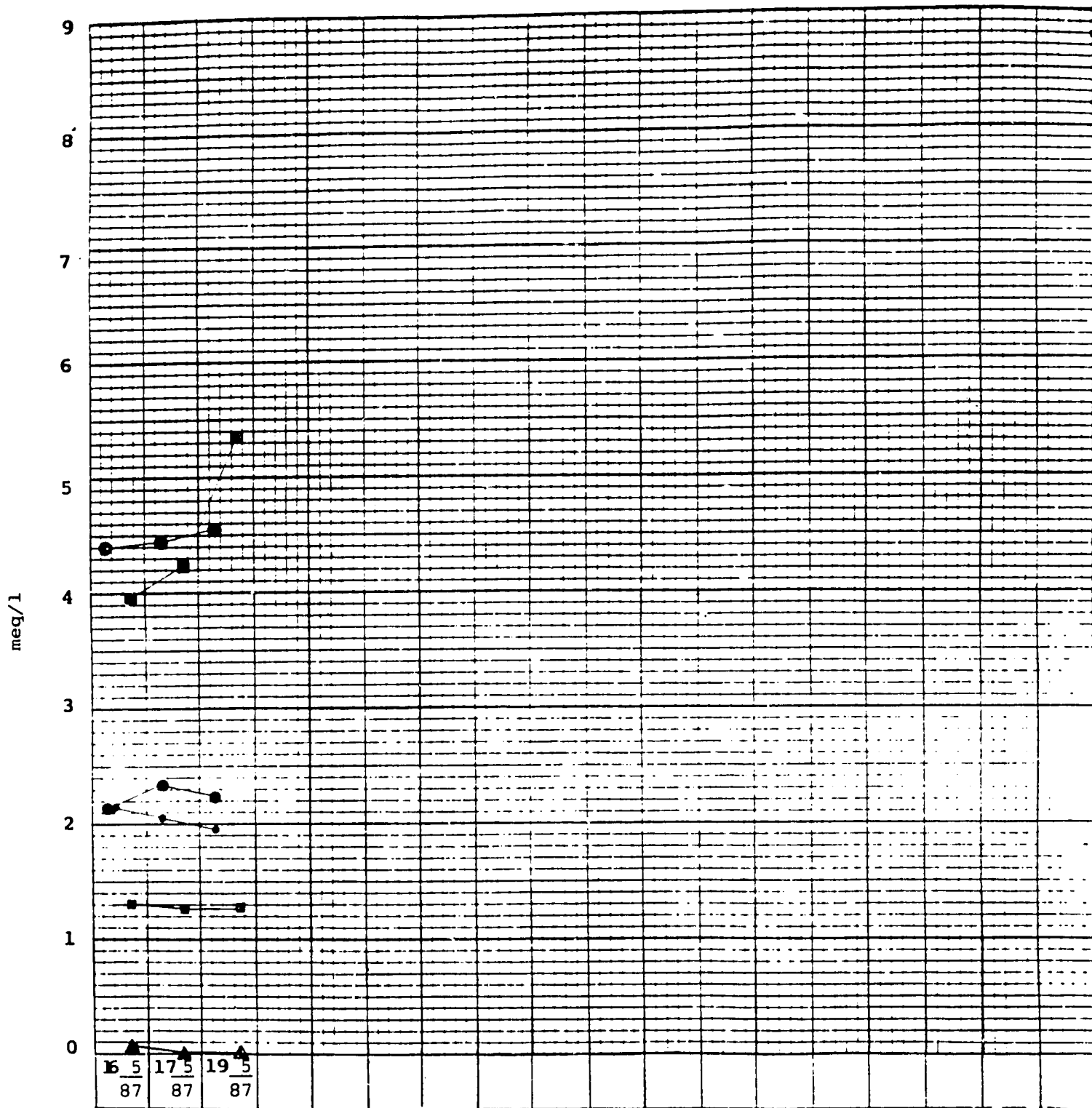
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND  
CATIONS IN WELL WATER**

28

AREA: BERNARD LODGE - PROJECT E

WELL NAME: CLIPTON B



Date

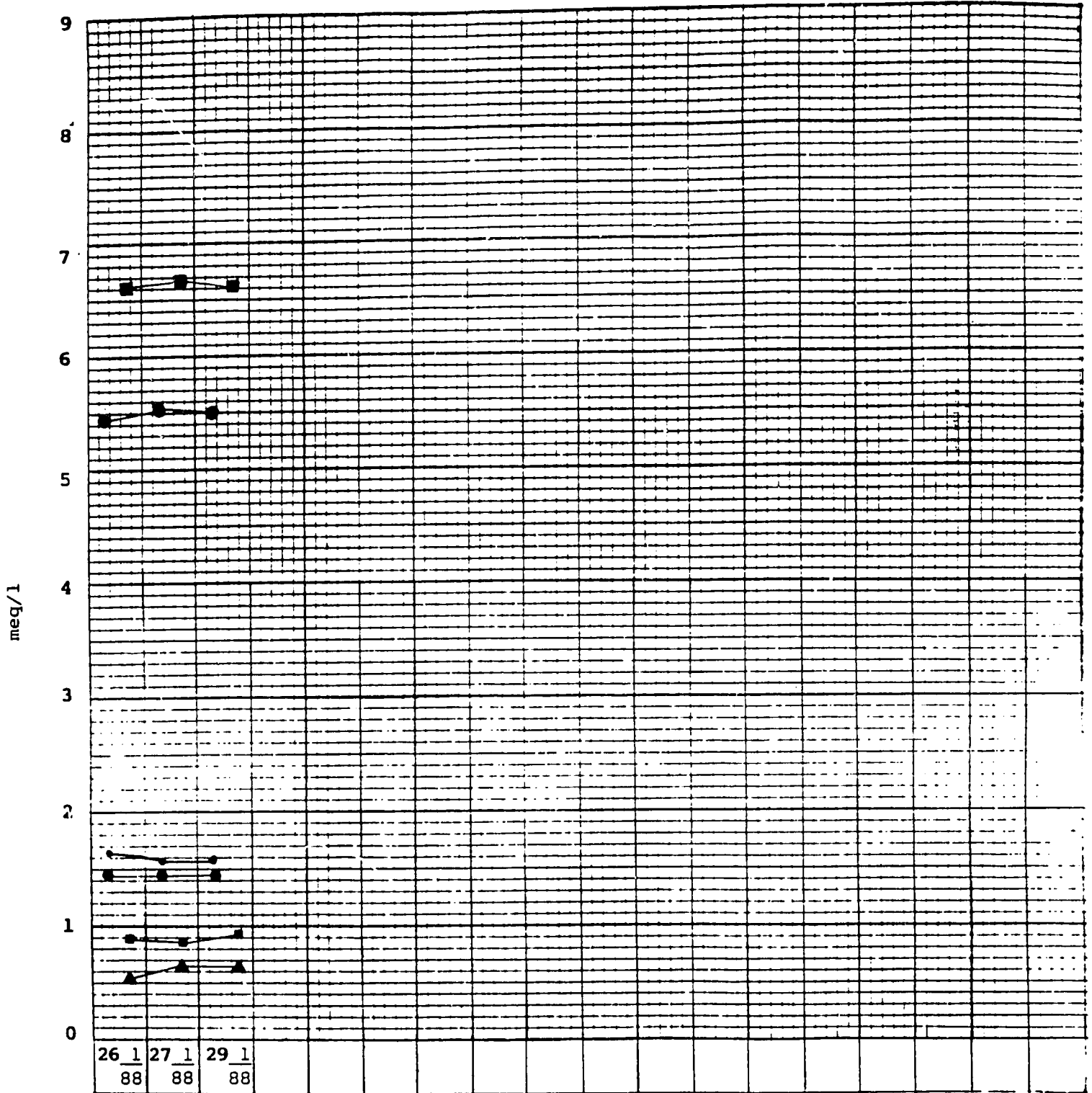
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

