A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-B, CAYMANAS AREA ST. CATHERINE

A REPORT ON THE

GROUNDWATER RESOURCES OF

PROJECT-B, CAYMANAS AREA

ST. CATHERINE

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A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-B, CAYMANAS AREA ST. CATHERINE PLAINS

TABLE OF CONTENTS

A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT 'B' - CAYMANAS AREA, ST. CATHERINE PLAINS

1. INTRODUCTION

Project 'B" is approximately 870 acres in extent and is bounded on the north by the Spanish Town/Kingston railway line, on the east by the Gregory Park/Naggo Head road on the south by Project 'A' and on th west by a small road. The Naggo Head spring channel passes through the southern part of the area in a west-east direction. The physiographic position is an alluvial plain and the topography is level to nearly level (0-2°). The elevation ranges from 25 ft. - 55 ft. above sea level. Caymanas sandy loam is the dominant soil type present in the area. The area forms a part of the south Caymanas Estate where sugar cane was under cultivation some years ago. Map-1 shows the location of the area and the wells in it.

2. GROUNDWATER RESOURCES

2.1 Background Information

The water supply to the area while it was under irrigation some years ago was through the Caymanas canal of the Half-Way-Tree branch of Cumberland Pen main canal and six wells, viz - North Syndicate, South Syndicate, Cedar Grove #2, Cedar Grove #1, Belmore #1 and Belmore #2. Of the six wells, only the first three were in existence in July-August, 1985, when the well rehabilitation programme was taken up by Agro-21 Corporation Limited. These wells were not in use for a long time and there were no pumps on these wells. In order to assess the condition of the wells and the quality of water, they were cleaned and tested in July-August 1985.

2.2 Cleaning and Testing of the Three Old Wells

The three old wells viz - North Syndicate, South Syndicate and Cedar Grove #2 were filled with sand and other materials to different levels. The wells were therefore cleaned ad tested for their yield. These operations were carried out by Caribbean Boring and Diamond Drilling Limited, Kingston. A Mayhew-1500, direct rotary rig was used to crush the hard material in the well and the crushed material was removed by bailing with a bailer and by blowing air into the well with an air compressor. A yield test was then conducted with a turbine pump.

The cleaning and testing operations indicated that North Syndicate and South Syndicate wells cannot be used in the existing condition and therefore they were abandoned. Cedar Grove #2 well yielded about 990 gpm and therefore it was decided to use this well in the existing condition. The results of cleaning and testing operations of North Syndicate and South Syndicate wells are given in the reports on the construction of replacement wells North Syndicate #2 and South Syndicate #2 and those of Cedar Grove #2 are given in Appendix-6.

2.3 Construction of New Wells

Five new wells were constructed as replacements for the five old wells as indicated below:

Old Wells	Replacement Wells
Belmore #1	Cow Park-A
Belmore #2	Guinep Pen
Cedar Grove #1	Naggo Head
North Syndicate	North Syndicate #2
South Syndicate	South Syndicate #2

The well construction reports are given as Appendices 1 to 5. A summary of the well construction particulars and the performance of the wells is given in Table-1.

2.4 Rate of Abstraction from Wells

The historical abstraction rate of the old wells, and licensed capacity of the new wells and the recommended abstraction rate based on the pumping tests conducted on the wells are given in the following Table-2:

Table-2: Licensed and Recommended Abstraction from Wells

Old Wells	Historical Abstraction (Entitlement)		Replacement (new) Wells	Capacity (USgpm)	
	Mil I.G.D.	USgpm		Lic.	Rec.
Belmore #1	0.36	300	Cow Park-A	450	400
Belmore #2	0.36	300	Guinep Pen	500	500
Cedar Grove #1	0.84	700	Naggo Head	500	500
North Syndicate	1.43	1190	North Syndicate #2	800	800
South Syndicate	0.40	333	South Syndicate #2	600	600
Cedar Grove #2	0.44	367	Cedar Grove #2	800	800
	TOTAL	3190		3650	3600

The overall recommended abstraction is 410 USgpm more than the entitlement. For the eight wells in Project 'A' the recommended abstraction is 1380 USgpm less than the licensed capacity. Thus the total recommended abstraction is less than the total licensed capacity for the two projects put together.

2.5 Sand Content in Well Water

Sand content in the water from wells Cow Park-A, Naggo Head and Guinep Pen was visually estimated to be less than 0.1 mg/l during the time-drawdown test. It was determined by installing a 'Rossum' sand content tester on the discharge pipe close to the discharge head during pumping tests in case of North Syndicate #2 and South Syndicate #2 wells. It was negligible in case of South Syndicate #2 well and 0.003 mg/l in case of North Syndicate #2 well during the time drawdown test. In case of Cedar Grove #2 well, the sand content in water was visually estimated to be about 5 mg/l during the pumping test. A sand separator has been installed on this well.

2.6 Quality of Water

Chemical analyses results of water samples collected from the five newly constructed wells during the pumping tests are given in Tables 3 - 7. Chemical analysis of one more water sample collected from Cow Park-A well during a trial run on 23/3/88, is also given in Table-3. The wells have not yet been put to regular use and therefore no more chemical analyses data is available. Water quality guidelines for irrigation are given in Table-8.

Specific conductance of the water ranges from 630 to 683 u/mhos/cm. Sodium adsorption ratio is less than 2.1, chloride is less than 27 mg/l, sodium is less than 59 mg/l (except for water from Guinep Pen well in which sodium is 72 to 74 mg/l) and boron is less than 0.2 mg/l. A comparison of the quality of groundwater in the area with that of the guidelines for irrigation shows that groundwater in the area does not pose any salinity or permeability problem. Toxicity of specific ions to sensitive crops can also be considered as nil as the concentrations of chloride, sodium and boron are within the limits (except that sodium is slightly more in case of water from Guinep Pen well, but if this water is mixed with water from other wells then sodium may be within the limits in the mixed water).

pH in some cases is more than the set limit of 8.4 and bicarbonate is also more than the set limit of 40 mg/l. pH sometimes varies widely and could be less than 8.4 at times. But bicarbonate in waters draining a limestone terrain cannot be less than 40 mg/l. Therefore, if the pH and bicarbonate content in the water create any irrigation problems, remedial measures may have to be implemented.

3. RECOMMENDATIONS

Groundwater abstraction from the wells may be limited to the recommended rate. Quality of groundwater and water levels from the wells may be monitored periodically to detect any deterioration in the quality of water well in time so that remedial measures could be adopted to prevent further deterioration.

REFERENCES

1. Johnson Division, UOP, Inc. 1982. Groundwater and Wells, Saint Paul, Minnesota.

2. John Hem. 1971. Study and Interpretation of Chemical Characteristics of Natural Water. USGS Water Supply Paper, 1473. Washington D.C.

3. Keith E. Anderson (Editor). 1979, Waterwell Handbook, Missouri Waterwell and Pump Contractors Association Inc. Belle.

4. Todd D.K. 1980, Groundwater Hydrology, John Wiley & Sons Inc., New York.

Summary of Well Construction Particulars and
Performance of Wells in Project 'B' - Caymanas Area

Table-1

Sl No	Well Name	Depth (ft.)	Diameter (inches)	Screen Setting (ft.)	Slot Size of Screen (inches)	Date of Test	Static Water level (ft.)	Pumping Water Level (ft)	Yield (USgpm)	Sand * Content In Water (mg/l)	Licensed Abstraction (USgpm)	Recommend Abstraction (USgpm)	Anticipated Pumping Water Level
1	Compark-A	66	14	41-56	0.100	Aug - 86	23	42	500	<0.1	450	400	40
2	North Syndicate-2	102	14	64-80 86-98	0.060 0.060	Nov. - 86	18	50	1000	0.003	800	800	44
3	South Syndicate-2	102	14	36-46 80-98	0.150 0.050	Oct. - 86	17	31	717	Almost Nil	600	600	29
4	Naggo Head	110	14	40-46 77-87 90-104	0.060 0.060 0.060	Sept - 86	18	38	500	<0.1	500	500	38
5	Guinep Fen	104	14	40-50 80-100	0.150 0.080	Sept.- 86	18	35	600	<0.1	500	500	29
6	Cedar Grove	88	18	From ground level	Perforated Pipe	Aug - 85	23	32	990	5 (approximate)	800	800	29

* Sand Content in water from wells at 2 & 3 determined using a 'Rossum' sand content tester. It was visually estimated in case of other wells. Well at 6 is an old well and a sand separator is proposed to be installed.

St. Catherine Plains

Chemical Analyses of Water Samples

Location: Cow Park-A

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
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

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

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_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR /ADJ SAR
				mg/l																
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	0.16				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

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: NAGGO HEAD Area: CAYMANAS - PROJECT 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total * Hardness	SAR /ADJ SAR
				← mg/l →															→	
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

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: North Syndicate #2

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
				←						mg/l									→	
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

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: South Syndicate-2 Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	@ Sp. Conduc-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			Total* Hardness	SAR/ADJ SAR
				←						mg/l						HCO_3	CO_3	Total	→	
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	19.20	35.50	2.80		22.99	50.01					286.01	22.16	308.17	242.00	1.0/2.6

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

WATER QUALITY GUIDELINES FOR IRRIGATION[1]

Type of Problem	Degree of Problem		
	None	Increasing	Severe
Salinity			
EC (mmho/cm) or	Less than 0.75	0.75-3.0	More than 3.0
TDS (mg/liter)	Less than 480	480-1920	More than 1,920
Permeability			
Low EC (mmho/cm) or	More than 0.5	0.5-0	Less than 0.2
Low TDS (mg/liter)	More than 320	320-0	—
SAR	Less than 6.0	6.0-9.0	More than 9.0
Toxicity of Specific Ions to Sensitive Crops			
Related to soil			
Sodium (evaluated by SAR)	SAR less than 3	3-9	More than 9
Chloride			
meq/liter	Less than 2	2-10	More than 10
mg/liter	Less than 70	70-345	More than 345
Boron (mg/liter)	1.0	1.0-2.0	2.0-10.0
Related to Foliar Adsorption (Sprinkler Irrigated)			
Sodium			
meq/liter	Less than 3.0	More than 3	—
mg/liter	Less than 70	70	—
Chloride			
meq/liter	Less than 3.0	More than 3	—
mg/liter	Less than 100	100	—
Miscellaneous			
NH_4 and NO_3-N (mg/liter)	Less than 5	5-30	More than 30
HCO_3			
meq/liter	Less than 1.5	1.5-8.5	More than 8.5
mg/liter	Less than 40	40-520	More than 520
pH	Normal range, 6.5-8.4	—	—

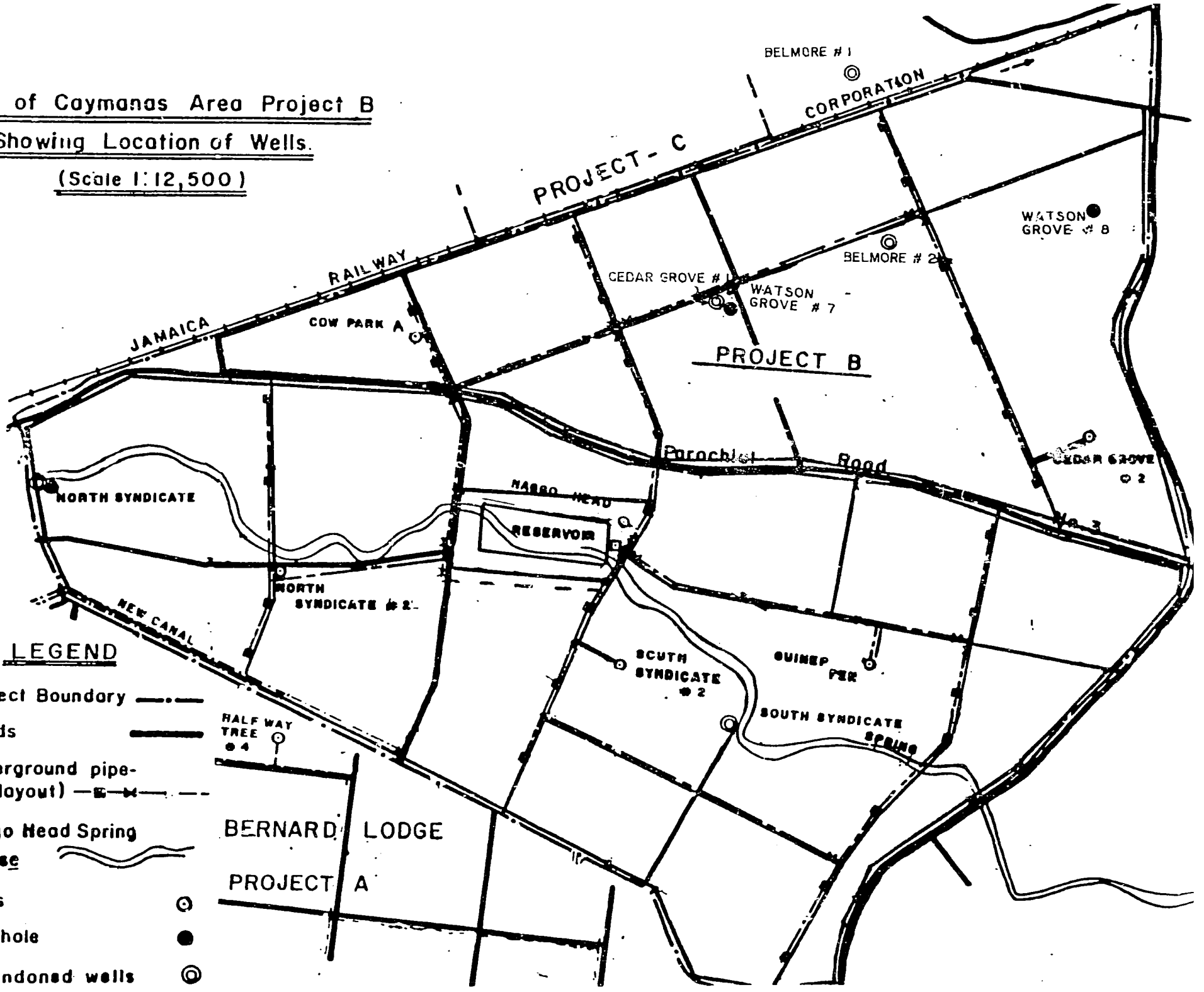
Adapted from D. S. Farnham, R. S. Ayers, and R. F. Hasek, Water Quality, University of California Division of Agricultural Science Leaflet 2995 (1977).

