CARIBBEAN FOOD CROPS SOCIETY

PROCEEDINGS

ELEVENTH ANNUAL MEETING

BACKGROUND PAPER

on

WATER SITUATION IN BARBADOS

Presented by

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1. INTRODUCTION

(1.1) Generally speaking, water is available in Barbados as ground water only. There are one or two small streams but these are seasonal and are of little consequence in this consideration. The absence of surface water in the island can be attributed to three main factors:-

(a) The Geology of the island.

(b) Comparatively low rainfall.

(c) Lack of forests or heavily wooded areas.

2. GEOLOGY

(2.1) The Island is substantially of coral formation, 85% of its total area being capped with coral limestone. The remaining 15% includes the heavily folded clay outcrop of the "Scotland Area." The theory is that this is geologically the oldest section of the Island from which the coral cap has been eroded. These two features are illustrated in Fig. 1.

(2.2) Other topographical features of interest are:-

1. A central dome with Mount Hillaby as its highest point.

2. A terraced formation surrounding this central dome.

3. The Christ Church dome in the south of the island running in an East-West direction.

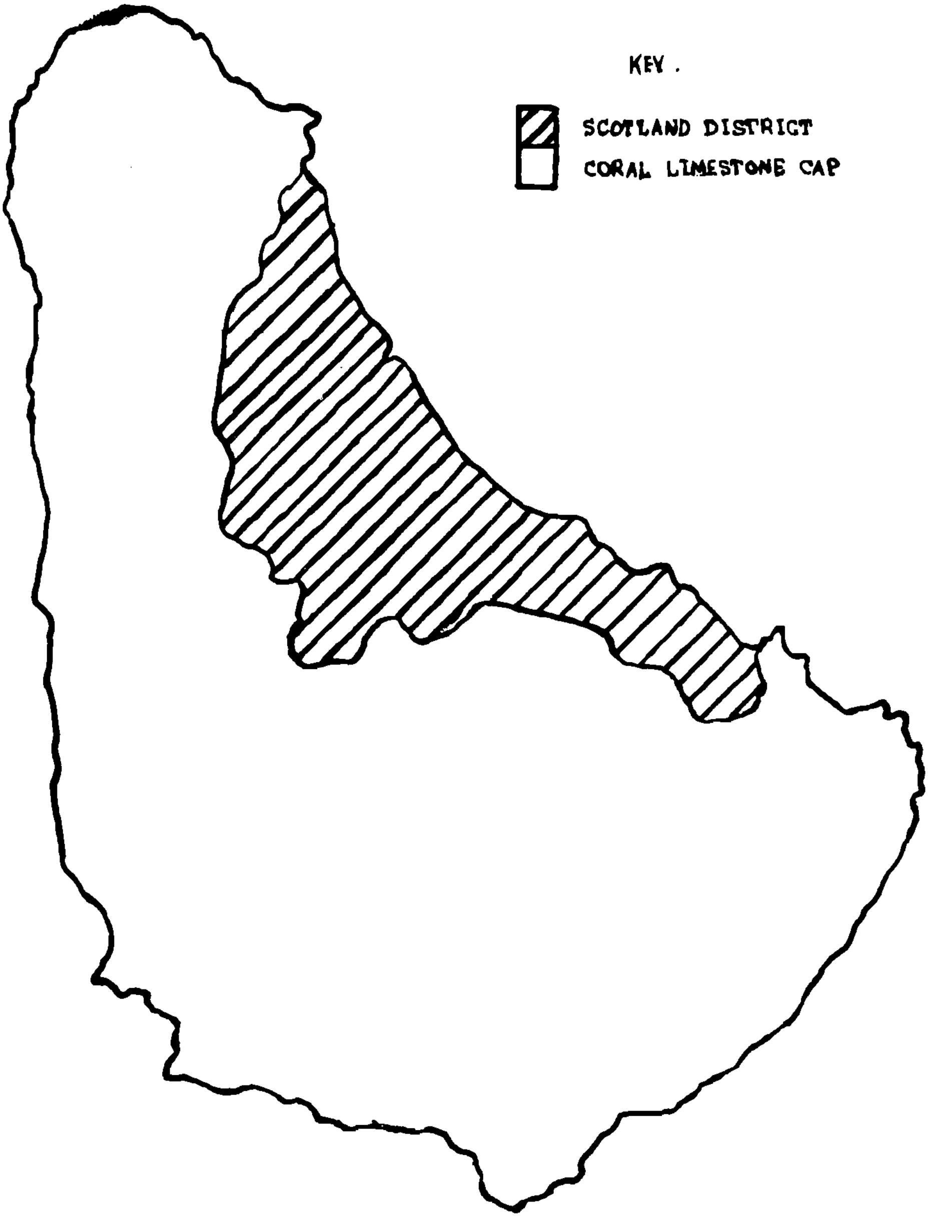
4. The St. George's Valley which also runs in an East-West direction between the southern slopes of the central dome and the northern slopes of the Christ Church ridge.