29

AREA: BERNARD LODGE - PROJECT B

WELL NAME: CLIPTON #5



Date

- calcium
- magnesium
- sodium

- chloride
- ▲ sulphate
- bicarbonate and carbonate

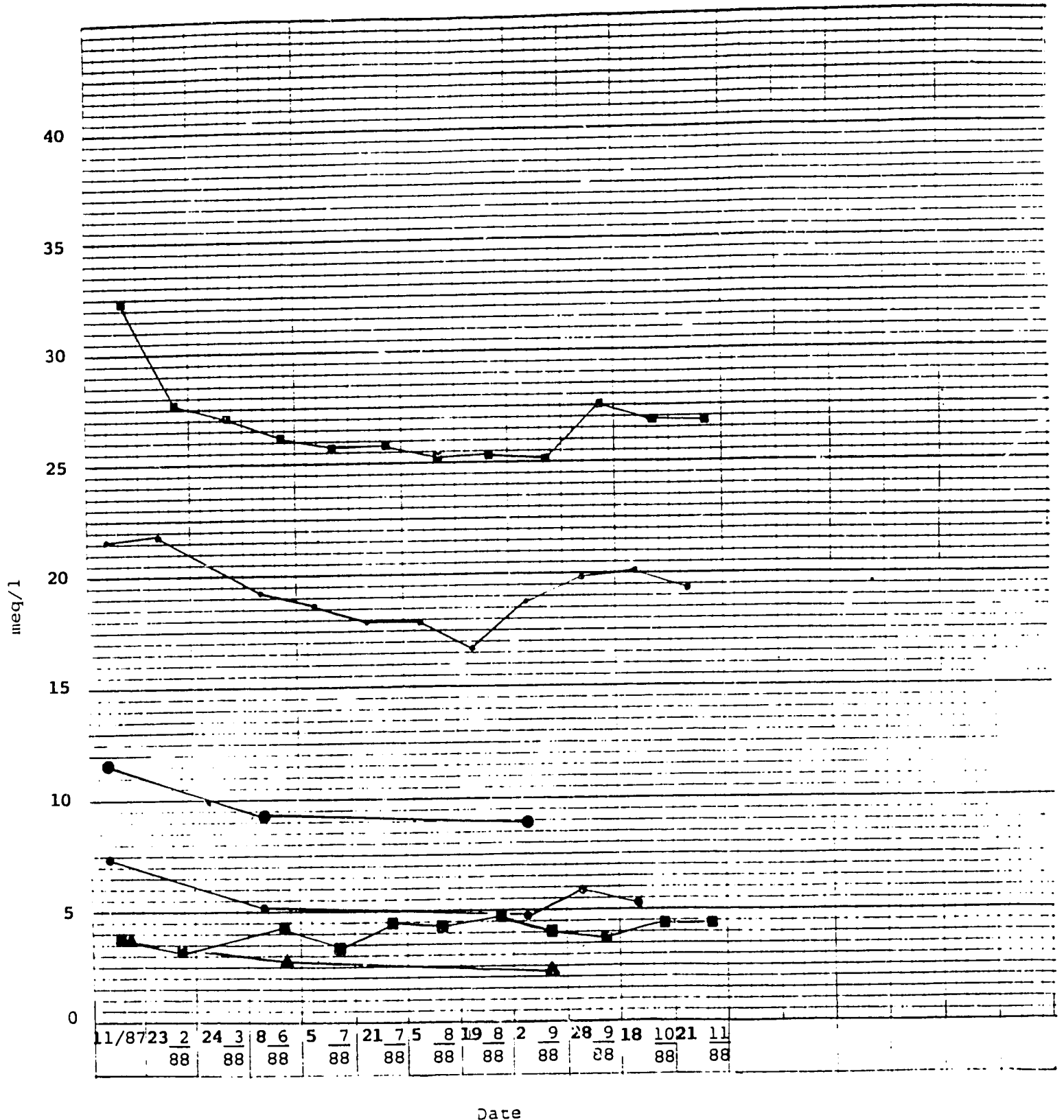


GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER

30

AREA: CAYMANAS

WELL NAME: WATERFORD (OBSERVATION)



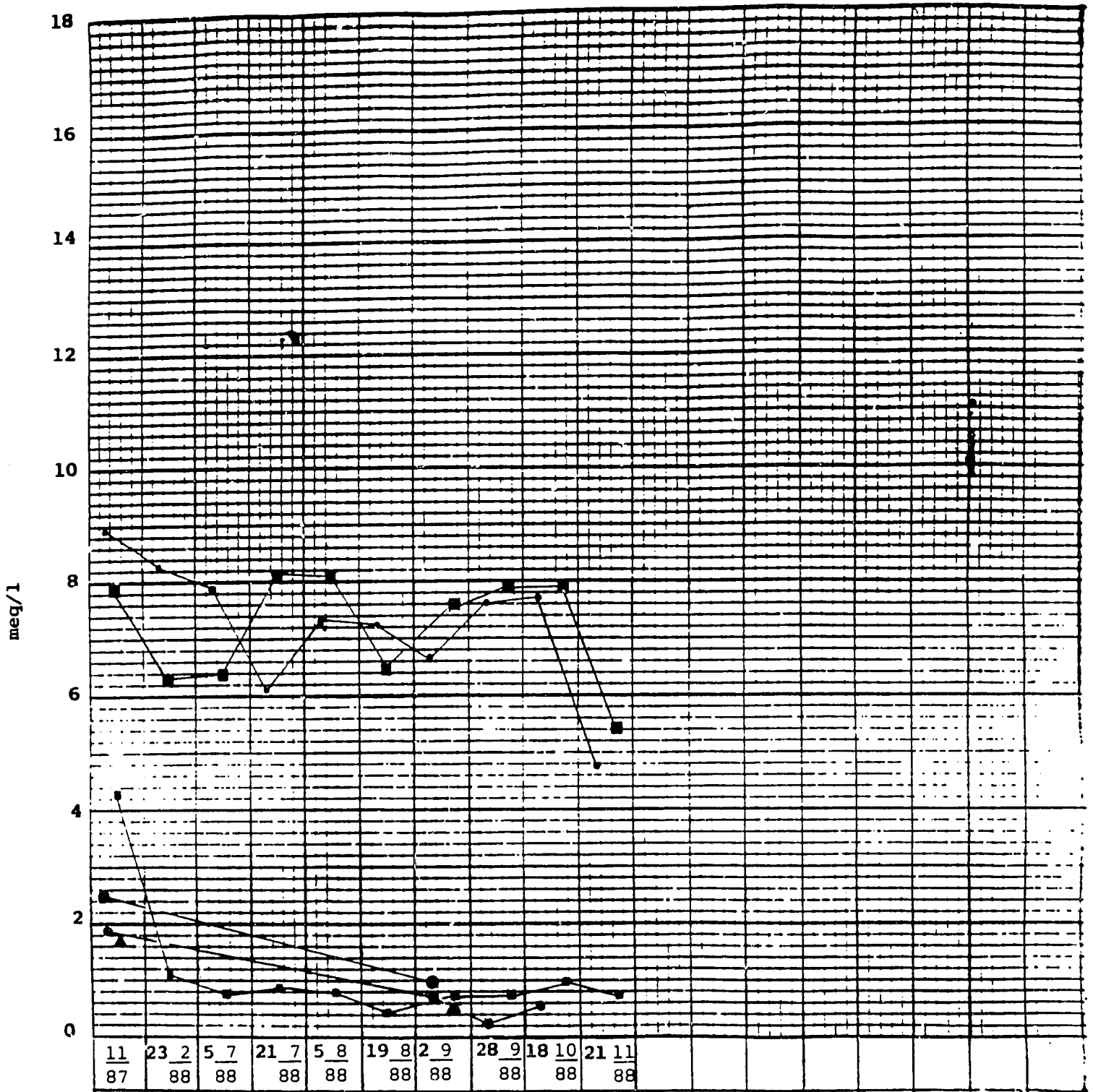
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER

31A

AREA: CAYMANAS

WELL NAME: CUMBERLAND PEN  
(SHALLOW OBSERVATION)