[1] Interpretation is related to type of problem and its severity, but is modified by circumstances of soil, crop, and locality.

Map of Caymanas Area Project B

Showing Location of Wells.

(Scale 1:12,500)



Project No.: 532-0123
Loan No.: 532-T-046
AND
532-T-046a

Date: September 25, 1985

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. Groundwater 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.

St. Catherine Plains

Caymanas Area - Project 'B'
Report on the Construction of Well
Cow Park A

Contents

Tables

Figures

St. Catherine Plains
Caymanas Area - Project B
Report on the construction of well
Cow Park - A*

1 Corehole Drilling

A corehole of 2" diameter was drilled down to a depth of 100 feet by the Caribbean Boring and Diamond Drilling Limited, Kingston, with a Boyles-37 rotary rig, from July 30, to August 1, 1985. Core samples were obtained at every 2 feet interval by split-spoon sampling method. The lithological log of the corehole is given in Table 1.

2. Sieve Analyses of Aquifer Samples

The lithological log of the corehole showed that only one aquifer occurs between 36 ft. and 56 ft. Three samples of the aquifer material from depths 46 ft. to 48 ft, 50 ft. to 56 ft. and 54 ft. to 56 ft. were subjected to sieve analyses and the results are given in Table 2. The sieve analyses curves are shown in Fig. 1. The aquifer material appears to be fairly uniform from top to bottom and consists mostly of fine to very coarse grained sand with 25% to 30% of fine gravel and about 5% of very fine silty sand and clay.

3. Well Design

The slot size of the well screen and the composition of the gravel pack material were worked out, using the sieve analyses curves. Six times the 70% retention size of the finest sample (0.020") was considered as the 70% retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity co-efficient of less than 2.5 to represent the composition of the gravel pack material. The gravel pack curve is also shown in Fig. 1. The gravel pack material consisted mostly of rounded to sub-rounded hard material like quartz, granite, etc. with a little limestone. The gravel size ranged from 0.094" to 0.250". 90% retention size of the gravel pack material (0.100") was selected as the slot size of the screen.

The well assembly was of 14" diameter and consisted of 52 ft. of 0.375" thick seamless plain casing and 15 ft. of 304 stainless steel non-clogging type well screens of slot size 0.100" (Manufactured by Johnson Division, U.S.A.). Though the thickness of the aquifer is 36 ft., beginning from 20 ft. below ground level, only 15 ft. of it from 41 ft. to 56 ft. was tapped so as to

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* A replacement well for Belmore #1

keep the top screen below the pumping water level. The bottom of the well assembly was sealed with a 0.375" thick steel plate. The well design is shown in Fig 2.

4. Well Construction

The well was constructed by the Underground Water Authority, Hope Gardens, Kingston 6, using a Davey 1500 direct rotary rig.

Drilling of a 24" diameter hole was started on July 3, 1986. After drilling down to 20 ft., the diameter of the hole was reduced to 22" and the drilling progressed down to the targeted depth of 66 ft. by July 7. The well assembly was lowered into the hole on July 8, and gravel packing of the well was done on the same day. The gravel level in the well was kept at 20 ft. A temporary casing of 24" diameter and 20 ft. length was lowered into the well on July 9, so as to prevent the collapse of the top section of the well (not packed with gravel) during development and testing. The rig and drilling equipment were removed from the site between July 10 and 14, 1986.

5. Well Development

The well was developed and tested by Jamaica Wells and Services Ltd., 3 Ballater Avenue, Kingston 10. A percussion rig was used for conducting these operations. The well was developed for a total of 107 hours by surging with a surge block and bailing (48 hours) with air compressor (27 hours) and with a turbine pump (32 hours). Two bags (100 lbs each) of -sodium hexa metaphosphate were used during the development to disperse the clay fractions. An account of the development operations is given below:

	Date	Method of Development	No. of Hours
a.	July 21-23	Surging with a surge block and bailing with a bailer.	24
b.	July 24-28	With an air compressor using an 8" eductor pipe and 1 1/4" air pipe.	27
c.	July 30-31 Aug. 1	As at (a)	24
d.	Aug. 2, 3, 5 and 6.	Turbine pump	32

At the end of the development operations the yield of the well was around 540 gpm for a pumping water level of 42 ft.

6. Step Drawdown Test

A step drawdown test was conducted on August 7, 1986 with discharge rates of 310, 415, 500 and 540 gpm, the duration of each step being 2 hours. The test data is given in Table 3 and the data plot is given as Fig. 3. Calculations of formation loss, well loss and well efficiency are shown in Table-4. The well loss co-efficient of 0.30 min2/m5 indicates that the well is properly constructed. The performance of the well is steady throughout the test.

7. Time Drawdown Test

A time drawdown test was conducted from August 8 to 10 for 50 hours at a discharge rate of 520 gpm. The static water level was 22.68 ft. and the pumping water level stabilized around 42 ft. after 35 hours of pumping. The test data is given in Table 5 and the time vs drawdown graph and the t/t' vs the residual drawdown graph are shown in Figs 4 and 5 respectively. The transmissivity of the formation as calculated by the drawdown and recovery methods is 183×10^3 gpd/ft and 196×10^3 gpd/ft respectively.

8. Quality of Water

Chemical analyses results of 3 water samples collected from the well during the time drawdown test are given in Table 6.

9. Rate of Abstraction

It is seen from the time drawdown test data that the well can yield steadily at the rate of 520 gpm for a pumping water level of about 42 ft. which is about 5 ft. below sea level. If the well is pumped at the rate of 400 gpm, the pumping water level would be around 35 ft. a foot above the sea level. The abstraction from the well may therefore be limited to 400 gpm which is also within the licensed capacity of 450 gpm for the well.

10. Grouting of the Well

During the development and testing of the well, the gravel level in the annular space between the temporary casing of 24" dia. and the well assembly was maintained around 18 ft. below ground level. After the time-drawdown test was over, the temporary casing was pulled out and a 4" dia. pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor the gravel level in the well

from time to time. The annular space was then grouted with cement concrete.

(The measure used is US gallons. The depths indicated are below ground level).

TABLE 1

ST. CATHERINE PLAINS

CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE

COWPARK A

DEPTH RANGE (FT)	THICKNESS (FT)	DESCRIPTION
0 - 14	14	Top soil and brown silty sand.
14 - 16	2	Dark brown clay.
16 - 22	6	Brown fine to medium grained sand with silt.
22 - 30	8	Stiff dark brown silty clay.
30 - 36	6	Brown fine silty and clayey sand.
36 - 56	20	Brown fine to very coarse sand with some gravel, slightly silty and clayey
56 - 70	14	Brown silty clay.
70 - 72	2	Brown silty clay with some sand.
72 - 94	22	Brown silty clay with some fine to coarse sand mixture at 80 - 86 feet, 88 - 90 feet and 92 -94 feet.
94 - 100	6	Stiff brown silty clay.

ST. CATHERINE PLAINS

SIEVE ANALYSIS RESULTS OF AQUIFER SAMPLES

(CUMMULATIVE PERCENT RETAINED)

Table -2

LOCATION: COWPARK - A COREHOLE

AREA: . CAYMANAS AREA - PROJECT "B"

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.)								
			1) 46-48			2) 50-52			3)54-56		
			A	B	C	A	B	C	A	B	C
1	6	0.132	31.3	31.3	17.7	9.7	9.7	7.6	19.4	19.4	11.5
2	8	0.094	18.2	49.5	28.0	8.0	17.7	13.8	10.9	30.3	18.0
3	12	0.066	18.0	67.5	38.3	9.1	26.8	21.0	13.1	43.4	25.8
4	16	0.047	23.7	91.2	51.7	15.9	42.7	33.4	18.8	62.2	37.0
5	20	0.033	21.5	112.7	63.9	19.5	62.2	48.7	20.3	82.5	49.1
6	30	0.023	17.6	130.3	73.9	20.0	82.2	64.4	21.8	104.3	62.1
7	40	0.016	16.3	146.6	83.2	20.4	102.6	80.4	24.7	129.0	76.8
8	50	0.012	10.4	157.0	89.1	12.4	115.0	90.1	14.5	143.5	85.5
9	70	0.008	7.8	164.8	93.5	6.5	121.5	95.2	10.2	153.7	91.6
10	100	0.006	4.8	169.6	96.2	2.9	124.4	97.5	5.7	159.4	95.0
11 PAN			6.6	176.2	100	3.2	127.6	100	8.4	167.8	100

* U.S.S. Sieve Series

(Analysed by Alex Campos and D.V. Ramanamurty)

A= Weight retained(in grams)

B= Cummulative weight retained(in grams)

C= Cummulative percentage retained

St. Catherine Plains

Step-Drawdown Test Data

Location:COWPARK - A Area: CAYMANAS - PROJECT - B

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 24.69 ft below M.P. which is 2 ft above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
7 8/86	1110	S T E P 1					
		2	33.59	8.90	10	310	
		6	34.10	9.41			
		7	34.15	9.46			
		8	34.25	9.56			
		10	34.45	9.76			
		12	34.32	9.63			
		14	34.38	9.69			
		16	34.45	9.76			
		18	34.40	9.71			
		20	34.35	9.66			
		25	34.52	9.83			
		30	34.55	9.86			
		35	34.65	9.96			
		40	34.72	10.03			
		45	34.71	10.02			
		50	34.80	10.11			
		60	34.82	10.13			
		70	34.98	10.29			
		80	34.82	10.13			
		90	34.67	9.98			

Table -3

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: COWPARK - A

P-2

1	2	3	4	5	6	7	8
7/8/86		100	34.52	9.83			
		110	34.52	9.83			
		120	34.67	9.98			
	1310	S T E P	2				
		1	38.56	13.87	18	415	
		2	38.10	13.41			
		3	38.20	13.51			
		4	38.20	13.51			
		5	38.25	13.56			
		6	38.29	13.60			
		7	38.37	13.68			
		10	38.36	13.67			
		12	38.38	13.69			
		14	38.40	13.71			
		18	38.42	13.73			
		20	38.45	13.76			
		25	38.51	13.82			
		30	38.57	13.88			
		35	38.63	13.94			
		40	38.64	13.95			
		45	38.64	13.95			
		50	38.66	13.97			
		55	38.75	14.06			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

P-3

Location: COWPARK - A

1	2	3	4	5	6	7	8
7 8/86		60	38.76	14.07			
		70	38.90	14.21			
		80	38.81	14.12			
		90	38.84	14.15			
		100	38.87	14.18			
		110	38.80	14.11			
		120	38.80	14.11			
	1510	S T E P	- 3				
		1	41.27	16.58	26	500	
		2	41.55	16.86			
		3	41.69	17.00			
		4	41.70	17.01			
		5	41.81	17.12			
		6	41.77	17.08			
		7	41.79	17.10			
		8	41.78	17.09			
		9	41.81	17.12			
		10	41.79	17.10			
		12	41.85	17.16			
		14	41.90	17.21			
		18	41.84	17.15			
		20	41.87	17.18			
		25	41.90	17.21			

Table -3

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: COWPARK - A P-4

1	2	3	4	5	6	7	8
7 8/86		30	41.84	17.15			
		35	41.96	17.27			
		40	42.00	17.31			
		45	41.86	17.17			
		50	41.96	12.27			
		55	41.97	17.28			
		60	42.10	17.41			
		70	42.40	17.71			
		80	42.40	17.71			
		90	42.00	17.31			
		100	42.00	17.31			
		110	42.10	17.41			
		120	42.10	17.41			
	1710	S T E P	- 4				
		1	43.39	18.70	30	540	
		2	43.43	18.74			
		7	43.62	18.93			
		8	43.64	18.95			
		9	43.65	18.96			
		10	43.64	18.95			
		12	43.66	18.97			
		14	43.60	18.91			
		16	43.72	19.03			

Table -3

St. Catherine Plains

Step-Drawdown Test Data (Continued)

P-5

Location: COWPARK - A

1	2	3	4	5	6	7	8
7 8/86		18	43.70	19.01			
		20	43.72	19.03			
		25	43.72	19.03			
		30	43.70	19.01			
		35	43.74	19.05			
		40	43.70	19.01			
		45	43.73	19.04			
		50	43.80	19.11			
		53	43.72	19.03			
	1810	60	43.72	19.03			
		65	43.81	19.12			
		70	43.80	19.11			
		80	43.82	19.13			
		90	43.88	19.19			
		100	43.70	19.01			
		110	43.83	19.14			
	1910	120	43.84	19.15			
		TEST OVER					

TABLE 4

ST. CATHERINE PLAINS

COW PARK A

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q) USgpm	Discharge (Q) m^3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
1	310	1.17	9.98	3.04	2.60	2.63	0.41	3.04	86.5	31.0
2	415	1.57	14.11	4.30	2.74	3.53	0.74	4.27	82.0	29.4
3	500	1.89	17.41	5.30	2.80	4.25	1.07	5.32	80.0	28.7
4	540	2.04	19.15	5.83	2.86	4.59	1.25	5.84	78.7	28.2

From the Graph (Figure 3)