5. A system of large deep gullies radiating from the central dome on the western side of the island.

(2.3) The geological formation of the island is in many respects suited for the provision of the good ground-water supply on which the island entirely depends. Fig 3 shows a simplified typical cross section of the island. The depth of top soil varies from nothing where the coral limestone outcrops to ten or more metres in sections of the St. George's valley. Underlying this is the coral cap of the island which varies in depth up to about 90 m. and then underneath this, the impervious oceanics.

(2.4) The occurrence of Ground water in Barbados has been superbly described by H. A. Sealy in his report on the "Development and Distribution of water supplies in Barbados"[1] from which I quote:

> "Rainfall which occurs predominantly in the central higher regions of the island averages sixty inches per year. It is estimated that one fifth of this volume of rain percolates through the pervious coral which has an infiltration rate of half a foot per day. As the water moves downwards under the action of gravity it eventually reaches the impervious clay, where its downward movement is arrested, and the


KEY .
SCOTLAND DISTRICT
CORAL LIMESTONE CAP

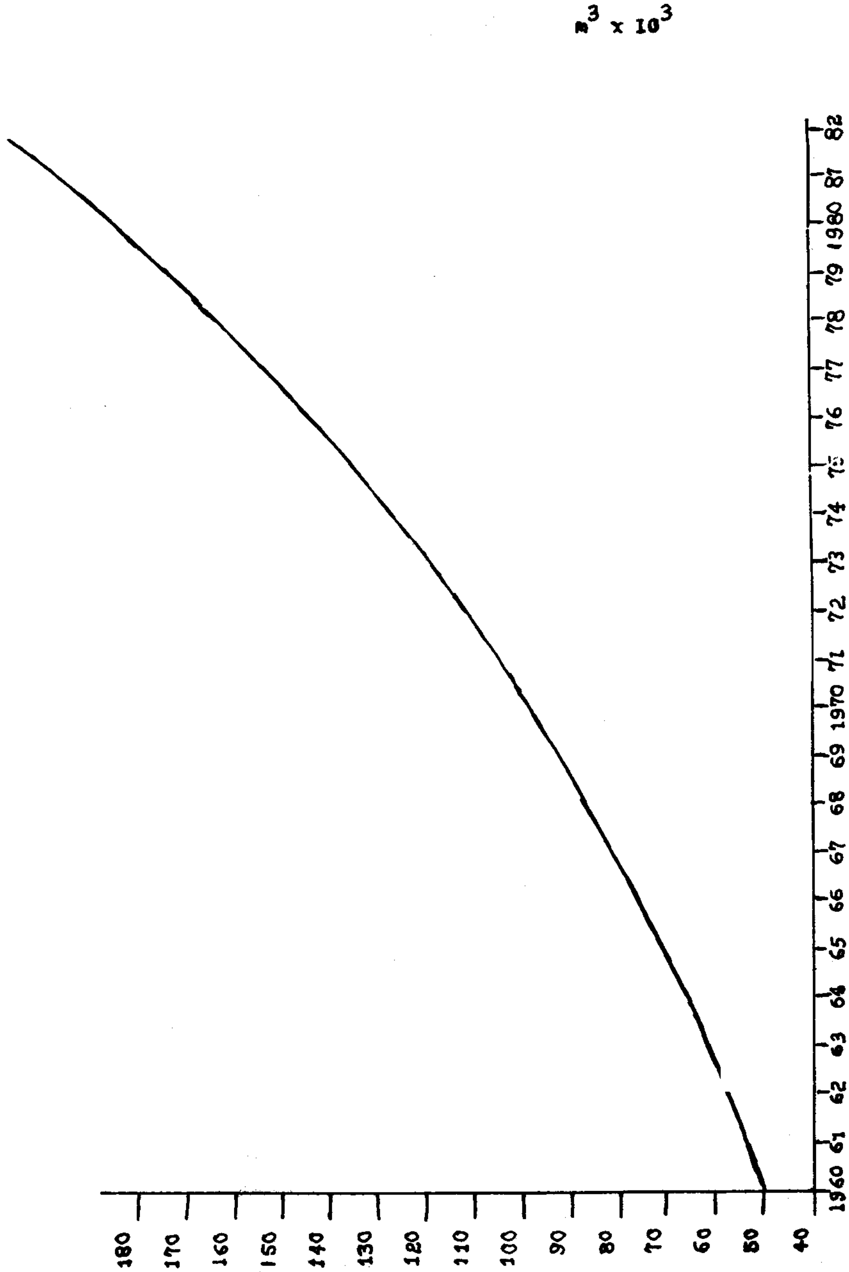
water then travels along the dip of the impervious stratum towards the sea. Near the sea shore, the heavier sea water forms a fairly effective barrier to the movement of the fresh water which eventually fills all the pore space of the coral to a height somewhat above sea level.