Date

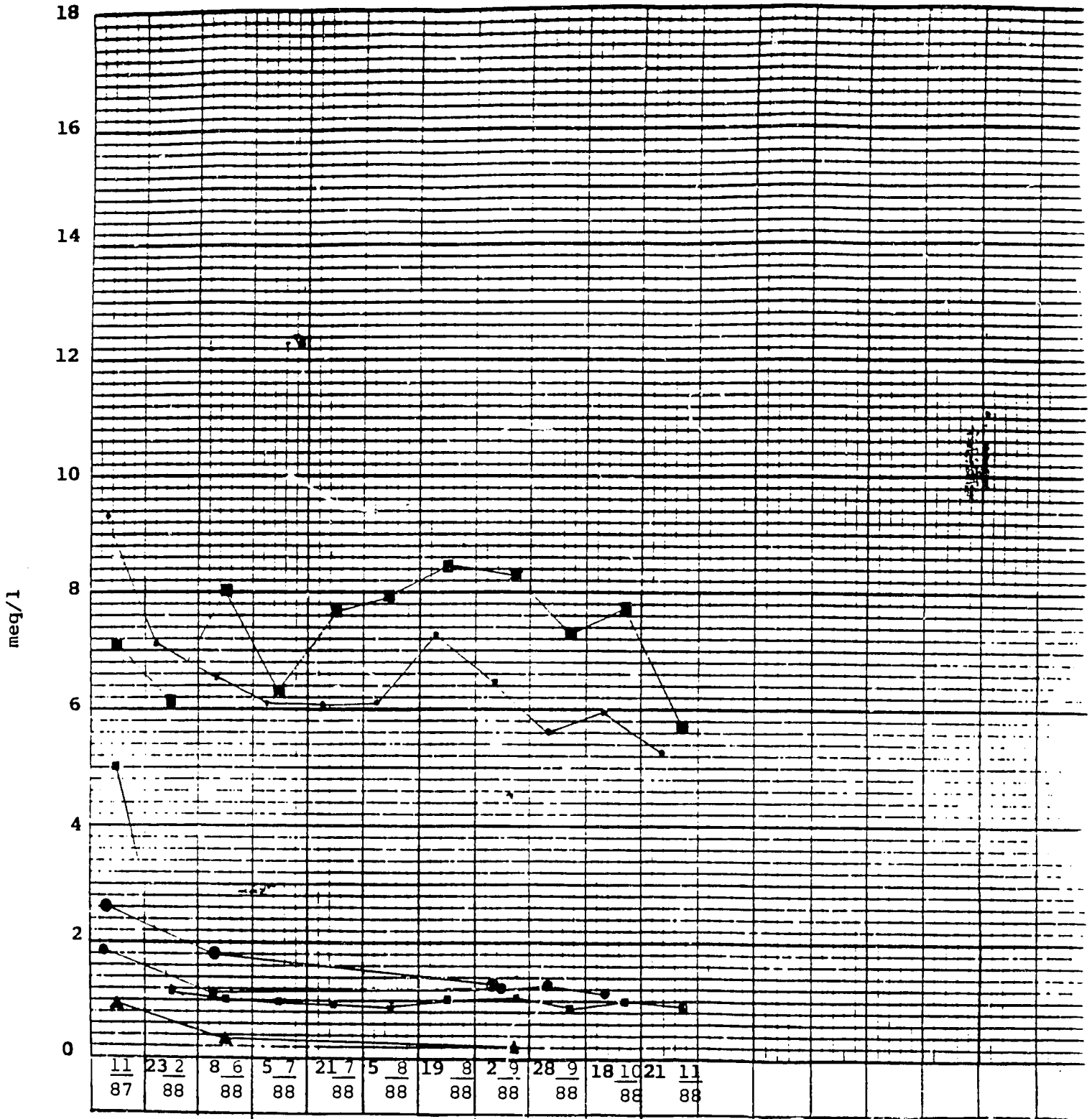
- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

31B

AREA: CAYMANAS

WELL NAME: CUMBERLAND PEN  
(DEEP OBSERVATION)



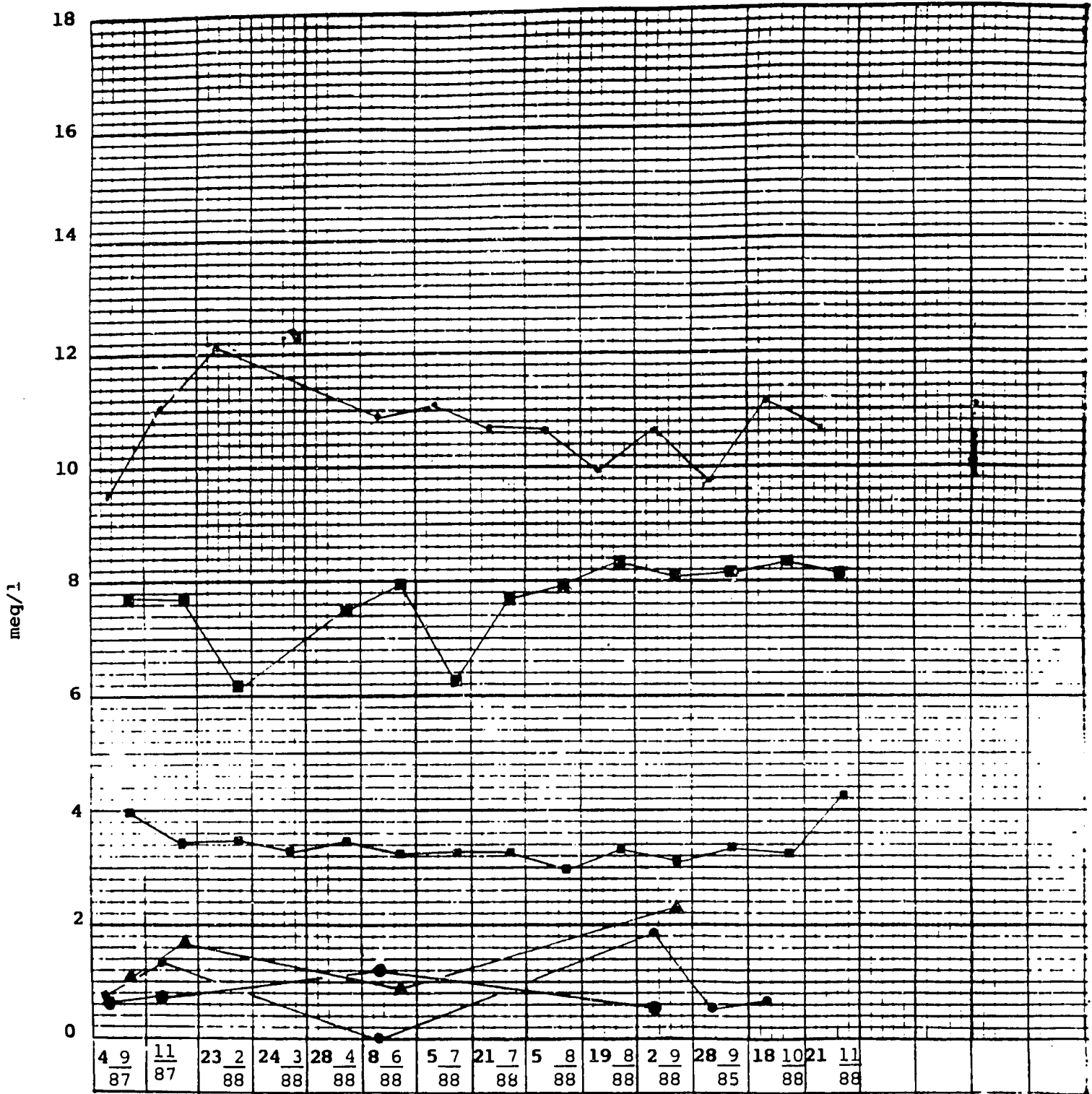
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE

WELL NAME: NAGGO HEAD  
(OBSERVATION)