Formation loss coefficient (B) = 2.25

Well loss coefficient (C) = 0.30

Well efficiency = $\frac{BQ}{SW} \times 100$

Table 5

St. Catherine Plains

Pumping Test Data

P-1

Location: COWPARK - A Area: CAYMANAS, PROJECT 'B'

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 24.68 ft below M.P. which is 2 ft above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
8 8/86	1100		P U M P I N G S T A R T E D				
		1	39.33	14.65	26	504	
		2	40.10	15.42			
		3	40.62	15.94			
		4	40.80	16.12			
		5	41.12	16.44			
		6	41.26	16.58			
		7	41.42	16.74			
		8	41.42	16.74			
		9	41.55	16.87			
		10	41.62	16.94			
		12	41.80	17.12			
		14	41.80	17.12	27	512	
		16	41.84	17.16			
		18	41.88	17.20			
		20	41.89	17.21			
		25	41.99	17.31			
		30	42.04	17.36	26	520	
		35	42.11	17.43			
		40	42.10	17.42			
		45	42.12	17.44			

Table 5

St. Catherine Plains

Pumping Test Data (Continued)

P-2

Location: COWPARK -A

1	2	3	4	5	6	7	8
8/8/86		50	42.13	17.45	28	520	
		55	42.17	17.49			
	1200	60	42.23	17.55			
		75	42.23	17.55			
		90	42.40	17.72			
		105	42.40	17.72			
	1300	120	42.40	17.72			
		150	42.55	17.87			
		180	42.62	17.94			
		210	42.62	17.94			
		240	42.73	18.05			
		270	42.73	18.05			
		300	42.80	18.12			
		360	42.90	18.22			
		420	42.90	18.22			
		480	42.95	18.27			
		540	42.95	18.27			
		600	43.00	18.32			
		660	43.20	18.52			
		720	43.22	18.54			
		780	43.22	18.54			
9/8/86	0100	840	43.22	18.54			
		900	43.23	18.55			

St. Catherine Plains

Pumping Test Data (Continued) P-3

Location: COWPARK - A

1	2	3	4	5	6	7	8
		960	43.24	18.56	28	520	
		1020	43.32	18.64			
		1080	43.55	18.87			
		1140	43.55	18.87			
		1200	43.62	18.94			
		1260	43.72	19.04			
		1320	43.72	19.04			
		1380	43.65	18.97			
9 8/86	1100	1440	43.62	18.94			
		1500	43.72	19.04			
		1560	43.74	19.06			
		1620	43.82	19.14			
		1680	43.73	19.05			
		1740	43.83	19.15			
		1800	43.81	19.13			
		1860	43.83	19.15			
		1920	43.84	19.16			
		1980	43.92	19.24			
		2040	43.91	19.23			
		2100	43.90	19.22			
		2160	43.87	19.19			
10 8/86		2220	43.86	19.18			
	0100	2280	43.89	19.21			

Table 5

St. Catherine Plains

Pumping Test Data (Continued)

P- 4

Location: COWPARK - A

1	2	3	4	5	6	7	8
10 8/86	0200	2340	43.89	19.21	28	520	
		2400	43.87	19.19			
		2460	43.87	19.19			
		2520	43.86	19.18			
		2580	43.50	18.82			
		2640	43.82	19.14			
		2700	43.84	19.16			
		2760	43.84	19.16			
		2820	43.84	19.16			
		2880	43.84	19.16			
		2940	43.87	19.19			
	1300	3000	43.87	19.19			
			Test Over				

Table 5

Pumping Test Data (Continued)

Location: COWPARK - A

Recovery Data

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED -t (MINUTES)	TIME SINCE PUMPING STOPPED -t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
10 8/86		RECOVERY DATA				
	1301	3001	1	28.30	3.62	3001
		3002	2	27.70	3.02	1501
		3003	3	27.29	2.61	1001
		3004	4	27.06	2.38	751
		3005	5	26.90	2.22	601
		3006	6	26.79	2.11	501
		3007	7	26.70	2.02	429
		3008	8	26.64	1.96	376
		3009	9	26.60	1.92	334
		3010	10	26.54	1.86	301
		3012	12	26.44	1.76	251
		3014	14	26.43	1.75	215
		3016	16	26.36	1.68	188
		3018	18	26.31	1.63	167
		3020	20	26.28	1.60	151
		3025	25	26.22	1.54	121
		3030	30	26.22	1.54	101
		3036	36	26.17	1.49	84
		3040	40	26.14	1.46	76
		3045	45	26.11	1.43	67
	1400	3060	60	26.05	1.37	51
		3120	120	25.89	1.21	26

Table 5

Pumping Test Data (Continued)

Location: COWPARK - A Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED $-t$ (MINUTES)	TIME SINCE PUMPING STOPPED $-t'$ (MINUTES)	DEPTH TO WATER (ft)	RESIDUAL DRAWDOWN (ft)	t/t'
		RECOVERY DATA				
10 8/86	1600	3180	180	25.79	1.11	17
		3240	240	25.75	1.07	13
		3300	300	25.70	1.02	11
		3360	360	25.62	0.94	9
		3420	420	25.50	0.82	8
		3540	540	25.42	0.74	6.5
		3600	600	25.50	0.82	6
11 8/86	0000	3660	660	25.36	0.68	5.5
		3720	720	25.30	0.62	5
		3780	780	25.23	0.55	4.8
		3840	840	25.23	0.55	4.5
		3900	900	25.20	0.52	4.3
		3960	960	25.20	0.52	4.1
		4020	1020	25.17	0.49	3.9
	0800	4140	1140	25.15	0.47	3.6

St. Catherine Plains

Chemical Analyses of Water Samples

Table 6

Location: Cow Park-A

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			Total* Hardness	SAR
				←						ppm						HCO_3	CO_3	Total	→	
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
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	10.8.86	8.00	660	464.6	82.16	17.28	58.0	1.10	0.15	22.49	17.28	0.10				318.55	27.70	346.25	276.3	1.5

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

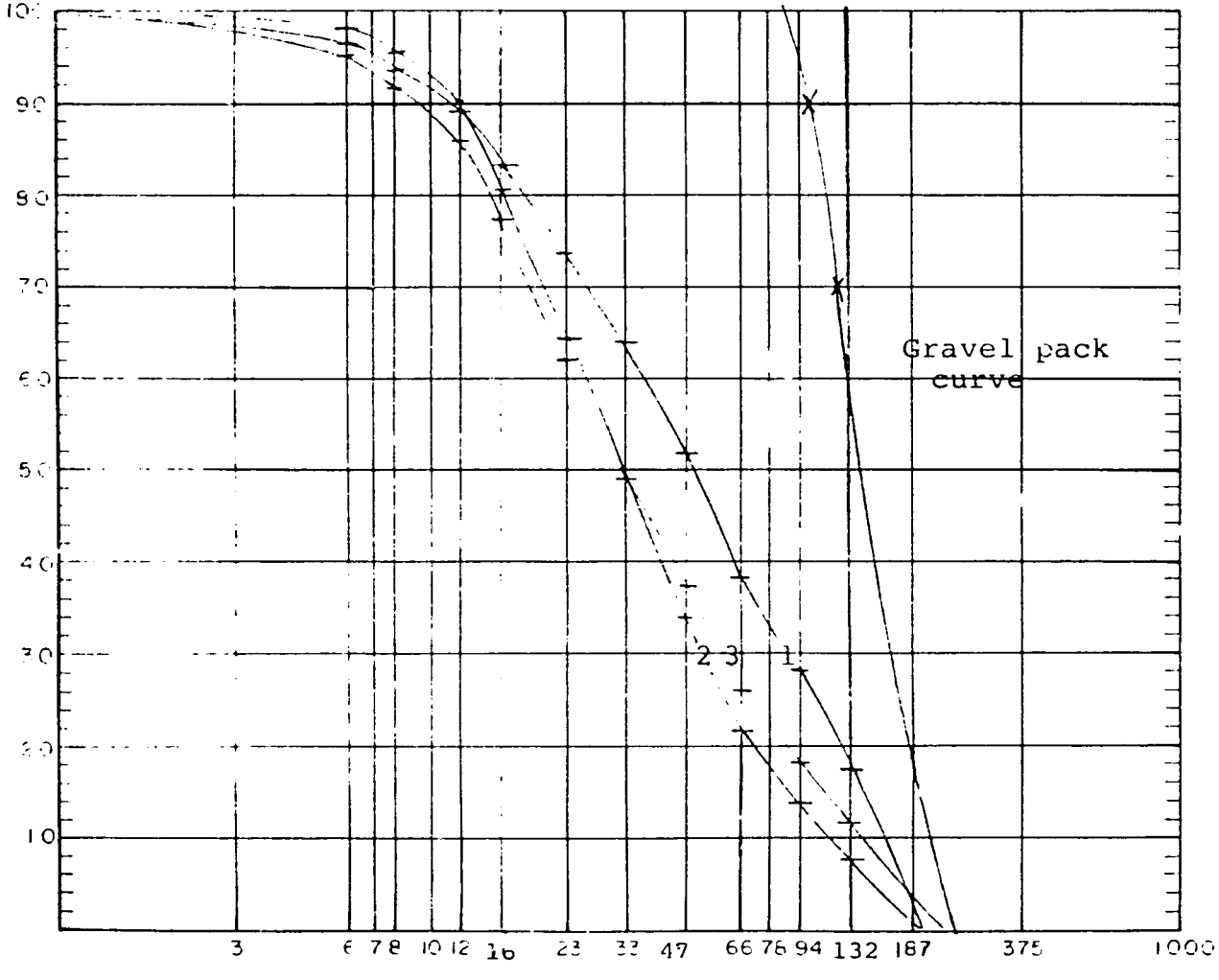
SIEVE ANALYSIS CURVES

Fig 1

Location: Cowpark A. Corehole

Depth Range: (ft.)

1) 46-48 (2) 50-52 (3) 54-56



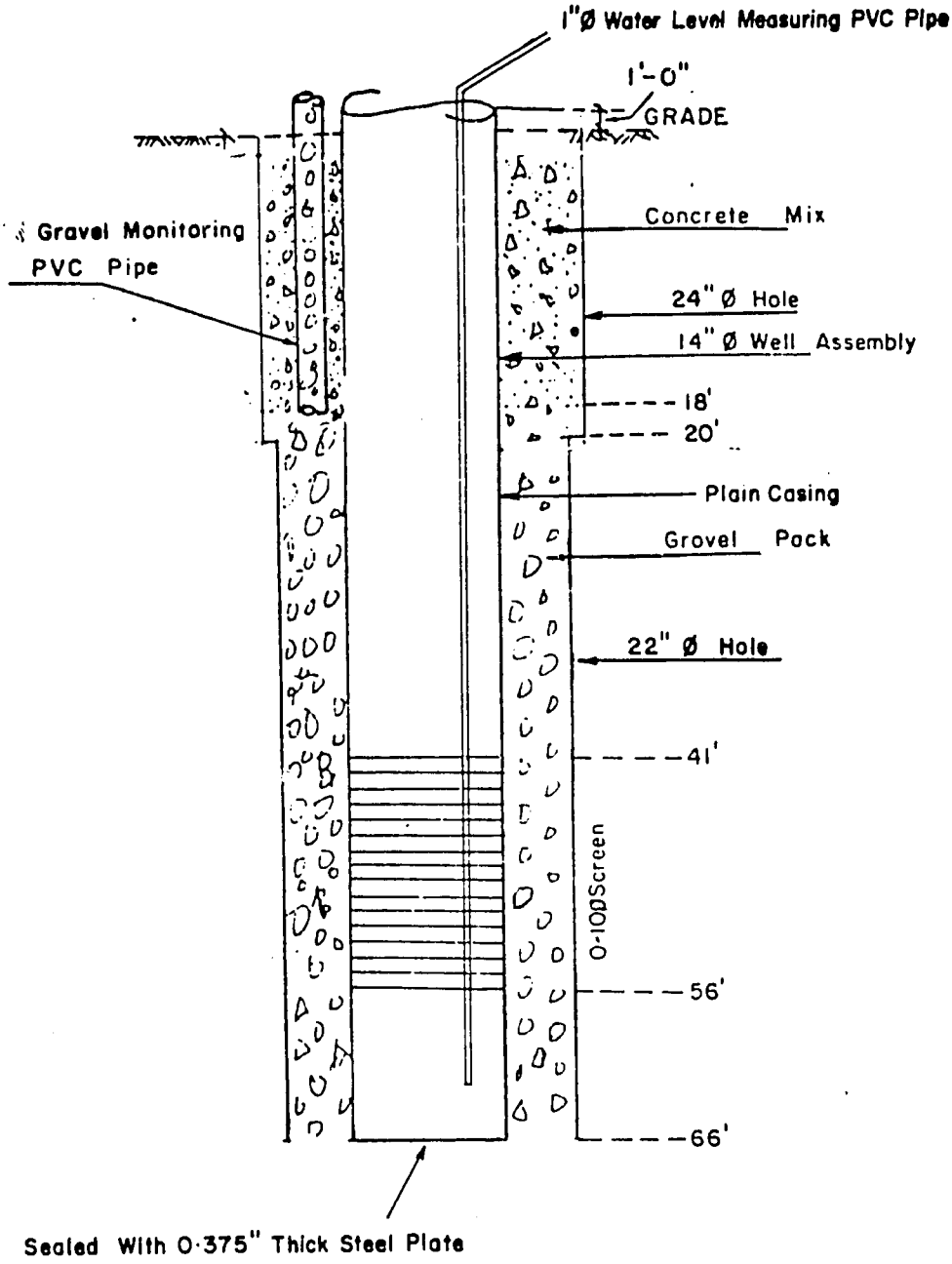
1. Finest sample is #3
2. 70% retention size of the sample. = 0.020"
3. 70% retention size of the gravel pack material = 0.020" x 6 = 0.120"
4. Slot size of the screen (90% retention size of the gravel pack material) = 0.100"
5. Uniformity coefficient of th sample = 5

ST. CATHERINE PLAINS

Fig. 2

Caymanas Area – Project 'B'

Well Design – Cow Park A.