The height above sea level to which fresh water rises is controlled partly by the permeability of the surrounding coral, and partly by the rate of inflow of fresh water into the reservoir.

Finally, after a period of time, the Fresh Water-Salt Water system reaches the hydrostatic balance of the Ghyben-Herzberg relation. This coastal reservoir of fresh water has been given the name "sheet water." The sheet water exists in a strip along the entire South and West Coasts of the Island, and extends landwards to the point where the clay stratum rises above mean sea level. The sheet water basin varies in width from a few hundred feet to about four miles in places. At the beginning of the sheet water system, the fresh water rises to a height of one to four feet above mean sea level.

The fresh water as it moves down the dip of the clay stratum before reaching the sheet water system described above, has formed for itself, over a period of years, rather discrete channels by solution of the coral along the coral/clay interface. The water which flows in these discrete channels is called 'stream water'."

(2.5) Apart from a quantity of water from three springs in the island varying between 5,000 & 15,000m^3/day depending on recent rainfall, all water used in Barbados is obtained by pumping from the sheet water area, directly from the stream water area, or from elevated basins which have been formed by faulting of the subterranean strata.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(2.6) Considerable research work has been done by A. Senn, [2] H. Tullstrom,[3] H. A. Sealy[4] and others into the water resources of the island. Tullstrom in his specifically applied research estimated that with an average rainfall of 1020 m.m. per annum, the ground water resources of the island would be of the order of 145,000 m^3/day, and for a rainfall average of 1530 m.m. per annum this figure would be increased to 200,000 m^3/day. These quantities are for potable water conforming to WHO standards and do not include a quantity of about 15,000 m^3/day of brackish water chiefly near the coast line which though unsuitable in its natural state for potable use is perfectly satisfactory for agricultural purposes, its total chlorides content being of the order of 700 milligrams per litre.