Date

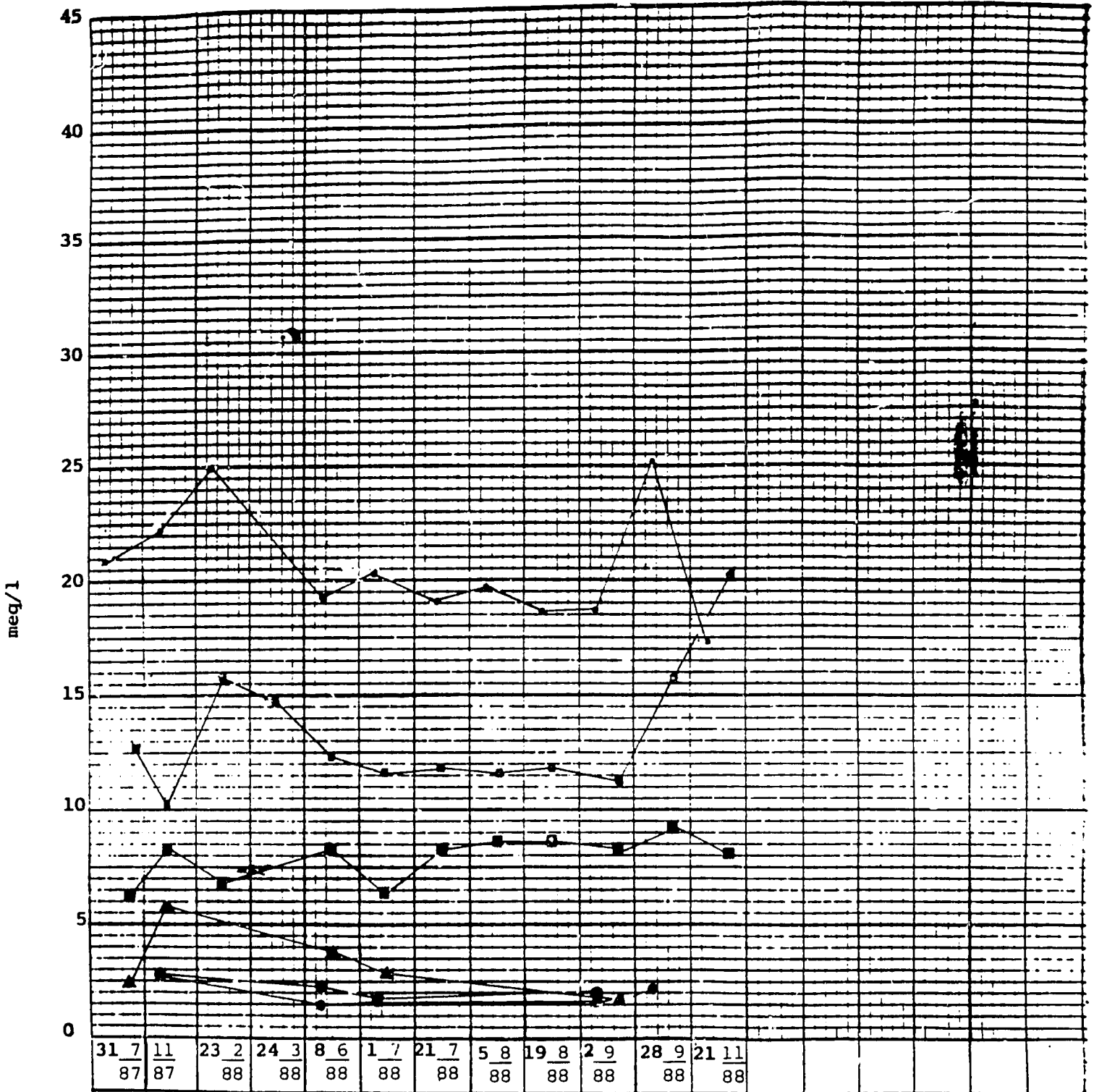
● calcium  
● magnesium  
● sodium

● chloride  
▲ sulphate  
■ bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE

WELL NAME: REIDS PEN (OBSERVATION)



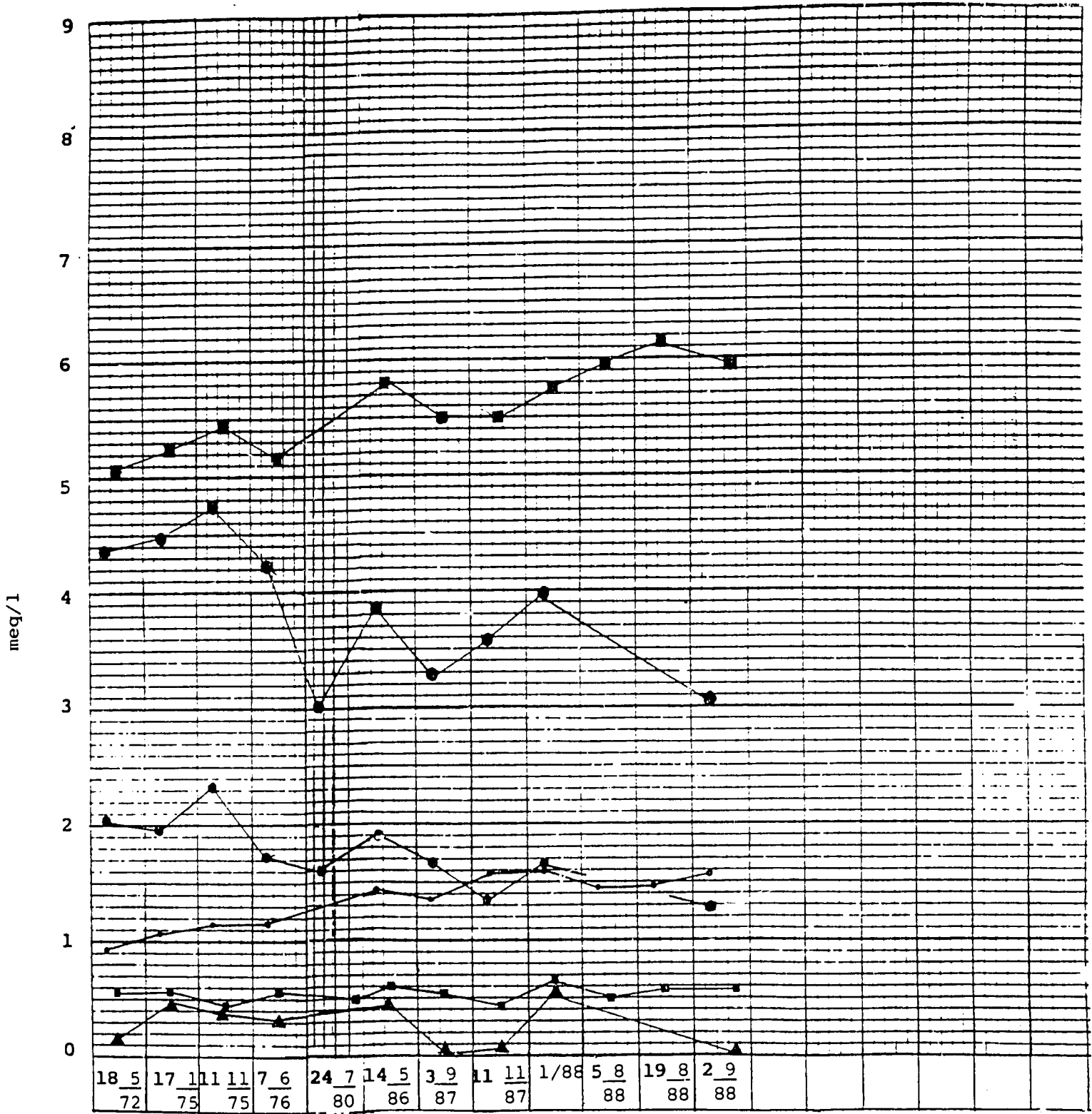
Date

- calcium
- magnesium
- ▲ sodium
- ◆ chloride
- ▼ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: CAYMANAS

WELL NAME: CUMBERLAND PEN (PUMPING)