DATE : 14·3·86
DRAWING NO. A-051
BY : D. RAMANAMURTY

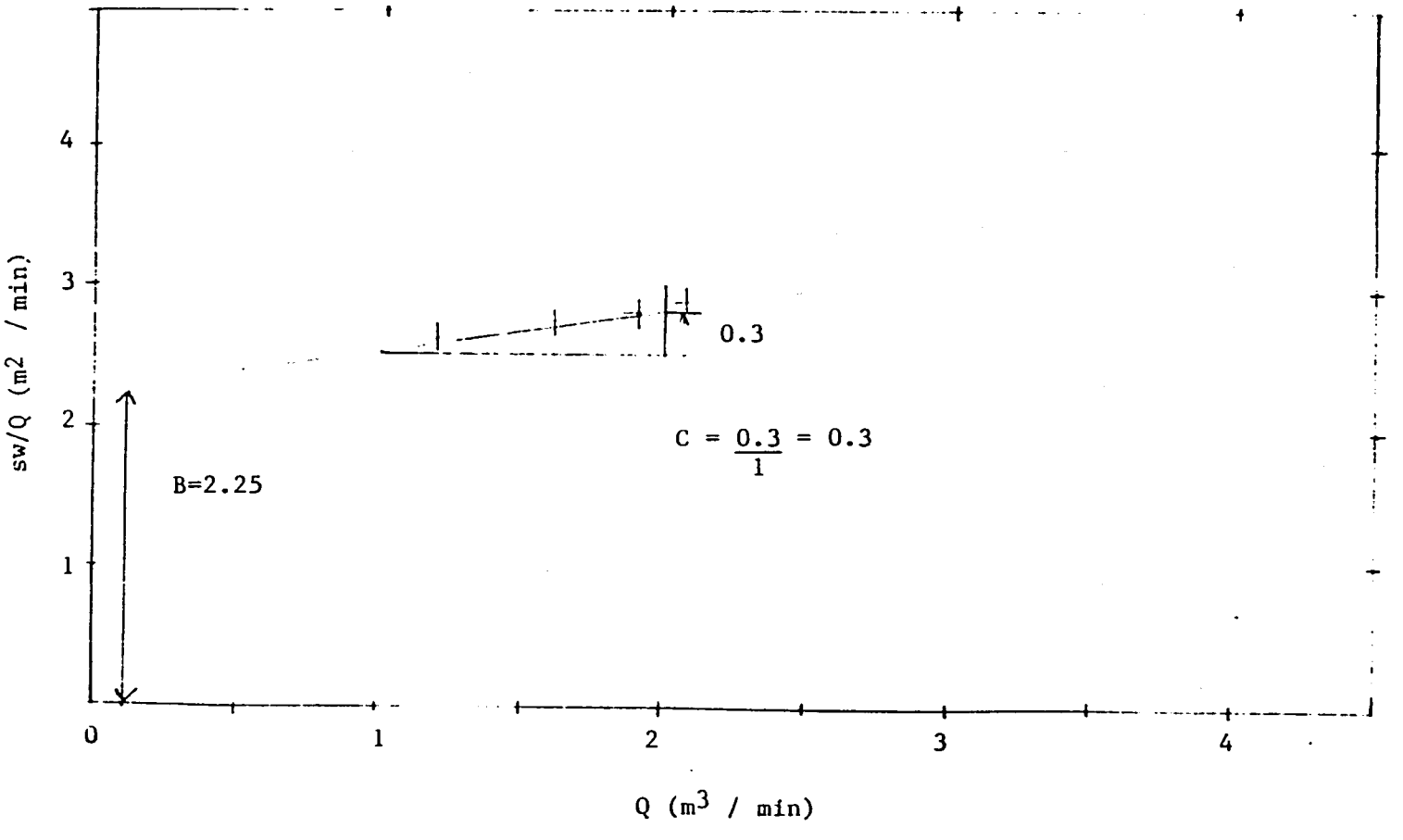
VERTICAL SCALE
0·8in = 10 ft.

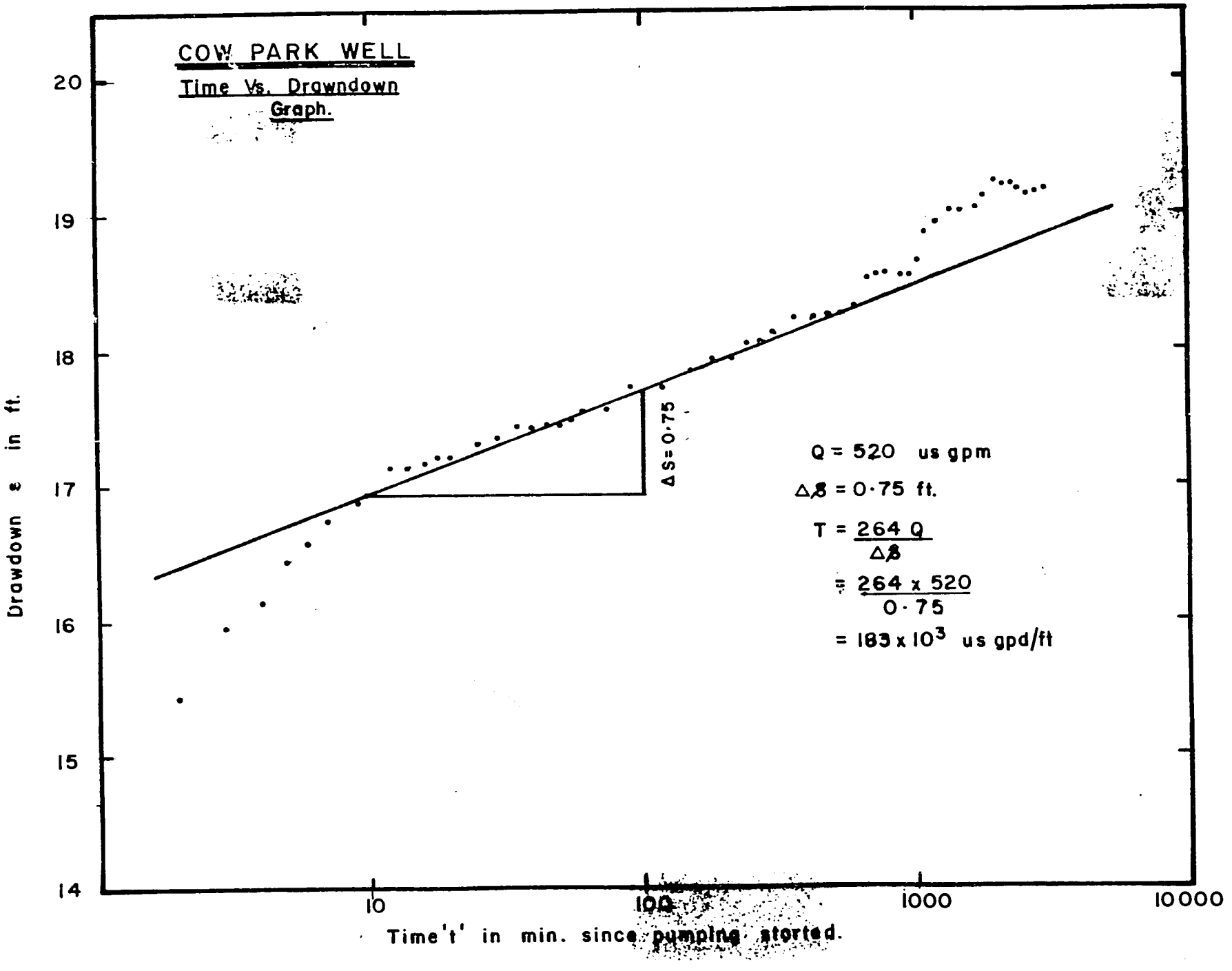
Fig. 3

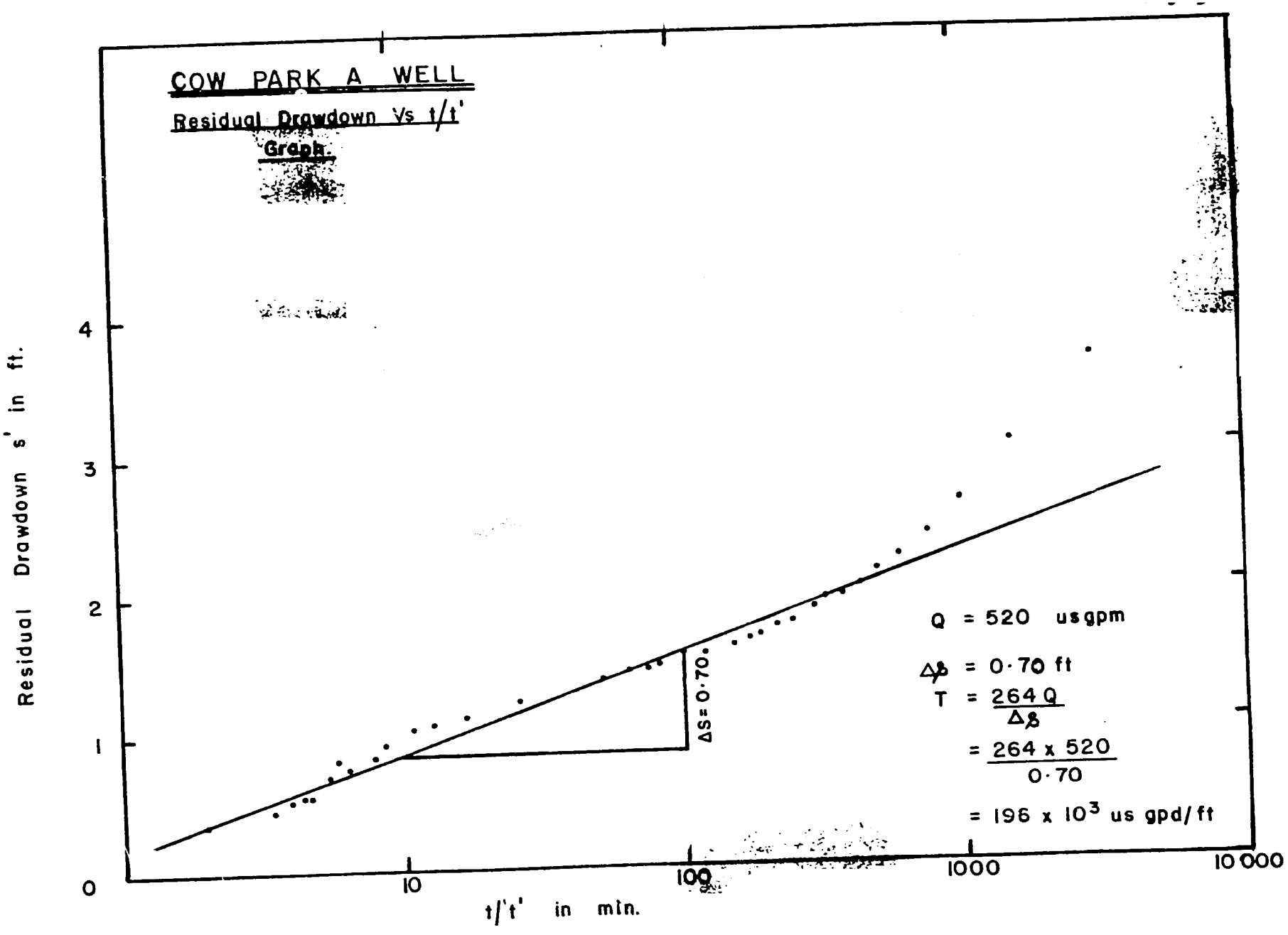
St. Catherine Plains

Cow Park -A

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'




COW PARK WELL
Time Vs. Drawndown
Graph.
20
19
18
17
16
15
14
Drawdown s in ft.
10
100
1000
10000
Time 't' in min. since pumping started.
Δs = 0·75
Q = 520 us gpm
Δs = 0·75 ft.
T = 264 Q / Δs
= 264 x 520 / 0·75
= 183 x 10³ us gpd/ft


COW PARK A WELL
Residual Drawdown Vs t/t' Graph.
Residual Drawdown s' in ft.
0
1
2
3
4
10
100
1000
10 000
t/'t' in min.
ΔS=0·70.
Q = 520 usgpm
Δs = 0·70 ft
T = 264 Q / Δs
= 264 x 520 / 0·70
= 196 x 10³ us gpd/ft

St. Catherine Plains

Caymanas Area - Project 'B'
Report on the Construction of Well

Guinep Pen *

Contents — Page No.

Tables

Figures

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
REPORT ON THE CONSTRUCTION OF WELL - GUINEP PEN

1. COREHOLE DRILLING

A corehole of 2" diameter was drilled down to a depth of 106 ft. by Caribbean Boring and Diamond Drilling Limited, Kingston, with a Boyles-37 rotary rig from September 27, 1985 to October 7, 1985. Core samples were obtained at every 2 ft. interval by split-spoon sampling method. Lithological log of the corehole is given in Table-1.

2. SIEVE ANALYSES OF AQUIFER SAMPLES

Lithological log of the corehole showed that two aquifer zones occur one between 40 ft. and 50 ft. and the other between 80 ft. and 100 ft. Three representative samples of aquifer material from depths of 42 ft. to 44 ft., 82 ft. to 84 ft. and 98 ft. to 100 ft. were subjected to sieve analyses and the results are given in Table-2. Sieve analyses curves are shown in Fig. 1. The composition of the aquifer material in the upper zone is uniform throughout the thickness. It consists mostly of fine to very coarse grained sand and gravel upto 0.25" in size, the latter forming about 20% of the material. The aquifer material in the lower zone is finer in the upper part than in the lower part where it is mostly medium to very coarse grained sand with gravel (upto 0.375" in size) forming about 50% of the material.