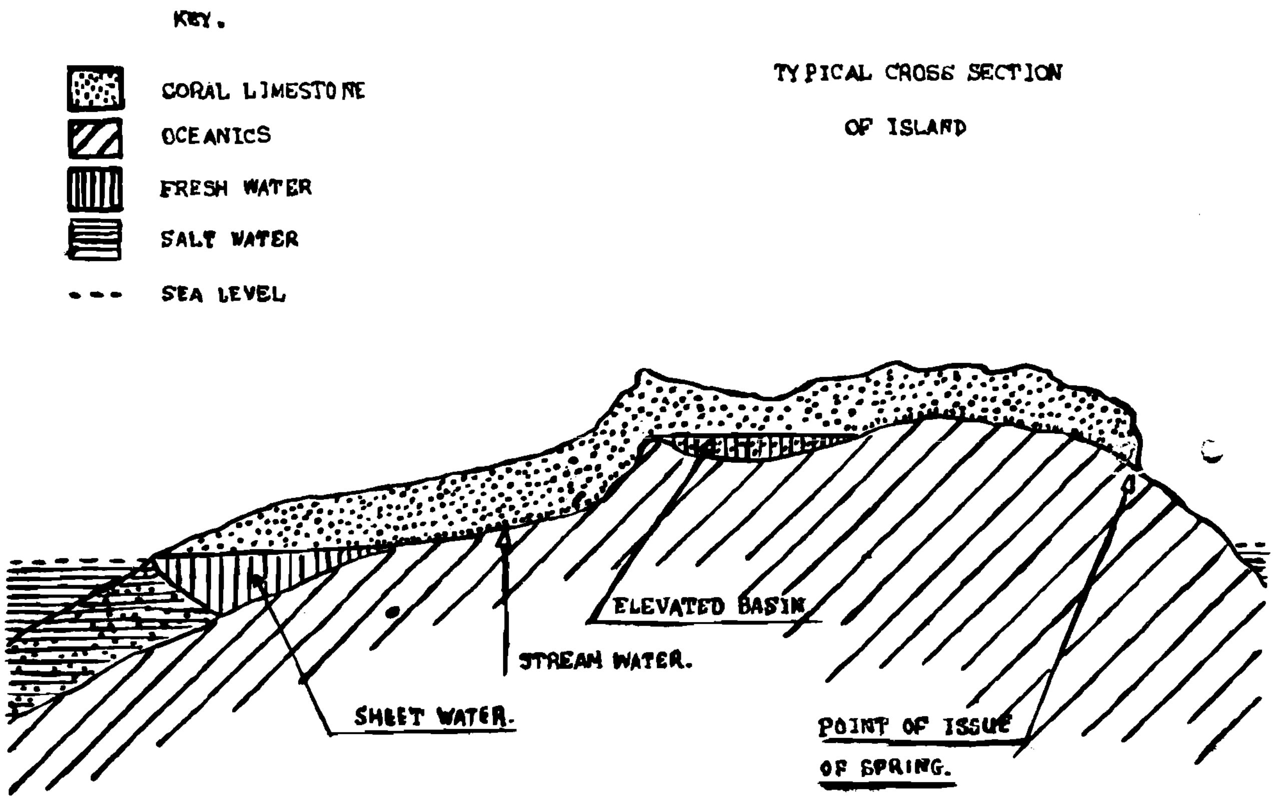
(2.7) Tullstrom also estimated that a further 45,000 m^3/day would be available in the Scotland District about two-thirds of which would be suitable for potable water supply but requiring the usual treatment of surface water supplies. The remaining 15,000 m^3/day because of high sulphate content would be suitable for agricultural purposes only.