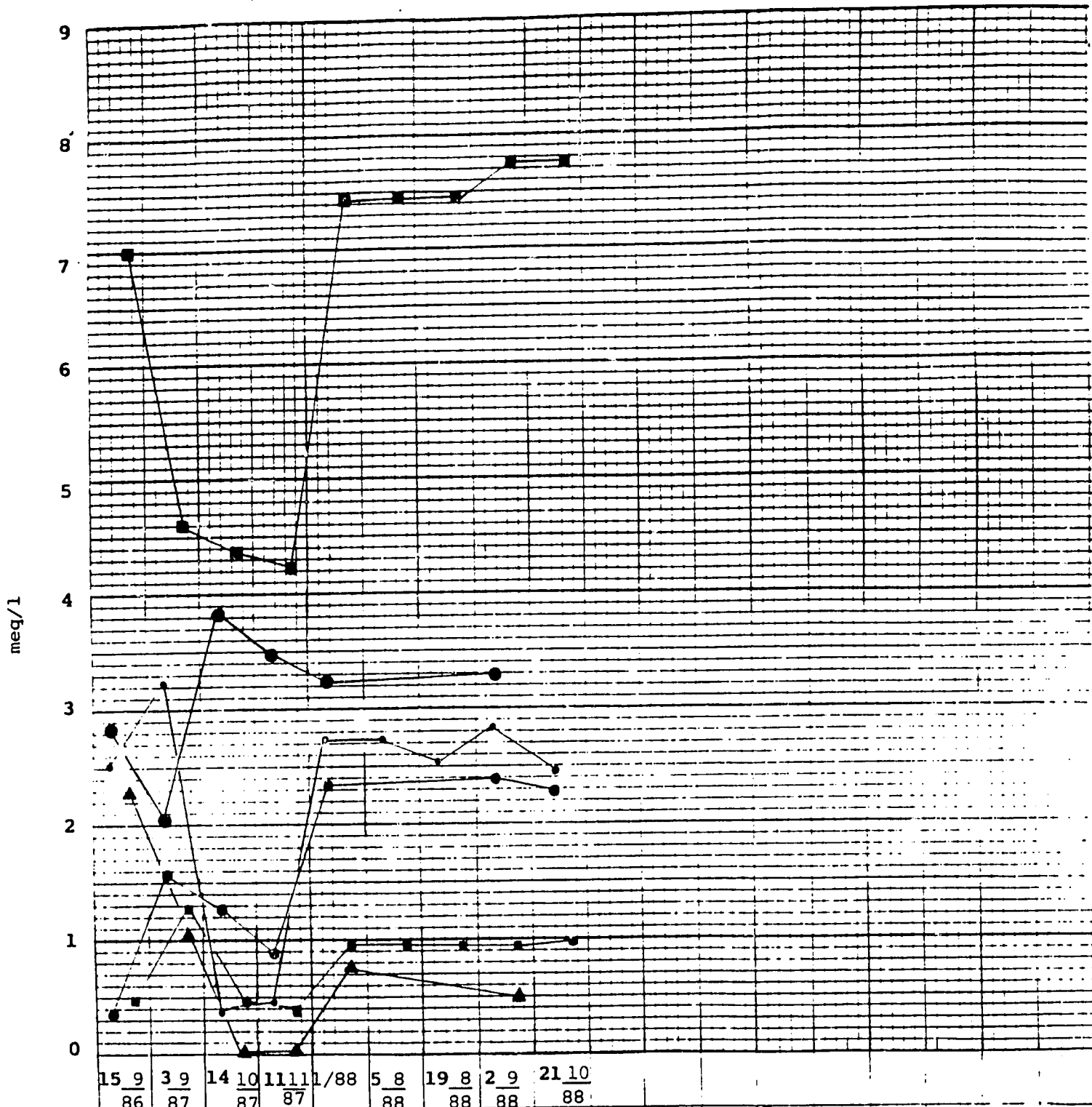
Date

- calcium
- magnesium
- sodium
- chloride
- ▲ sulphate
- bicarbonate and carbonate

**GRAPH SHOWING THE CONCENTRATION OF ANIONS AND CATIONS IN WELL WATER**

AREA: BERNARD LODGE EAST

WELL NAME: PORTMORE #2 (NWC)



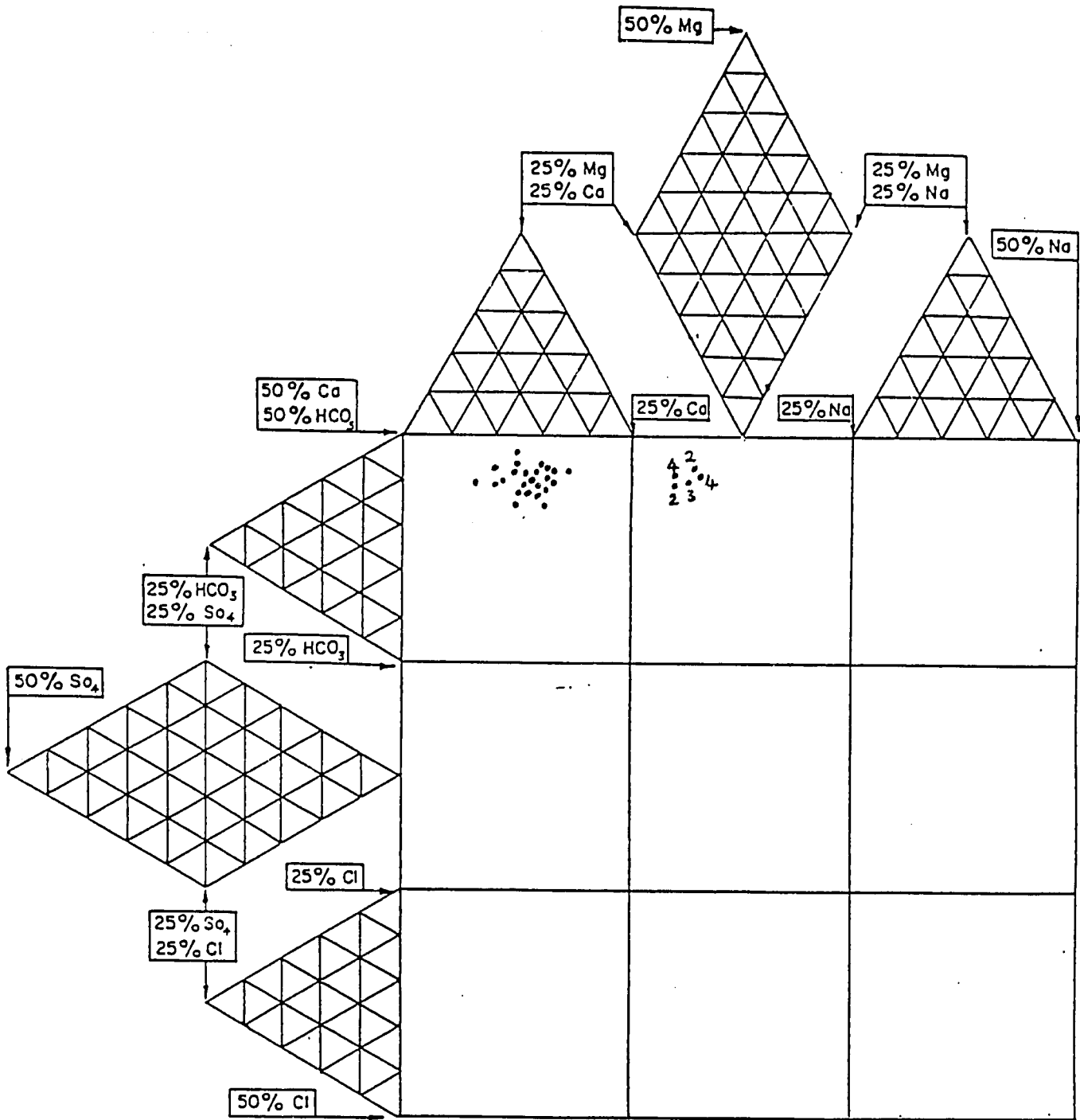
Date

- calcium
- magnesium
- sodium
- ◆ chloride
- ▲ sulphate
- bicarbonate and carbonate