3. WELL DESIGN

Using the sieve analyses data, slot size of the well screens and composition of the gravel pack material were worked out. Six times the 70% retention size of the finest sample (the only sample for the upper aquifer and from depth 82 ft. - 84 ft. for the lower aquifer) was considered as the 70% retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity co-efficient of less than 2.5 to represent the composition of the gravel pack material.

A replacement well for Belmore #2

The gravel pack curve is also shown in Fig 1. Specifications of the gravel pack material are given below:

	Size	Percentage
Upper aquifer	0.094" - 0.250"	50
	0.250" - 0.375"	30
	0.375" - 0.500"	20
Lower aquifer	0.066" - 0.094"	30
	0.094" - 0.250"	50
	0.250" - 0.375"	20

The material consisted mostly of rounded to sub-rounded hard material like quartz and granite with a little limestone impurity. Ninety percent retention size of the gravel pack material was selected as the slot size of the well screens i.e. 0.150" for the upper zone and 0.080" for the lower zone.

The well assembly was of 14" diameter and consisted of 77 ft. of 0.375" thick steel seamless plain casing and 30 ft. of 304 stainless steel non-clogging type well screens (10 ft. of 0.150" slot size and 20 ft. of 0.080" slot size) manufactured by Johnson Division, U.S.A. The bottom of the assembly was sealed with a steel plate. The well design is shown in Fig 2.

4. WELL CONSTRUCTION

The well was constructed by Underground Water Authority, Hope Gardens, Kingston, using a Davey-1500 direct rotary rig. Drilling operations were started on July 15, 1986, and completed only July 23, 1986 at the targeted depth of 106 ft. The diameter of the hole was 24" down to 20 ft. and 22" below that depth. The well assembly was lowered on July 24 and gravel packing was done on the same days. The gravel level was kept at about 18 ft. below ground level. Temporary casing of 24" diameter and 20 ft. length was installed in the well on July 25 (keeping one foot of the casing above ground level) so as to prevent any collapse of the top section of the well that was not packed with gravel, during development and testing. The rig and equipment were moved to North Syndicate #2 well site by August 6, 1986.

5. WELL DEVELOPMENT

The well was developed and tested by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10. A percussion rig was used for conducting these operations.

The well was developed for a total period of 120 hours by surging with a surge block and bailing (48 hours) with an air compressor (53 hours) and with a turbine pump (19 hours). Two bags of sodium hexa-metaphosphate (100 lbs. each) were used during the development to disperse the clay fractions. An account of the development operations is given below:

	Date	Method of Development	No. of hours
a)	Aug. 14-18	Surging with a surge block and bailing	32
b)	Aug. 19-21	With an air compressor using an 8" eductor pipe and 1 1/4" air pipe	19
c)	Aug. 22-24	as at (a)	16
d)	Aug. 25-29	as at (b)	34
e)	Sept. 1-2	With a turbine pump	19

At the end of the development operations the yield of the well was around 700 gpm for pumping water of about 32 ft.

6. STEP-DRAWDOWN TEST

A step-drawdown test was conducted on September 9, 1986, with discharge rates of 460, 504, 624 and 700 gpm the duration of each step being 2 hours. The test data is given in Table-3. Calculations of formation loss, well loss and well efficiency are shown in Table-4. The well loss co-efficient of 0.20 min /m indicates that the well is properly constructed and developed. The performance of the well is steady throughout the test.

7. TIME-DRAWDOWN TEST

A time-drawdown test was conducted for a period of 72 hours from 10:10 a.m. on September 7, 1986 at a discharge rate of 620 gpm. The static water level was 17.91 ft. and the maximum drawdown was 13.39 ft. The drawdown in the period from 56 hours after pumping started to the end of the test was around 13 ft. The specific capacity works out to 46 gpm/ft. The test data is given in Table-50 and the time-drawdown and t/t' vs drawdown graphs are given in Fig 3. and Fig 4. respectively. The transmissivity of the formation works out to 130 x 10 gpd/ft. by the drawdown method and 81 x 10 gpd/ft. by the recovery method.

8. QUALITY OF WATER

Chemical analyses results of two water samples collected during the time-drawdown test are given in Table-6.

9. RATE OF ABSTRACTION

The time-drawdown test was conducted at the rate of 620 gpm and the performance of the well was fairly steady. However, the rate of abstraction from the well may be limited to 500 gpm which is the licensed capacity of the well.

10. GROUTING OF THE WELL

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" diameter and the well assembly was maintained around 18 ft. After the time drawdown test was over, the temporary casing was pulled out and a 3" diameter pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The annular space was then grouted with cement concrete.

(The measure used is US gallons. The depths indicated are below ground level)

REFERENCES

1. Johnson Division, UOP, Inc. 1982. Groundwater and Wells, Saint Paul, Minnesota.

2. John Hem. 1971. Study and Interpretation of Chemical Characteristics of Natural Water. USGS Water Supply Paper, 1473. Washington D.C.

3. Keith E. Anderson (Editor). 1979, Waterwell Handbook, Missouri Waterwell and Pump Contractors Association Inc. Belle.

4. Todd D.K. 1980, Groundwater Hydrology, John Wiley & Sons Inc., New York.

TABLE-1

ST. CATHERINE PLAINS

CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE

GUINEP PEN

DEPTH RANGE (ft)	THICKNESS (ft)	DESCRIPTION
0 - 4	4	Brown silty top soil
4 - 20	16	Brownish grey silty fine grained sand
20 - 24	6	Brownish grey fine silty sand and clay
26 - 40	14	Brownish grey medium to fine grained silty sand with some clay and occasional coarse grained sand and gravel.
40 - 50	10	Fine to very coarse grained sand with about 20% gravel (up to 0.25" in size) and a little silt.
50 - 52	2	Medium to coarse grained sand and stiff brown clay.
52 - 54	2	Stiff dark brown clay.
54 - 56	2	Brown silty fine sand and stiff dark brown clay.
56 - 64	8	Stiff brown sandy silty clay.
64 - 72	8	Brown silty sandy clay with a little gravel.
72 - 74	2	Yellowish brown silty clay (moist).
74 - 80	6	Brownish grey, medium to coarse grained sand, with a little gravel and much clay.
80 - 94	14	Brownish gray fine to very coarse grained sand with about 20% of angular gravel (up to 0.375" in size) and a little silt
94 - 100	6	Brownish grey medium to very coarse grained sand with about 50% of gravel (upto 0.375" in size) slightly clayey
100 - 106	6	Brownish grey medium to coarse grained sand with much clay; last one foot stiff brown clay.

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: Guinep Pen Corehole

Area: Caymanas Project 'B'

SERIAL	@ SIEVE NO.	* MESH OPENING	DEPTH RANGE(FT.) 42 - 44			82 - 84			98 - 100		
			A	B	C	A	B	C	A	B	C
1.	3/8"	375	—	—	—	3.2	3.2	1.4	16.7	16.7	6.2
2.	4	187	11.4	11.4	5.6	13.5	16.7	7.5	55.4	72.1	26.6
3.	8	94	42.0	53.4	26.3	26.8	43.5	19.5	58.3	130.4	48.2
4.	12	66	21.5	74.9	36.9	18.4	61.9	27.6	35.90	166.3	61.4
5.	16	47	41.2	116.1	57.2	21.8	83.7	37.4	31.40	197.7	73.0
6.	20	33	27.2	143.3	70.6	23.8	107.5	48.1	27.40	225.1	83.2
7.	30	23	20.8	164.1	80.8	24.4	131.9	58.9	21.60	246.7	91.1
8.	40	16	14.5	178.6	87.9	24.3	156.2	69.8	12.10	258.8	95.6
9.	50	12	8.5	187.1	92.1	16.2	172.4	77.1	6.00	264.8	97.8
10.	100	6	10.1	197.2	97.1	42.4	214.8	96.1	4.2	269.0	99.3
11.	PAN		5.90	203.1	100.0	8.8	223.6	100.0	1.70	270.7	100.0

* Thousandth of an Inch

@ U.S.S. Sieve Series

(Analysed by Jamaica Engineering & Technical Services Ltd, Kingston)

A = Weight retained (grams)

B = Cummulate weight retained (")

C = Cummulative percentage retained

St. Catherine Plains

Step-Drawdown Test Data

Location: Guinep Pen Area: Caymanas Project "B"

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 19.96 ft. below M.P. which is about 2 ft. above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
	1000		STEP I				
3 9/86		5	26.93	6.97	18.5	432	
		10	27.33	7.37	18.5		
		20	27.60	7.64	18.5		
		30	27.71	7.75	18.5	432	
		40	28.10	8.14	19	438	
		50	28.15	8.19	"		
		60	28.23	8.27	"		
		70	28.25	8.29	20	449	
		80	28.25	8.29	"		
		90	28.26	8.30	"		
		100	28.35	8.39	21	460	
		110	28.38	8.42	"		
		120	28.42	8.46	"		
	1200		STEP II				
		1	29.20	9.24	26	504	
		10	29.85	9.89	"		
		20	29.85	9.89	"		
		40	29.85	9.89	"		
		50	29.85	9.89	"		
		60	29.88	9.92	"		

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Guinep Pen SWL - 19.96 ft.

1	2	3	4	5	6	7	8
		70	29.85	9.89	26	504	
		80	29.75	9.79	"		
		90	29.75	9.79	"		
		100	29.75	9.79	"		
		110	29.76	9.80	"		
		120	29.80	9.84	"		
	1400		STEP III				
		5	31.55	11.59	40	616	
		10	31.85	11.89	"		
		20	31.90	11.94	41	624	
		30	31.92	11.96	"		
		40	32.12	12.16	"		
		50	32.10	12.14	"		
		60	32.13	12.17	"		
		70	32.22	12.26	"		
		80	32.19	12.23	"		
		90	32.14	12.18	41	624	
		100	32.22	12.26	"		
		110	32.25	12.29	"		
		120	32.30	12.34	"		
	1600		STEP IV				
		10	33.45	13.49	51	693	
		20	33.55	13.59	"		

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Guinep Pen SWL - 19.96 ft.

1	2	3	4	5	6	7	8
		30	33.71	13.75	51	693	
		40	33.62	13.66			
		50	33.60	13.64			
		60	33.70	13.74			
		70	33.75	13.79	52	700	
		80	33.71	13.75	"		
		90	33.70	13.74			
		100	33.60	13.64			
		110	33.70	13.74			
		120	33.70	13.74			
		Test Stopped at 1 800 hrs.					

TABLE 4

ST. CATHERINE PLAINS

GUINEP PEN

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q)		Drawdown (SW)		SW/Q	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity
	USgpm	m^3/min	Ft.	m	(m^2/min)					(USgpm/ft)
1	460	1.74	8.46	2.58	1.48	2.00	0.61	2.61	77	54.4
2	504	1.91	9.84	3.00	1.57	2.19	0.73	2.92	75	51.2
3	624	2.36	12.34	3.76	1.59	2.71	1.11	3.82	71	50.6
4	700	2.65	13.74	4.19	1.58	3.05	1.40	4.45	69	50.9

From the Graph (Figure 3)

Formation loss coefficient (B) = 1.15

Well loss coefficient (C) = 0.20

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Location: GUINEP PEN Area: CAYMANAS PROJECT "B"

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 19.91 ft below M.P. which is about 2 ft above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
4 9/86	1010	P U M P I N G T E S T S T A R T E D					
		1	28.35	8.44			
		2	28.39	8.48	40.5	620	
		3	29.55	9.64			
		4	29.68	9.77			
		6	29.68	9.77			
		7	29.95	10.04			
		8	30.00	10.09			
		9	30.01	10.10			
		10	30.15	10.24			
		12	30.30	10.39			
		14	30.36	10.45			
		16	30.44	10.53			
		18	30.52	10.61			
		20	30.57	10.66			
		25	30.82	10.91			
		30	30.83	10.92			
		35	31.30	11.39			
		40	31.80	11.89			
		45	31.80	11.89			

St. Catherine Plains

Pumping Test Data (Continued)

Location: GUINEP PEN

1	2	3	4	5	6	7	8
9/86	1100	50	31.23	11.32	40.5	620	
		55	31.23	11.32			
		60	31.24	11.33			
		75	31.47	11.56			
		90	31.60	11.69			
"		105	31.62	11.71			
		120	31.65	11.74			
		150	31.80	11.89			
		180	31.86	11.95			
		210	31.90	11.99			
		240	31.91	12.00			
		270	31.90	11.99			
		300	32.00	12.09			
		360	32.40	12.49			
	1710	420	32.32	12.41			
		480	32.30	12.39			
		540	32.76	12.85			
		600	32.42	12.51			
		660	32.45	12.54			
		720	32.47	12.56			
		780	32.49	12.58			
5 9/86	0010	840	32.48	12.57			
		900	32.48	12.57			

St. Catherine Plains

Pumping Test Data (Continued)

Location: GUINEP PEN

1	2	3	4	5	6	7	8
5/9/86	0210	960	32.50	12.59			
		1020	32.51	12.60			
		1080	32.52	12.61			
		1140	32.58	12.67			
		1200	32.60	12.69			
		1260	32.67	12.76			
		1320	32.84	12.93			
		1380	32.68	12.77			
	1010	1440	32.65	12.74	40.5	620	
		1500	32.63	12.72			
		1560	32.70	12.79			
		1620	32.73	12.82			
		1680	32.74	12.83			
		1740	32.80	12.89			
		1800	32.76	12.85			
	1710	1860	32.72	12.83			
		1920	32.70	12.79			
		1980	32.70	12.79			
		2040	32.70	12.79			
		2100	32.73	12.82			
		2160	32.74	12.83			
		2220	32.75	12.84			
6/9/86	0010	2280	32.76	12.85			

St. Catherine Plains

Pumping Test Data (Continued)

Location: GUINEP PEN

1	2	3	4	5	6	7	8
6 9/86		2340	32.77	12.86			
		2400	32.78	12.87			
		2460	32.79	12.88			
		2520	32.82	12.91			
		2580	32.83	12.92			
		2640	32.85	12.94			
		2700	32.88	12.97			
		2760	32.87	12.96			
		2820	32.83	12.92			
	1010	2880	32.84	12.93			
		2940	32.85	12.94			
		3000	32.86	12.95			
		3060	32.91	13.00			
		3120	32.88	12.97			
		3180	32.93	13.02			
		3240	32.93	13.02			
		3300	32.93	13.02			
		3360	32.91	13.00			
		3420	32.97	13.06			
		3480	32.98	13.07			
		3540	32.99	13.08			
		3660	32.99	13.08			
7 9/86	0010	3720	32.92	13.01			

St. Catherine Plains

Pumping Test Data (Continued)

Location: Guinep Pen

1	2	3	4	5	6	7	8
7/9/86	0110	3780	32.94	13.03			
	0210	3840	32.97	13.06			
	0310	3900	33.00	13.09			
	0410	3960	33.10	13.19			
	0510	4020	33.21	13.30			
	0610	4080	33.21	13.30			
	0710	4140	33.12	13.21			
	0810	4200	33.30	13.39			
	1910	4260	33.10	13.19			
	1010	4320	32.85	12.94	40.5	620	
			Test over at 1010 hrs.				