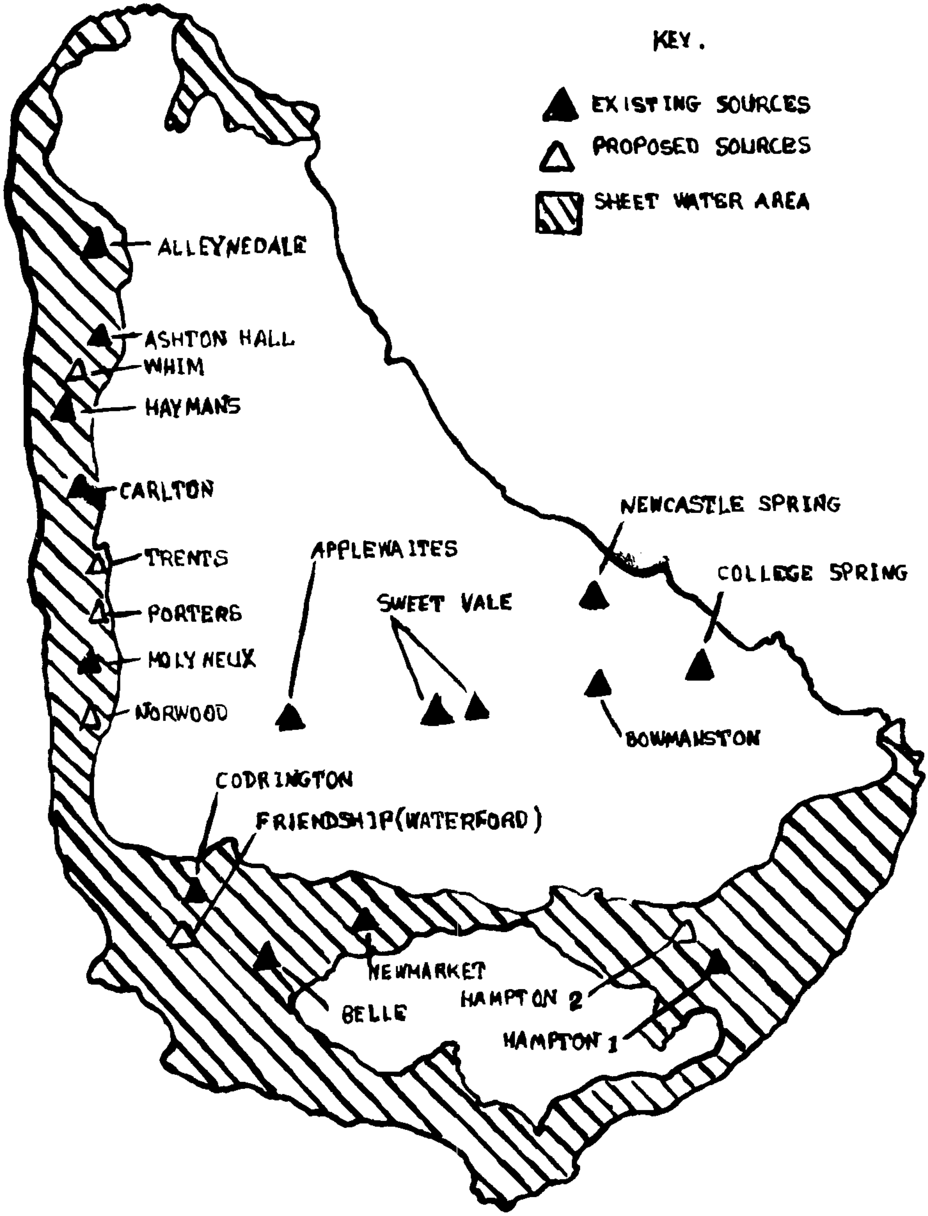
(2.8) Because of the inherent topographical instability of the Scotland District the construction of the required impounding reservoirs to conserve the available water in this area could prove to be prohibitively expensive. A possible solution to the problem could be to construct comparatively small collecting chambers from which the water could be pumped over the central dome and discharged into recharge wells in the limstone cap on the western slopes of the island. However, because of the greater engineering problems involved in utilising this source and the higher costs of production, this will probably be the last natural source of water to be developed.

3. GROUND WATER EXTRACTION

(3.1) The public water supply for the island is derived from a total of fifteen (15) sources which includes two (2) spring supplies.

(3.2) The spring supplies, though small, are of historical interest in that they provided for the first public water supply system in the island. The springs issue on the eastern side of the island at elevations


KEY.
CORAL LIMESTONE
OCEANICS
FRESH WATER
SALT WATER
SEA LEVEL
TYPICAL CROSS SECTION
OF ISLAND
ELEVATED BASIN
STREAM WATER.
SHEET WATER.
POINT OF ISSUE
OF SPRING.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EXISTING SOURCES
PROPOSED SOURCES
SHEET WATER AREA
ALLEYNEDALE
ASHTON HALL
WHIM
HAYMANS
CARLTON
TRENTS
PORTERS
MOLYNEUX
NORWOOD
APPLEWAITES
SWEET VALE
NEWCASTLE SPRING
COLLEGE SPRING
BOWMANSTON
CODRINGTON
FRIENDSHIP(WATERFORD)
NEWMARKET
BELLE
HAMPTON 2
HAMPTON 1

of 102 m. and 109 m. above mean sea level. The water was then piped under gravity flow through 26 km. of cast iron water main to a reservoir on the west of the island strategically located to supply almost the entire Bridgetown area. This sytem is now some 140 years old and is still in use though in a considerable modified form.