125

# DUROV DIAGRAM - 1

## Classification of Well Waters

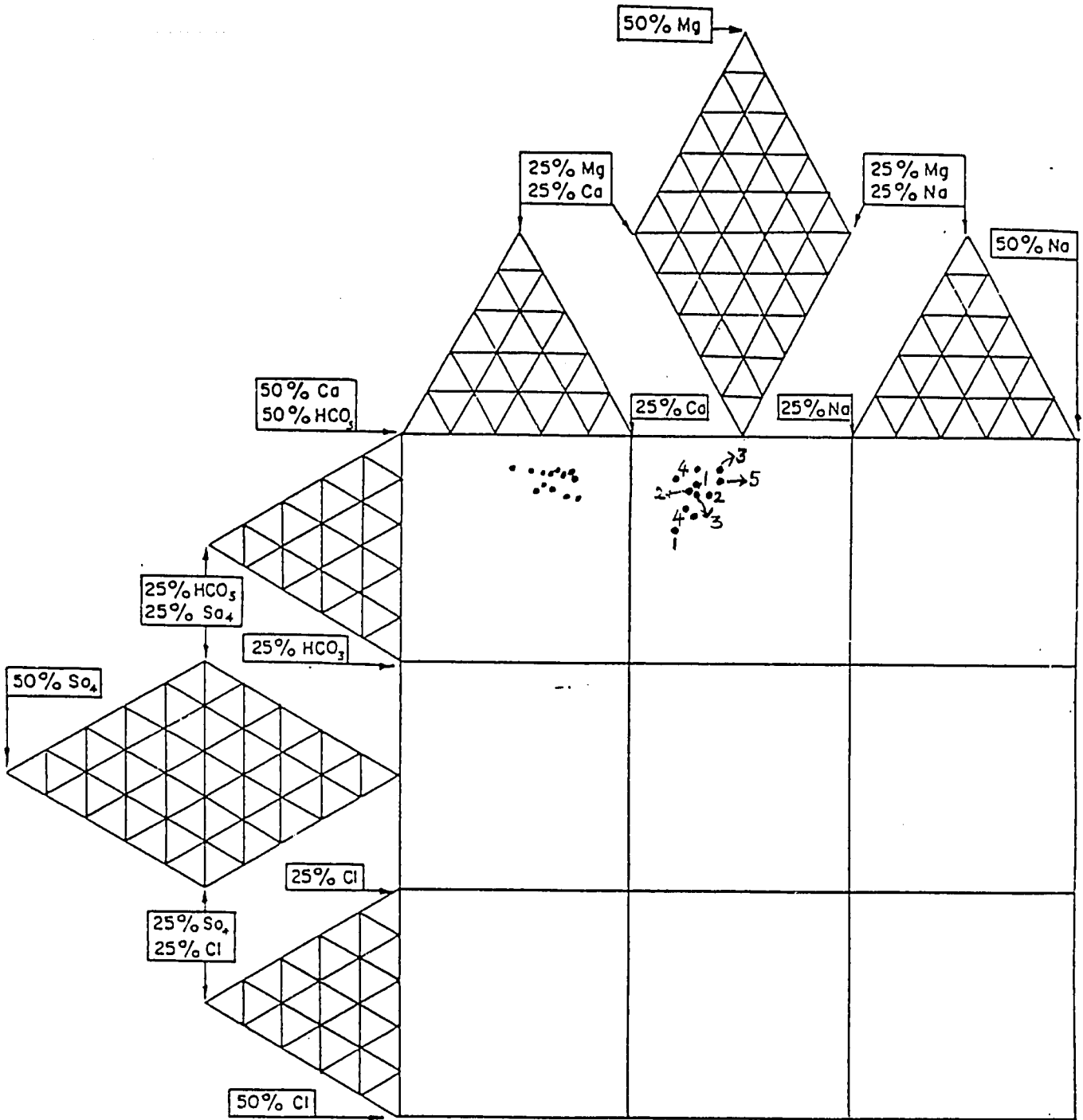


### PROJECT "A" WELLS

1. Half-Way-Tree #2
2. Half-Way-Tree #4
3. Half-Way-Tree #5
4. Half-Way-Tree #6



DUROV DIAGRAM - 2  
 Classification of Well Waters

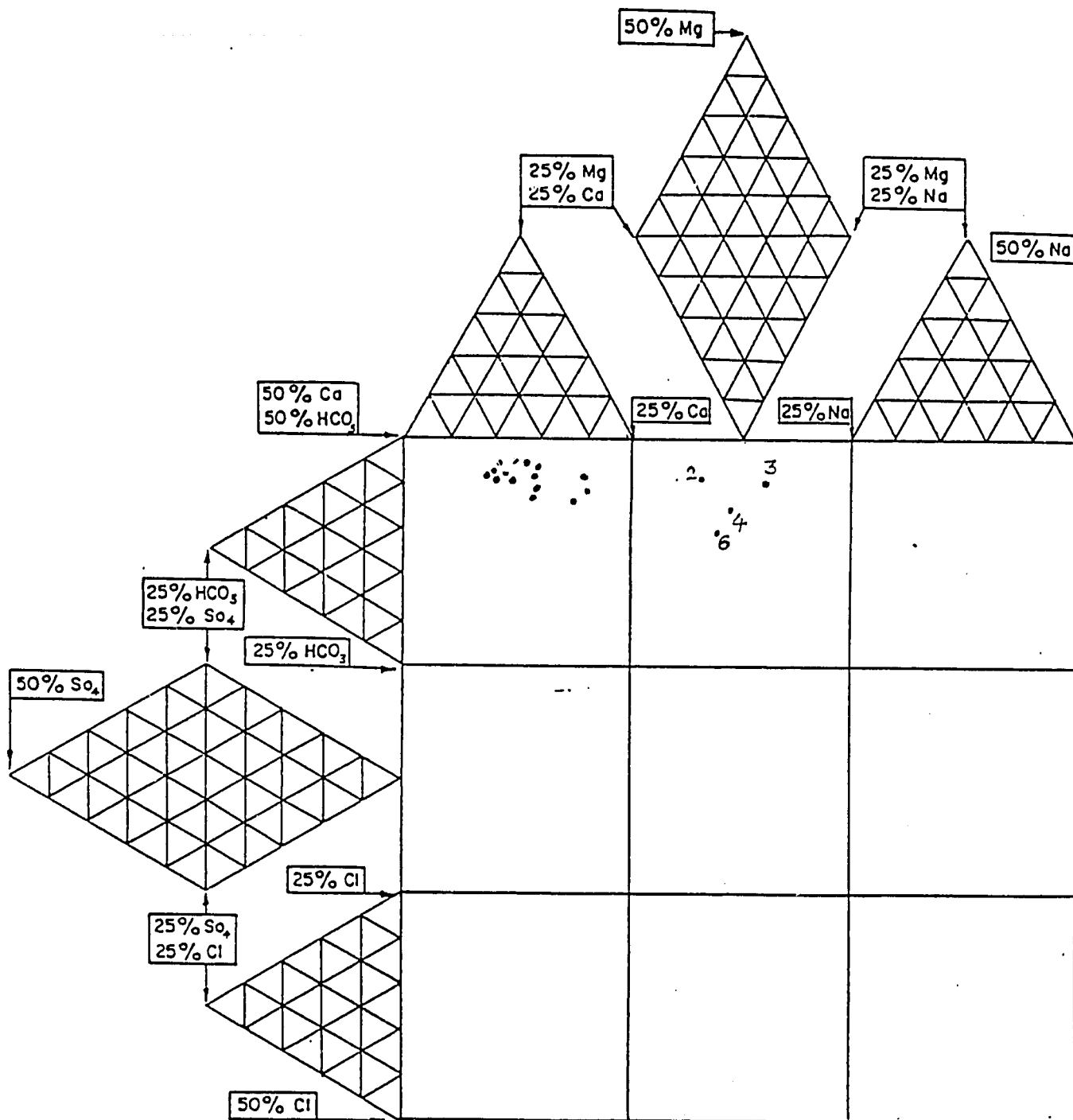


PROJECT "A" WELLS

1. Cookson #3
2. Cookson #4
3. Newlands #2
4. Newlands #2A
5. Newlands #3

# DUROV DIAGRAM - 3

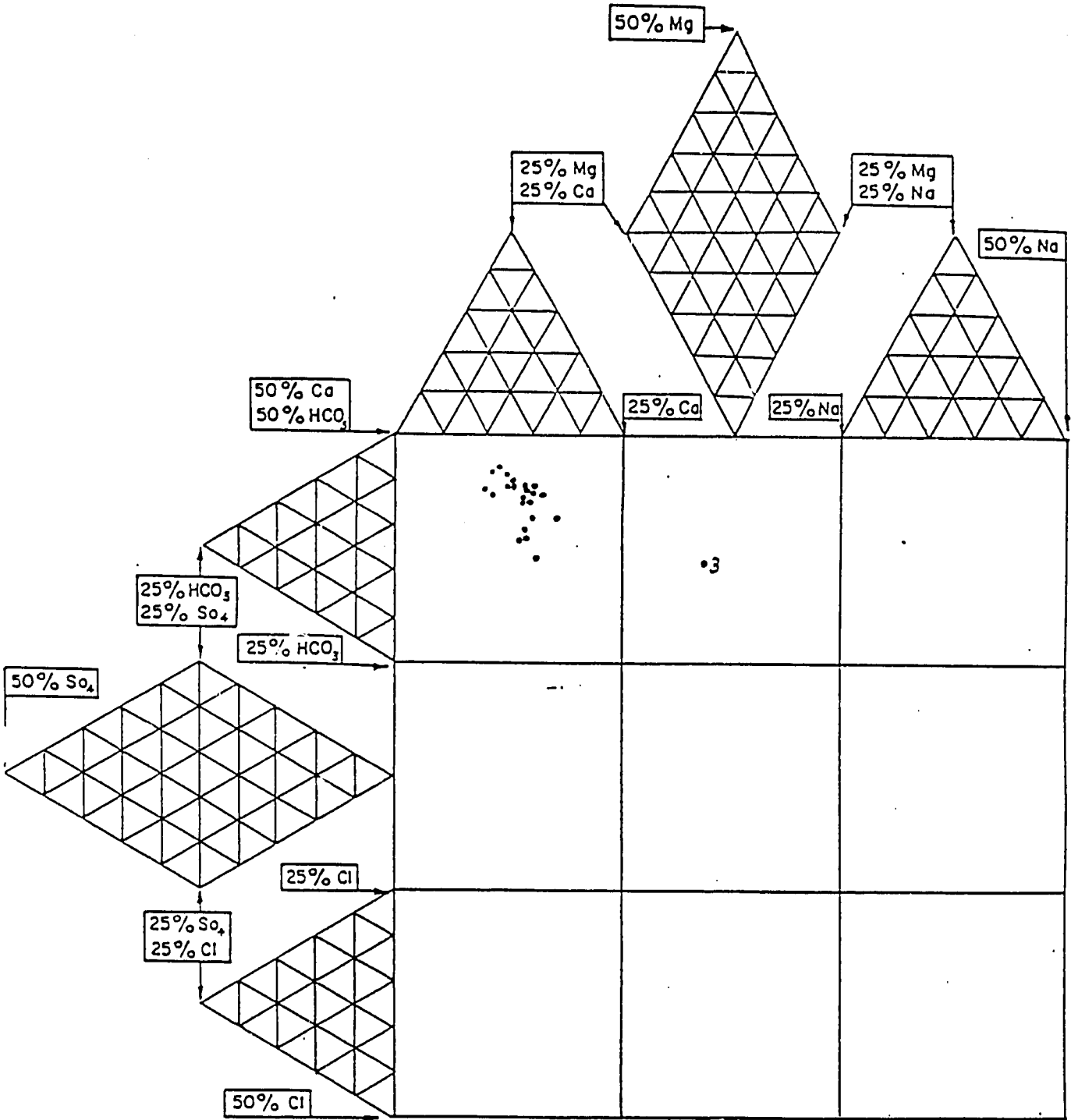