Pumping Test Data (Continued)

Location: GUINEP PEN Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED -t (MINUTES)	TIME SINCE PUMPING STOPPED -t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
		RECOVERY DATA				
7 9/86	1011	4321	1	24.40	4.49	4321
		4322	2	23.95	4.04	2161
		4323	3	23.68	3.77	1441
		4324	4	23.44	3.53	1081
		4325	5	23.19	3.28	865
		4326	6	23.05	3.14	721
		4327	7	22.90	2.99	618
		4328	8	22.80	2.89	541
		4329	9	22.66	2.75	481
		4330	10	22.60	2.69	433
		4332	12	22.34	2.43	361
		4334	14	22.22	2.31	309
		4336	16	22.16	2.25	271
		4338	18	22.09	2.18	241
		4340	20	21.99	2.08	217
		4345	25	21.77	1.86	174
		4350	30	21.64	1.73	145
		4355	35	21.45	1.54	124
		4360	40	21.34	1.43	109
		4365	45	21.34	1.43	97
	1100	4370	50	21.20	1.29	87
		4375	55	21.18	1.27	79

Pumping Test Data (Continued)

Location: GUINEP PEN Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED -t (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (.ft.)	t/t'
		RECOVERY DATA				
7 9/86		4380	60	21.06	1.15	73
		4390	70	21.01	1.10	63
		4400	80	20.91	1.00	55
		4410	90	20.86	0.95	49
		4420	100	20.68	0.77	44
	1200	4430	110	20.66	0.75	40
		4440	120	20.57	0.66	37
		4455	135	20.56	0.65	33
		4470	150	20.44	0.53	30
		4485	165	20.41	0.50	27
	1310	4500	180	20.34	0.43	25
		4515	195	20.33	0.42	23
		4530	210	20.31	0.40	21
		4540	220	20.30	0.39	20
		4555	235	20.20	0.29	19
		4570	250	20.10	0.19	18
		4585	265	20.00	0.09	17
	1450	4600	280	20.00	0.09	16

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_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR /ADJ SAR
				mg/l																
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	0.16				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

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

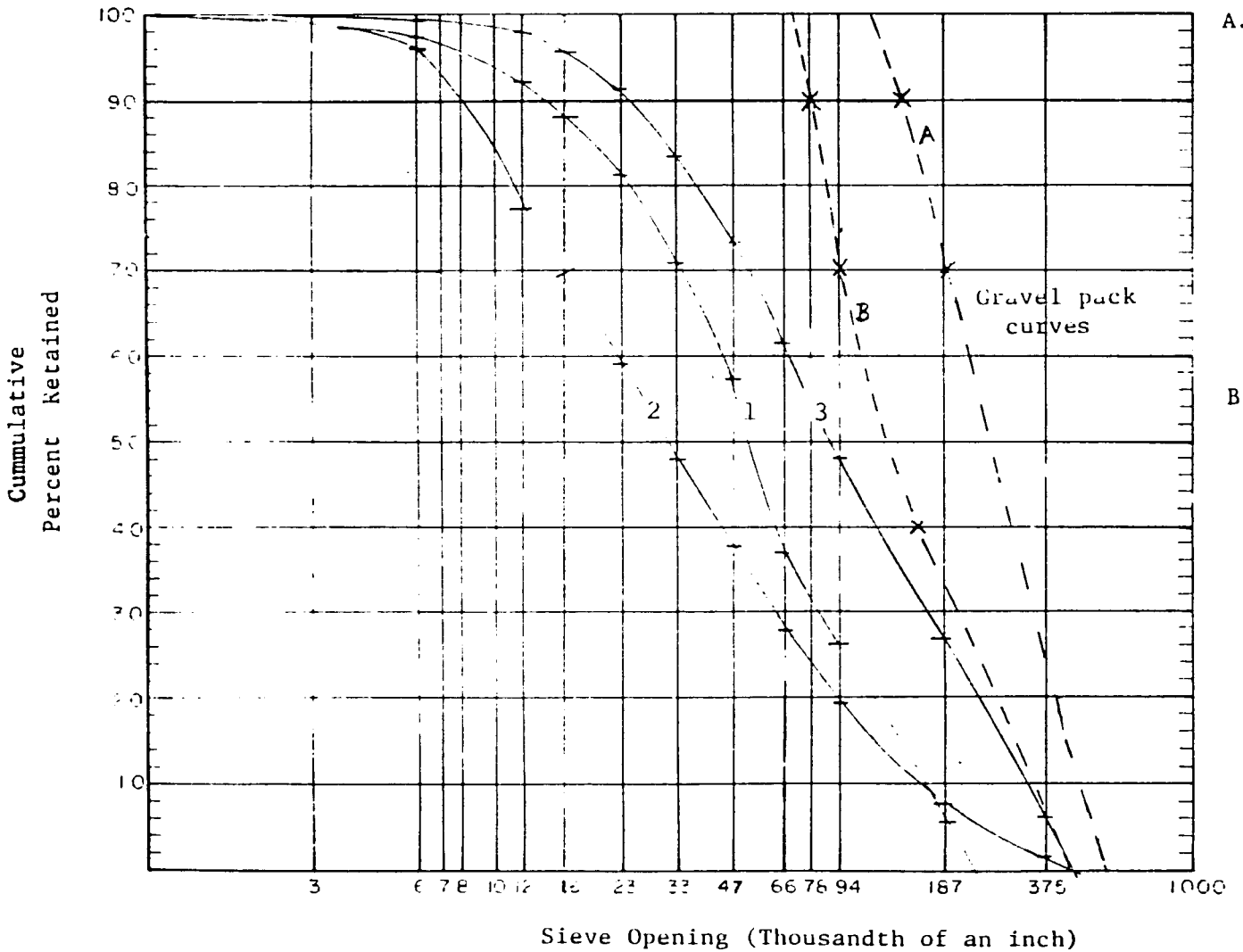
SIEVE ANALYSIS CURVES

Location: Guineppen Corehole

Depth Range: (ft.)

1) 42-44 (Upper Aquifer)

2) 82-84 (3) 98-100 (Lower Aqifer)



A. UPER AQUIFER

1. 70% retention size of the sample = 0.033"
2. 70% retention size of the gravel pack material = 0.033" x 6 = 0.198"
3. Slot size of the screen (90% retention size of the gravel pack material) = 0.150"
4. Uniformity coefficient of the sample = 4.6

B. LOWER AQUIFER

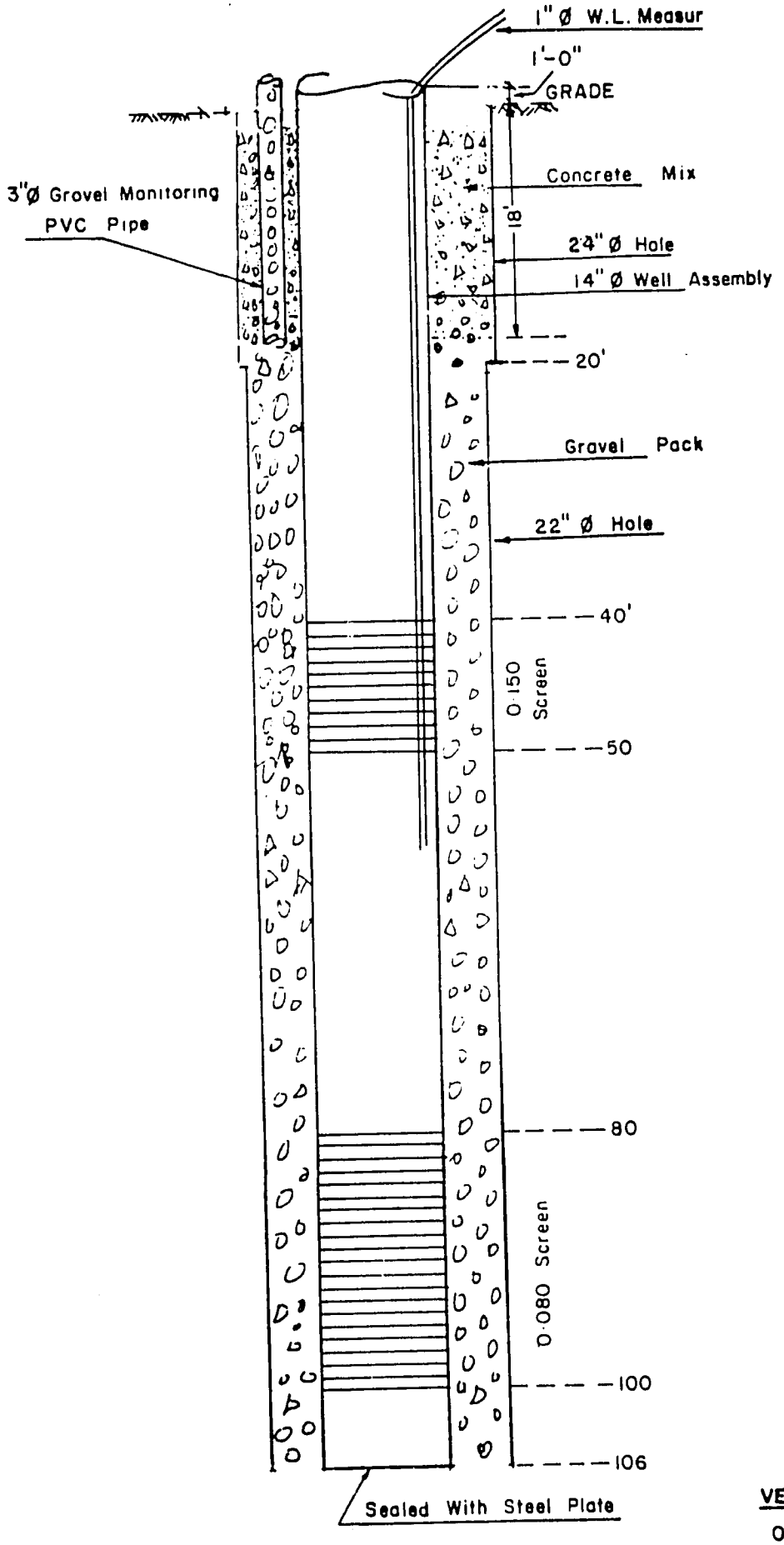
1. Finest sample is #2
2. 70% retention size of the sample =0.016"
3. 70% retention size of the gravel pack material = 0.016" x 6 = 0.096"
4. Slot size of the screen (90% retention size of the gravel pack material) = 0.080"
5. Uniformaity coefficient of the sample = 5.7

ST. CATHERINE PLAINS

Fig. 2

Caymanas Area – Project 'B'

Well Design – Guinep Pen.