TABLE I

Source	Present Rate of Extraction m³/day	Estimated safe yield m³/day
Alleynedale	3,750	6,250
Applewhaites	2,500	15,000
Ashton Hall	2,000	5,000
Belle	40,000	40,000
Bowmanston	9,500	10,000
Carlton	2,250	5,000
Codrington	14,650	–
Hampton–1	20,500	20,000
Haymans	7,000	4,250
Molyneux	5,000	4,000
Newmarket	10,700	1[illegible],[illegible]00
Sweet Vale	4,150	6,250
Springs	4,000	3,750
Total	126,000	132,000

TABLE 2

Proposed Source	Estimated safe yield m^3/day	Estimated by
Friendship	7,750	Sealy
Hampton–2	21,500	Sealy
Norwood	1,250	Tullstrom
Porters	3,500	Tullstrom
Trents	5,000	Tullstrom
Whim	4,000	Tullstrom
Total	43,000	

(3.3) The thirteen well extraction points are scattered throughout the island, nine (9) of them located in the sheet water area and the remaining four (4) located either directly on the streams or on the elevated basins referred to in (2.5). The locations of all sources presently in production are shown in Fig. (4), daily average output from each source together with the estimated safe yields as determined by Tullstrom are shown in Table (1).

(3.4) The Waterworks Department in conjunction with the Ministry of Agriculture carries out a continuous programme of research to up date and clarify existing data and also to determine the best sites for proposed future wells. The Department proposes to sink a total of six new wells within the present decade, the first of which is in process of construction. This is the well at Waterford which is intended to replace the old source at Codrington, considered by some to be geologically unsuitably located and presenting too high a risk of faecal pollution. The Waterford well being in the same sheet water area cannot therefore be considered as an addition to the total number of sources. The six proposed wells are shown in Fig. (4) together with the existing sources. Their anticipated safe yields as determined by Tullstrom and Sealy are given in Table (2).

(3.5) As stated earlier, it is expected that all the proposed new wells will be in production by 1980 and if the growth in demand continues at its present rate, (see Fig. 2) by then too, the island will have reached the limit of its safe yield under the present rate of natural aquifer replenishment.

4. POSSIBILITIES FOR FUTURE AUGMENTATION OF GROUND WATER SUPPLIES

Artificial Aquifer Recharge

(4.1) Reference has already been made to one possible method of artificial recharge entailing the pumping of some 30,000 m^3/day from the Scotland District into recharge wells on the western slopes of the island.

(4.2) Considering that only an estimated 20% of rainfall percolates the coral to replenish the ground water aquifers, some improvement could be effected by the construction of more recharge wells at strategic points to take advantage of the run-off water which follows every heavy rainfall. This would have the additional advantage of minimising the dangers and damage due to flooding.

(4.3) With active consideration now being given to a central sewage treatment facility, suitably treated effluent could be recharged into the aquifer or utilised as a hydraulic dam between fresh and salt water, thus effectively increasing the sheet-water basin capacity. The decision as to which method would be used would have to be based on biological, engineering and economic considerations. However, let us not lose sight of the fact that because of the present methods of waste water disposal practised in the island, a certain amount of effluent recharge is already taking place.

Use of Brackish Water

(4.4) Reference has already been made to the availability of some 15,000 m^3/day of brackish water. As the chlorides content of the majority of the island's ground-water is low by WHO drinking-water standards, it would be feasible to effect a dilution system where this brackish water could be mixed with other water of low chlorides content to give a resultant water well within the acceptable standards.

Desalination of Sea Water

(4.5) This once-considered uneconomic method of potable water supply is getting more-and-more into common use. The technology of the methods used varies, and with it the cost of production. Claims for plant operating costs vary between U.S. 13 cents per m^3 and U.S. 80 cents per m^3 of potable water produced.

These figures do not take plant maintenance and amortisation costs into consideration, but the true cost is likely to be in the vicinity of twice the quoted figures as plant maintenance replacements are very costly. Compared then with a current total average cost of production in Barbados of U.S. 8 cents per m^3 desalinated water is extremely expensive and unless there is some significant technological break through in this field Barbados would not consider this method except as a final resort.

(4.6) It should be pointed out that where desalination can be combined with other processes such as power generation, then the overall economy of the operation assumes more attractive significance.

5. PRESENT WATER USAGE IN BARBADOS

(5.1) Total water use in the island can be accounted for under three main heads.

(a) Public Water Supply by the Waterworks Department.