## Classification of Well Waters



### PROJECT B WELLS

1. Cow Park-A
2. Naggo Head
3. Guinep Pen
4. South Syndicate #2
5. North Syndicate #2
6. Cedar Grove #2

DUROV DIAGRAM - 4  
 Classification of Well Waters

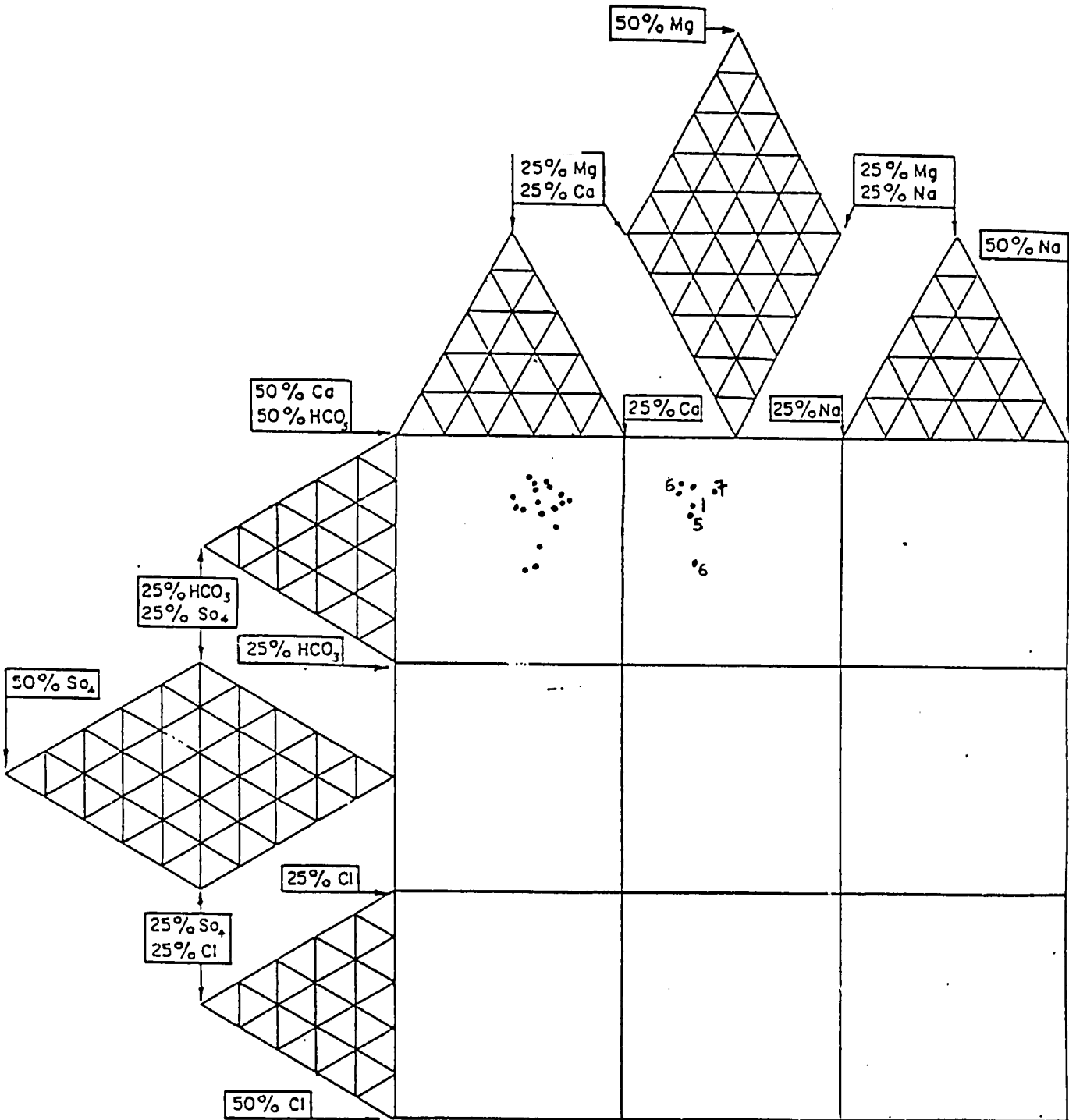


PROJECT "C" WELLS

1. Riversdale #1
2. Watson Grove #2
3. Watson Grove #3

DUROV DIAGRAM - 5

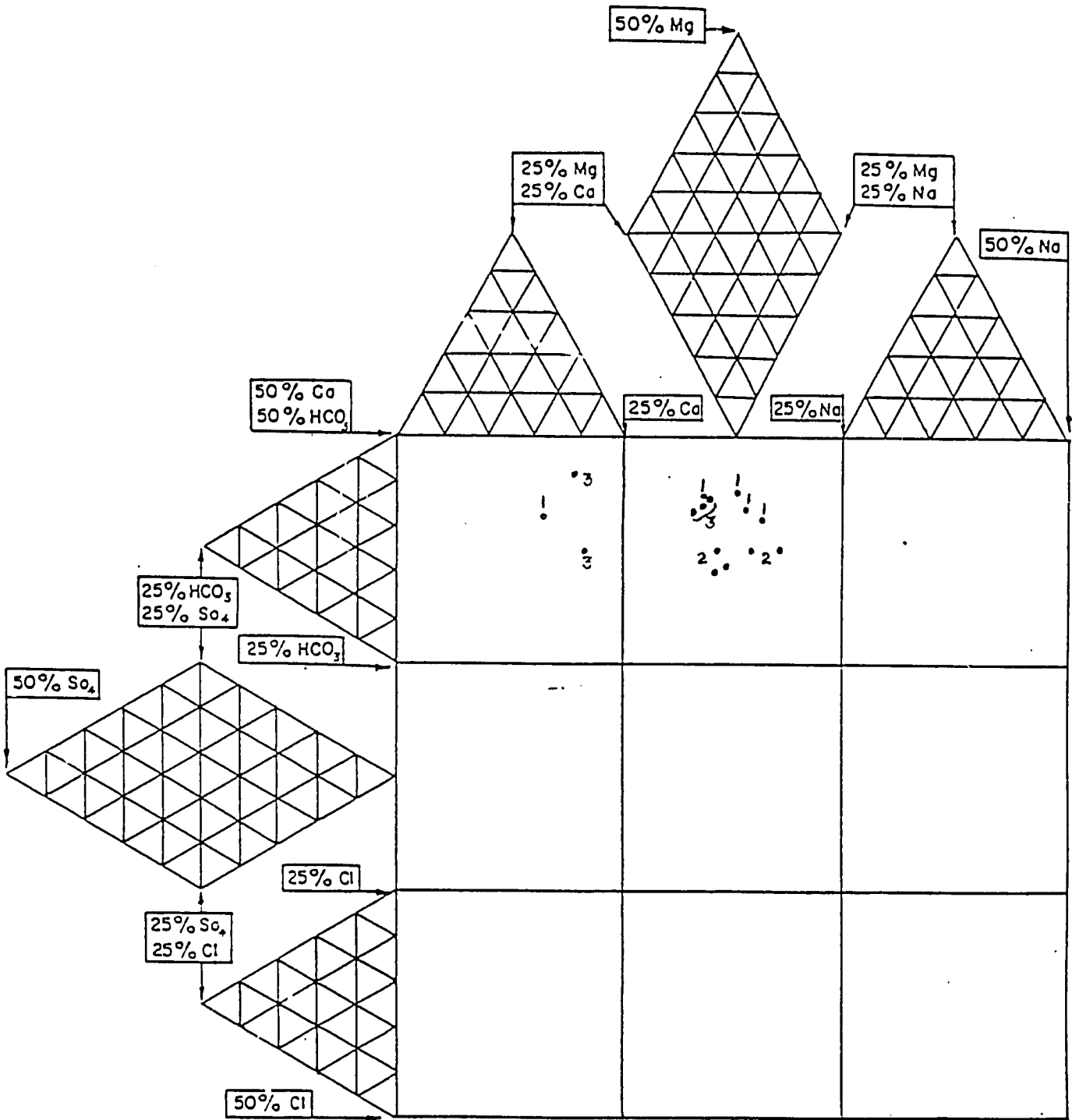
Classification of Well Waters



PROJECT

1. Government Park
2. Clifton
3. Clifton-B