DATE : 14·3·86
DRAWING NO. A-052
BY : D. RAMANAMURTY

VERTICAL SCALE
0·8" = 10 Feet

Fig. 3

St. Catherine Plains

Guinep Pen

Step - Drawdown Test Data Plot

Determination of 'B' and 'C'

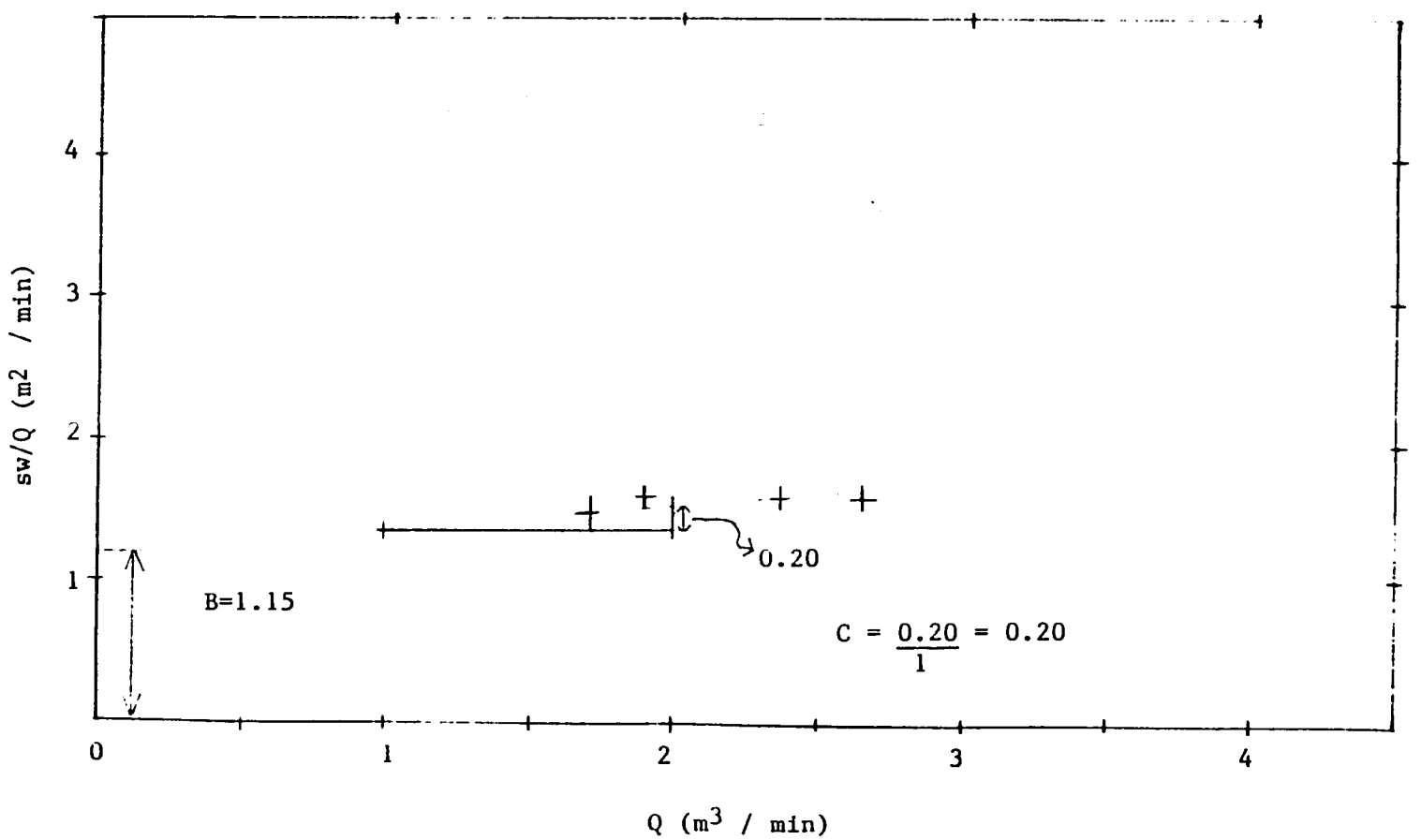


Fig. 4

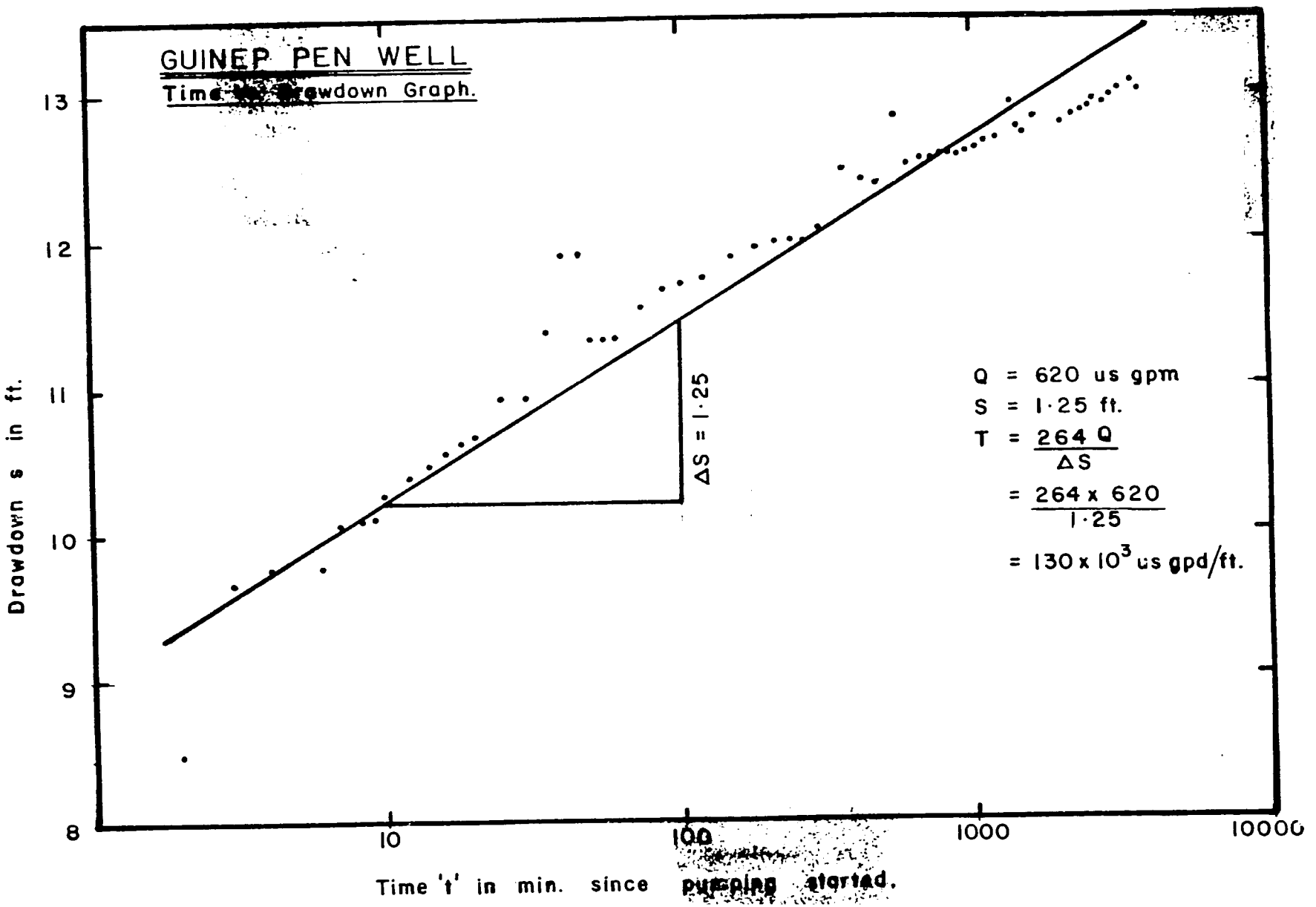
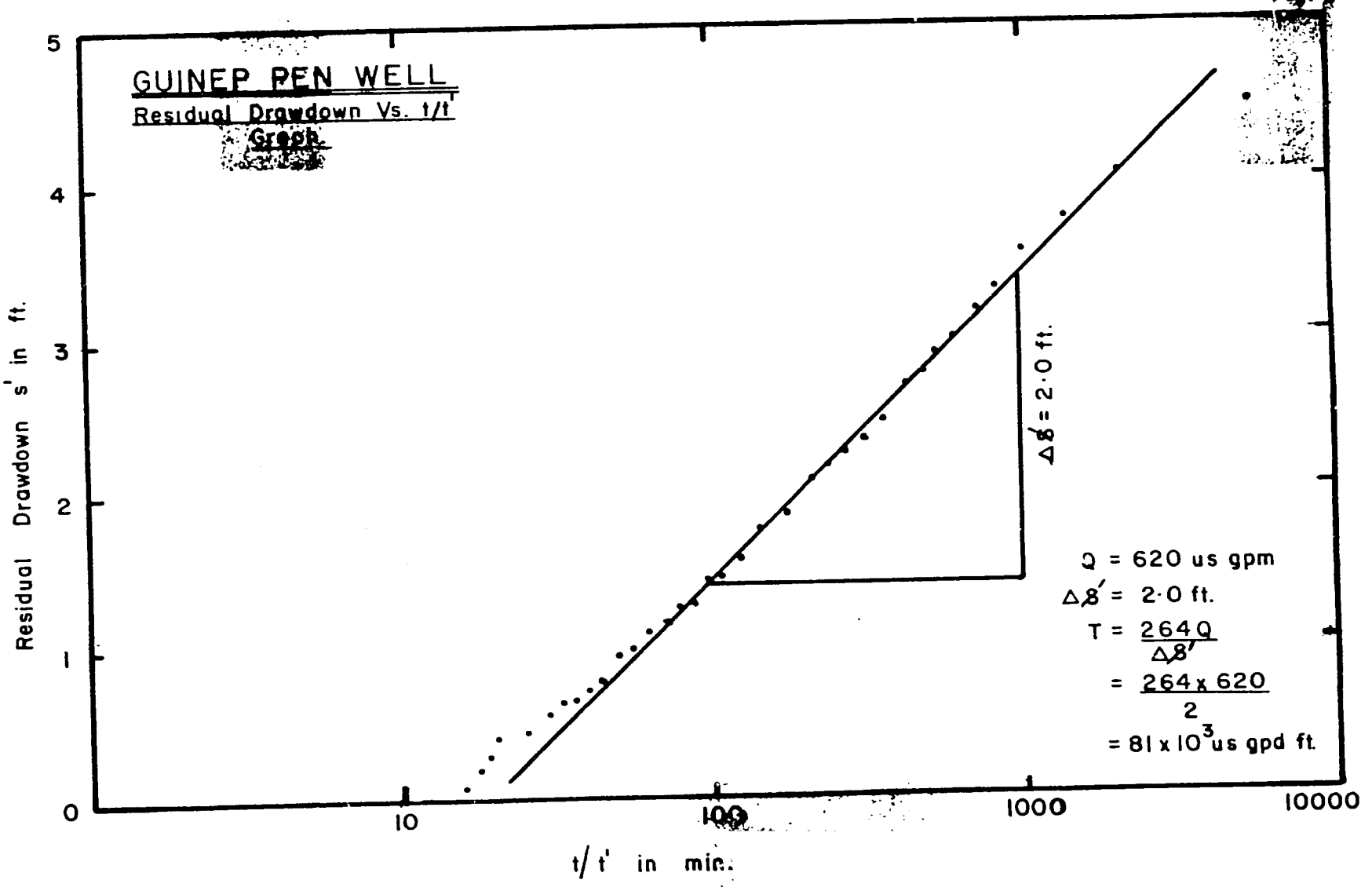

GUINEP PEN WELL
Time [illegible] Drawdown Graph.
Drawdown s in ft.
13
12
11
10
9
8
10
100
1000
10000
Time 't' in min. since pumping started.
ΔS = 1·25
Q = 620 us gpm
S = 1·25 ft.
T = 264 Q / ΔS
= 264 x 620 / 1·25
= 130 x 10³ us gpd/ft.

Fig. 5


GUINEP PEN WELL
Residual Drawdown Vs. t/t'
Graph
Residual Drawdown s' in ft.
t/t' in min.
0
1
2
3
4
5
10
100
1000
10000
Δs' = 2·0 ft.
Q = 620 us gpm
Δs' = 2·0 ft.
T = 264Q / Δs'
= 264 x 620 / 2
= 81 x 10³ us gpd ft.

St. Catherine Plains

Caymanas Area - Project 'B'
Report on the Construction of Well
Naggo Head

Contents

Tables

Figures

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
REPORT ON THE CONSTRUCTION OF WELL - NAGGO HEAD *

1. COREHOLE DRILLING

A corehole of 2" diameter was drilled down to a depth of 110 ft. by Caribbean Boring and Diamond Drilling Limited, Kingston, with a Boyles-37 rotary rig from September 20 to 26, 1985. Core samples were obtained at every 2 ft. interval by split-spoon sampling method. Lithological log of the corehole is given in Table-1.

2. SIEVE ANALYSES OF AQUIFER SAMPLES

Lithological log of the corehole showed that two aquifer zones occur one between 32 ft. and 46 ft. and the other between 75 ft. and 106 ft. Three representative samples of aquifer material from depths of 38 ft. to 40 ft., 84 ft. to 86 ft. and 94 ft. to 96 ft. were subjected to sieve analyses and the results are given in Table-2. Sieve analyses curves are shown in Fig 1. Composition of the aquifer material is more or less the same in both the aquifer zones. It consists mostly of fine to very coarse grained sand with about 20% of gravel upto 0.375" in size.

3. WELL DESIGN

Using the sieve analyses data, the slot size of the well screens and the composition of the gravel pack material were worked out. Six times the 70% retention size of the finest sample (38-40 ft. depth) was considered as the 70% retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity co-efficient of less than 2.5 to represent the composition of the gravel pack material. The gravel pack curve is also shown in Fig 1. Specifications of the gravel pack material are given below:

Size	Percentage
0.047" - 0.094"	40
0.094" - 0.250"	60

The material consisted mostly of rounded to sub-rounded to hard material like quartz and granite with a little limestone impurity.

A replacement well for Cedar Grove #1

Ninety percent retention size of the gravel pack material (0.060") was selected as the slot size of the well screens.

The well assembly was of 14" diameter and consisted of 79 ft. of 0.375" thick steel seamless plain casing and 32 ft. of 304 stainless steel non-clogging type well screens of slot size 0.060" (manufactured by Johnson Division, U.S.A.) The bottom of the assembly was sealed with a steel plate. The well design is shown in Fig 2.

4. WELL CONSTRUCTION

The well was constructed by Caribbean Boring and Diamond Drilling Limited, Kingston using a Mayhew-1500 direct rotary rig. Drilling operations were started on July 9, 1986, and completed on July 11, 1986. The diameter of the hole was 24" down to 20 ft. and 22" below that depth. The well assembly was lowered into the hole on July 13, but it did not go below 33 ft. The hole was therefore abandoned and another hole was drilled about 15 ft. to the north of the first one. Drilling operations were started on July 16 and completed on July 19. Well assembly was lowered into the hole on July 23. The hole was then washed with water on July 24 and gravel packing was done on July 24 and 25. The gravel level was kept at about 18 ft. below ground level. Temporary casing of 24" diameter and 20 ft. length was installed in the well on July 26 (keeping one foot of the casing above ground level) so as to prevent any collapse of the top section of the well that was not packed with gravel during development and testing. The rig and equipment were moved to the South Syndicate #2 well site by July 28, 1986.