(b) Private extraction for irrigation both for private and commercial purposes.

(c) Extraction by sugar factories during sugar cane reaping season for boiler feed and processing water.

(5.2) The Waterworks Department at present puts into supply an average of just under 130,000 m^3/day. Due to the prolonged drought conditions this represents a deficit of demand over supply of about 5,000 m^3/day. This deficit is experienced in the highest levels only which obtain their supplies from the stream water and elevated basin sources, these being directly dependent on a fairly constant replenishment rate if they are to maintain a constant yield. Work at present in hand will provide for transfer of water from the sheet water sources into the higher level reservoirs and these measures should be operative before the next dry season. There is a seasonal variation in demand of about 10%, with the lowest demand days occurring between June and November, and the highest demand days usually between March and May. This variation is somewhat masked by the annual growth in demand attributable to increasing numbers of individual service connections and increasing per capita demands consequent on improved standards of living. With a population of just under a quarter of a million, the present average per capita consumption is 0.52 m^3/day. A large proportion of the population, however, have a per capita consumption very much in excess of this figure. When one considers that 35% of the population receives its potable water supplies from stand-pipes and the average stand-pipe user consumes about 0.05 m^3/day, the average for the remainder of the population stands at over 0.77 m^3/day.

(5.3) Private extraction for irrigation purposes both non-commercial and commercial, swimming pools, golf courses etc. is increasing in the island. With Government encouragement and aided schemes for the purchase and installation of irrigation equipment there has been considerable stimulation of interest in this field. The total amount used for these purposes (excluding that taken from the public water supply) is still comparatively low, being estimated to be between 12,000 and 15,000 m^3/day.

(5.4) This section of water extraction from the aquifer is, of course, seasonal and is mostly confined to the months of February to

June. The quantity extracted varies to some extent with availability, many of the factory wells being so located as to be seriously affected by drought conditions. Such has been the case this year where many factories have had to take all or a large portion of their water requirements from the public water supply system. The estimated average factory extraction for the whole island is about 7,000m^3/day during the sugar-cane reaping season.

(5.5) Present maximum extraction rates from the island's resources are therefore made up of the quantities arrived at in (5.2), (5.3) and (5.4) giving a total of about 150,000 m^3/day. The sum of the estimated safe yields as indicated in Tables 1 & 2 is 175,000 m^3/day indicating that there could be yet 25,000 m^3/day available immediately if wells already existed in the appropriate locations.

6. CONCLUSIONS

(6.1) Undoubtedly this conference is primarily concerned with the production of food and consequently its greatest interest in the present water situation in Barbados is what proportion of the total available water in the island can be utilised for food-crop production. The statistics already produced speak for themselves but must be considered in conjunction with the water demand graph depicted in Fig. 3. The effect of more universal metering if and when introduced is sure to reduce the present rate of increase in water demand, but experience in other countries has shown that such reduction is only temporary and can be considered only as a period of respite during which further development of resources can take place.

(6.2) In summarising I present the following statistics as those most important to your deliberations over the next few days as far as water available for agriculture is concerned.

(a) Present potable water demand 135,000 m^3/day.

(b) Present potable water available from coral sources 175,000 m^3/day.

(c) Possible potable water available from Scotland District 30,000 m^3/day.

(d) Brackish water at present available 15,000 m^3/day.

(e) Non-potable water possibly available from Scotland District 15,000 m^3/day.

(6.3) The Water situation in Barbados is at present serious but not yet critical. By total and careful resource control including large-scale if not universal metering, the safe yield of our resources under present demand and population trends could satisfy our potable water requirements for the next two decades. The world is now verging on a new technological field called "Water Quality Engineering" which aims at maximum utilisation of water by establishing a long-cycle use. Such a process would achieve greatest usefulness in an industrial society but there may be benefits in this approach for our own mixed agricultural/industrial society. And finally, we may have but one option – desalination, which, when we need it, will have to be paid for.

REFERENCES

(1) Sealy, H.A. — 1968 – "Development and Distribution of Public Water Supplies of Barbados"

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(3) Tullstrom, H. — 1963 – "Water Supply of Barbados"

(4) Sealy, H. A. — 1968 – "Development and Distribution of Public Water Supply of Barbados"