4. Clifton-5
5. Goshen-3A
6. Goshen-2
7. Congrieve Park
8. Limetree #1

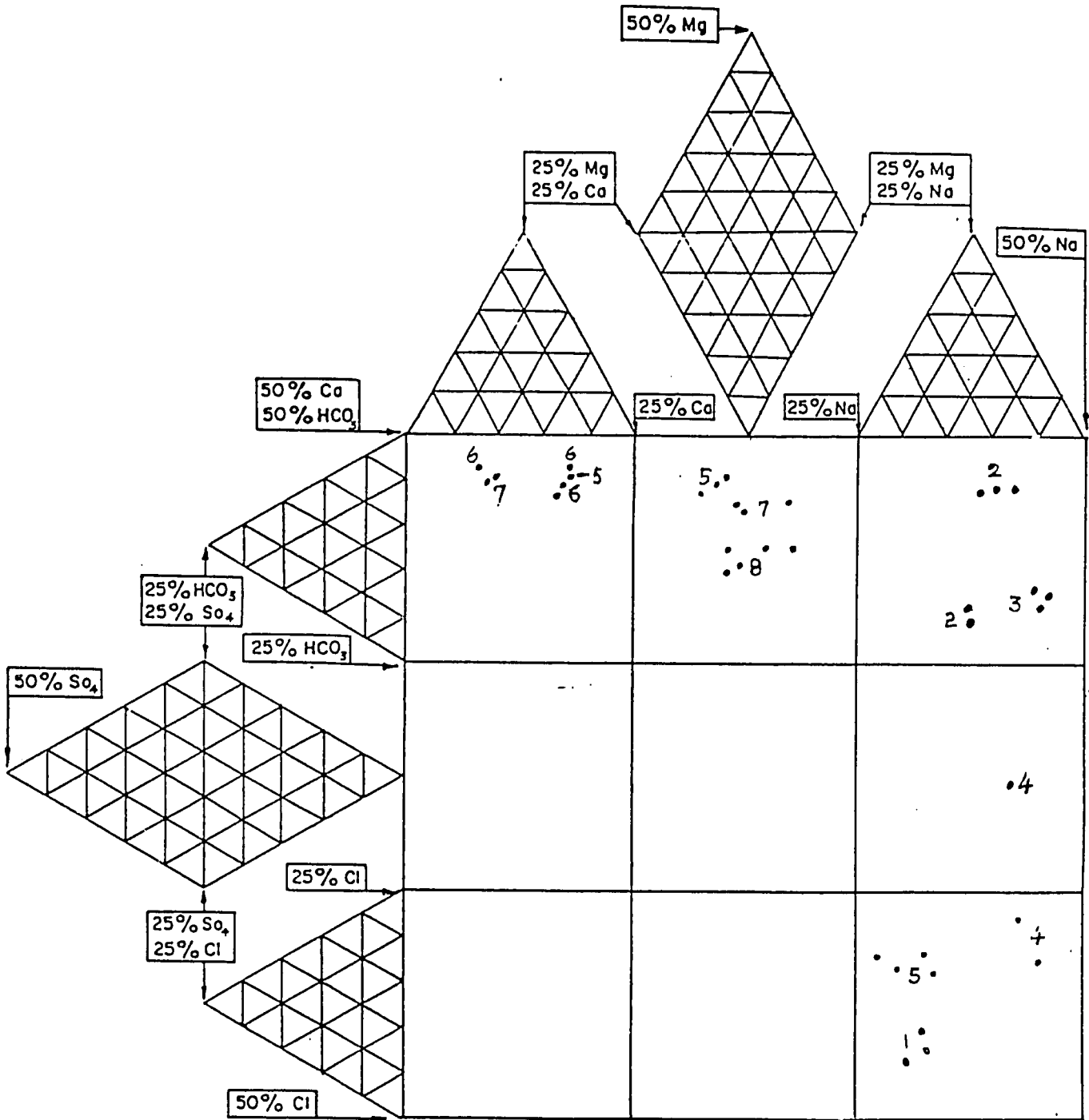
DUROV DIAGRAM - 6  
 Classification of Well Waters



PROJECT "E" WELLS

1. Salt Pond #7
2. Reids Pen #1
3. Reids Pen #2

**.DUROV DIAGRAM - 7**  
**Classification of Well Waters**



**OBSERVATION WELLS**

**PUMPING WELLS**

1. Waterford
2. Cumberland Pen
3. Naggo Head
4. Reidspen
5. Newlands #2

6. Cumberland Pen
7. Portmore #2 (NWC)
8. Reidspen #1