5. WELL DEVELOPMENT

The well was developed and tested by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10. A percussion rig was used to conduct these operations. The well was developed for a total period of 141 hours by surging with a surge block and bailing (67 hours) with an air compressor (56 hours) and with a turbine pump (16 hours) from August 26, 1986 to September 18, 1986. An account of the development operations is given below:

	Date	Method of Development	No. of Hours
a)	Aug. 26-29	Surging with a surge block and bailing	32

	Date	Method of Development	No. of Hours
b)	Sept. 2-8	With an air compressor using an 8" eductor pipe and 1 1/4" air pipe	40
c)	Sept. 9-15	As at (a)	37
d)	Sept. 16-19	As at (b)	16
e)	Sept. 21-22	With a turbine pump	16

At the end of the development operations the yield of the well was around 600 gpm for a pumping water level of about 45 ft.

6. STEP-DRAWDOWN TEST

A step-drawdown test was conducted on September 23, 1986, with discharge rates of 420, 496, 576 and 624 gpm the duration of each step being 2 hours. The test data is given in Table-3 and the data plot is given as Fig 3. Calculations of formation loss, well loss and well efficiency are shown in Table-4. The well loss coefficient of 0.8 min^2/m^5 indicates mild clogging of the well.

7. TIME-DRAWDOWN TEST

A time-drawdown test was conducted for a period of 51 hours beginning at 10 a.m. on September 25, 1986, and ending at 1 p.m. on September 27, 1986, at a discharge rate of 504 gpm. The static water level was 17.84 and the pumping water stabilized around 38 ft. after 12 hours of pumping. The specific capacity works out to 22 gpm/ft. The test data is given in Table-5 and the time vs drawdown graph and t/t' vs drawdown graph are given as Fig 4 and Fig 5 respectively. The transmissivity of the formation as calculated by the drawdown and recovery methods is 156 x 10^3 gpd/ft. and 140 x 10^3 gpd/ft. respectively.

8. QUALITY OF WATER

Chemical analyses results of 3 water samples collected during the time-drawdown test are given in Table-6.

9. RATE OF ABSTRACTION

It is seen from the time-drawdown test data that the well can yield steadily at the rate of 500 gpm. The abstraction from the well may therefore be limited to 500 gpm which is also the licensed capacity of the well.

10. GROUTING OF THE WELL

During the development and testing of the well, the gravel level in the annular space between the temporary casing 24" dia. and the well assembly was maintained around 18 ft. below ground level. After the time-drawdown test was over, the temporary casing was pulled out and a 4" dia. pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor the gravel level in the well from time to time. The annular space was then grouted with cement concrete.

(The measure used is US gallons. The depths indicated are below ground level).

REFERENCES

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2. John Hem. 1971. Study and Interpretation of Chemical Characteristics of Natural Water. USGS Water Supply Paper, 1473. Washington D.C.

3. Keith E. Anderson (Editor). 1979, Waterwell Handbook, Missouri Waterwell and Pump Contractors Association Inc. Belle.

4. Todd D.K. 1980, Groundwater Hydrology, John Wiley & Sons Inc., New York.

St. Catherine Plains

Caymanas Area

Lithological Log of Corehole

Naggo Head

Depth Range (Ft.)	Thickness (Ft.)	Description
0-6	6	Top soil and brown silty sand with a little clay.
6-10	4	Brown silty and clayey sand.
10-15	5	Dark brown silty clay with a little fine to coarse grained sand.
15-32	17	Dark brown stiff silty clay with some fine to coarse grained sand.
32-46	14	Brown very fine to very coarse grained sand with about 20% of angular gravel (upto 0.375" in size) and a little silt and clay
46-49	3	Stiff brown sandy clay.
49-58	9	Brown fine to coarse grained sand with much of clay.
58-60	2	Hard brown silty clay with coarse grained sand at the bottom.
60-75	15	Stiff brown to dark brown clay silty and sandy.
75-87	12	Brown very fine to very coarse grained sand with about 20% of angular gravel (upto 0.25" in size) and a little silt and clay
87-90	3	Stiff brown caly, slightly sandy and silty.
90-106	6	As at 75-87 ft.
106-110	4	Stiff dark brown silty clay.

St. Catherine Plains

Sieve Analys s Results of Aquifer Samples

Location: NAGGO HEAD COREHOLE

Area: CAYMANAS PROJECT 'B'

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 38-40			84-86			94 - 96					
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	-	-	-	-	-	-	-	-	-			
2.	3/8"	0.375	6.2	6.2	4.7	-	-	-	-	-	-			
3.	4	0.187	7.1	13.3	10.1	4.6	4.6	3.6	8.8	8.8	6.6			
4.	10	0.078	15.8	29.1	22.0	18.6	23.2	18.0	18.0	26.8	20.0			
5.	16	0.047	12.3	41.4	31.3	18.2	41.4	32.1	12.8	39.6	29.6			
6.	30	0.023	25.3	66.7	50.4	31.1	72.5	56.2	31.4	71.0	53.1			
7.	50	0.012	30.0	96.7	73.1	22.8	95.3	73.9	27.8	98.8	73.9			
8.	80	0.007	14.4	111.1	84.0	12.2	107.5	83.4	13.5	112.3	83.9			
9.	100	0.006	4.5	115.6	87.4	3.5	111.0	86.1	5.1	117.4	87.8			
10.	200	0.003	8.7	124.3	94.0	8.8	119.8	92.9	11.2	128.6	96.2			
11.	PAN	--	7.9	132.2	100.0	9.1	128.9	100.0	5.1	133.7	100.0			

@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A - weight retained (grams)
B - cumulative weight retained (grams)
C - cumulative percentage retained

St. Catherine Plains

Step-Drawdown Test Data

Location: NAGGO HEAD Area: CAYMANAS

Diameter- Discharge Pipe 8 ins. Orfice 5 ins.

Static Water Level 20.00 ft.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
23/9/86	1 130	S	T	E	P	I	
		5	33.46	13.46	16.5	408	
		10	33.96	13.96	17.5	420	
		15	34.37	14.37	18	426	
		20	34.54	14.54	17.5	420	
		25	34.71	14.71			
		30	34.29	14.29			
		40	35.21	15.21			
		50	35.21	15.21			
		60	35.00	15.00	17.5	420	
		75	35.00	15.00			
		90	35.08	15.08			
		105	35.08	15.08			
		120	35.08	15.08	17.5	420	
	1 330	S	T	E	P	II	
		10	38.84	18.8.	25	496	
		15	39.12	19.12			
		20	38.84	18.84			
		25	38.84	18.84			
		30	39.08	19.08	25	496	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: NAGGO HEAD

1	2	3	4	5	6	7	8
		40	39.00	19.00	25	496	
		50	39.02	19.02			
		60	39.08	19.08			
		75	39.08	19.08			
		90	39.08	19.08			
		105	39.08	19.08			
		120	39.12	19.12	25	496	
23/9/86	1 530	S	T	E	P	III	
		5	43.41	23.41	37	592	
		10	43.91	23.91	36	584	
		15	44.08	24.08			
		20	44.16	24.16	36	584	
		25	44.20	24.20	35.5	580	
		30	44.08	24.08	35	576	
		40	44.08	24.08			
		50	44.08	24.08			
		60	44.08	24.08	35	576	
		75	44.00	24.00			
		90	44.00	24.00			
		105	44.00	24.00			
		120	44.00	24.00	35	576	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: NAGGO HEAD

1	2	3	4	5	6	7	8
23/9/86	1 730	S	T	E	P	IV	
		5	46.08	26.08	40.5	620	
		10	45.79	25.79	41	624	
		15	45.79	25.79	41	624	
		20	45.79	25.79			
		25	45.75	25.75			
		30	45.83	25.83			
		40	43.83	25.83	41	624	
		50	45.79	25.79	41.5	628	
		60	45.75	25.75	41	624	
		75	45.75	25.75			
		90	45.83	25.83	41.5	628	
		105	46.00	26.00			
		120	46.00	26.00	41	624	
		TEST OVER AT 1930 HRS.					

TABLE 4

ST. CATHERINE PLAINS

NAGGO HEAD

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q) USgpm	Discharge (Q) m^3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
1	420	1.59	15.08	4.60	2.89	2.46	2.02	4.48	55	27.8
2	496	1.88	19.12	5.83	3.10	2.91	2.83	5.74	51	25.9
3	576	2.18	24.00	7.31	3.35	3.35	3.80	7.18	47	24.0
4	624	2.36	26.00	7.92	3.35	3.66	4.46	8.12	45	24.0

From the Graph (Figure 3)

Formation loss coefficient (B) = 1.55
Well loss coefficient (C) = 0.80

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Location: NAGGO HEAD Area: CAYMANAS

Diameter- Discharge Pipe 8 ins. Orfice 5 ins.

Static Water Level 19.84 ft. below M.P. which is about 2 ft. above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
25/9/86	1 000	PUMPING STARTED					
		2	32.92	13.08	26	504	
		3	36.71	16.87			
		4	37.29	17.45			
		5	37.69	17.85			
		6	37.96	18.12			
		7	38.08	18.24			
		8	38.25	18.41			
		9	38.66	18.82			
		10	38.92	19.08			
		12	38.84	19.00			
		14	39.00	19.16			
		16	39.12	19.28			
		18	39.66	19.82	26	504	
		20	39.29	19.45			
		22	39.41	19.57			
		24	39.41	19.57			
		26	39.45	19.61	26	504	
		28	39.45	19.61			
		30	39.45	19.61			
		35	39.62	19.78			

St. Catherine Plains

Pumping Test Data (Continued)

Location: NAGGO HEAD S.W.L. - 19.84 ft.

1	2	3	4	5	6	7	8
25/9/86		40	39.62	19.78			
		45	39.75	19.91			
		50	39.75	19.91			
		55	39.71	19.87			
		60	39.67	19.83			
		65	39.71	19.87			
		70	39.69	19.85			
		75	39.69	19.85			
		80	39.71	19.87			
		85	39.71	19.87			
		90	39.69	19.85	26		
		105	39.71	19.87			
		120	39.71	19.87			
		135	39.92	20.08			
		180	39.92	20.08			
		195	39.92	20.08			
		210	39.92	20.08			
		240	39.92	20.08			
		270	40.00	20.16			
		300	40.00	20.16			
		330	40.00	20.16			
		360	40.25	20.41			
		420	40.16	20.32			

St. Catherine Plains

Pumping Test Data (Continued)

Location: NAGGO HEAD S.W.L. - 19.84 ft.

1	2	3	4	5	6	7	8
		480	40.04	20.20	26	504	
		540	40.25	20.41			
		600	40.29	20.45			
		660	40.29	20.45			
		720	40.25	20.41			
"		780	40.25	20.41			
26/9/86	0000	840	40.25	20.41			
		900	40.25	20.41			
		960	40.25	20.41			
		1,020	40.25	20.41			
		1,080	40.25	20.41			
		1,140	40.25	20.41			
		1,200	40.25	20.41			
		1,260	40.25	20.41			
		1,320	40.16	20.32			
		1,380	40.08	20.24			
		1,440	40.04	20.20			
		1,500	40.00	20.16			
		1,560	40.00	20.16			
		1,620	40.00	20.16			
		1,680	40.00	20.16			
		1,740	40.00	20.16			
		1,800	40.00	20.16			

St. Catherine Plains

Pumping Test Data (Continued)

Location: NAGGO HEAD S.W.L.- 19.84ft.

1	2	3	4	5	6	7	8
		1,860	40.00	20.16	26	504	
		1,920	40.00	20.16			
		1,980	40.00	20.16			
		2,040	40.00	20.16			
		2,100	40.02	20.18			
		2,160	40.04	20.20			
		2,220	40.04	20.20			
27/9/86	0000	2,280	40.04	20.20			
		2,340	40.06	20.22			
		2,400	40.06	20.22	26	504	
		2,460	40.08	20.24			
		2,520	40.12	20.28			
		2,580	40.16	20.32			
		2,640	40.12	20.28			
		2,700	40.12	20.16			
		2,760	40.00	20.08			
		2,820	39.92	20.08			
		2,880	39.92	20.08			
		2,940	39.92	20.08			
		3,000	40.00	20.08			
		3,060	40.00	20.16	26	504	
		PUMPING STOPPED AT 1300 HRS					

Pumping Test Data (Continued)

Location: NAGGO HEAD Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
2./9/86	1 300	PUMPING	STOPPED			
		3061	1	30.00	10.16	3061
		3062	2	23.00	3.16	1531
		3063	3	21.54	1.70	1021
		3064	4	20.83	0.99	766
		3065	5	20.66	0.82	613
		3066	6	20.51	0.67	511
		3067	7	20.42	0.58	438
		3068	8	20.33	0.49	383
		3069	9	20.31	0.47	341
		3070	10	20.25	0.41	307
		3071	11	20.20	0.36	279
		3072	12	20.16	0.32	256
		3073	13	20.12	0.28	236
		3074	14	20.08	0.24	219
		3075	15	20.00	0.16	205
		3077	17	20.00	0.16	181
		3078	18	20.00	0.16	171
		3079	19	20.00	0.16	162
		3080	20	20.00	0.16	154
		3085	25	19.92	0.08	123
		3090	30	19.92	0.08	103

Pumping Test Data (Continued)

Location: Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
29/9/86		3095	35	19.92	0.08	88
		3100	40	19.92	0.08	77
		3105	45	19.92	0.08	69
		3120	60	19.92	0.08	52
		3135	75	19.88	0.04	41
		3150	90	19.85	0.01	35
		3180	120	19.84	0.00	26

Table-6

Chemical Analyses of Water Samples

Location: NAGGO HEAD

Area: CAYMANAS - PROJECT 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	S	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR /ADJ SAR
				← mg/l →																
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

@/u/mhos/cm at 25°C * as $CaCo_3$

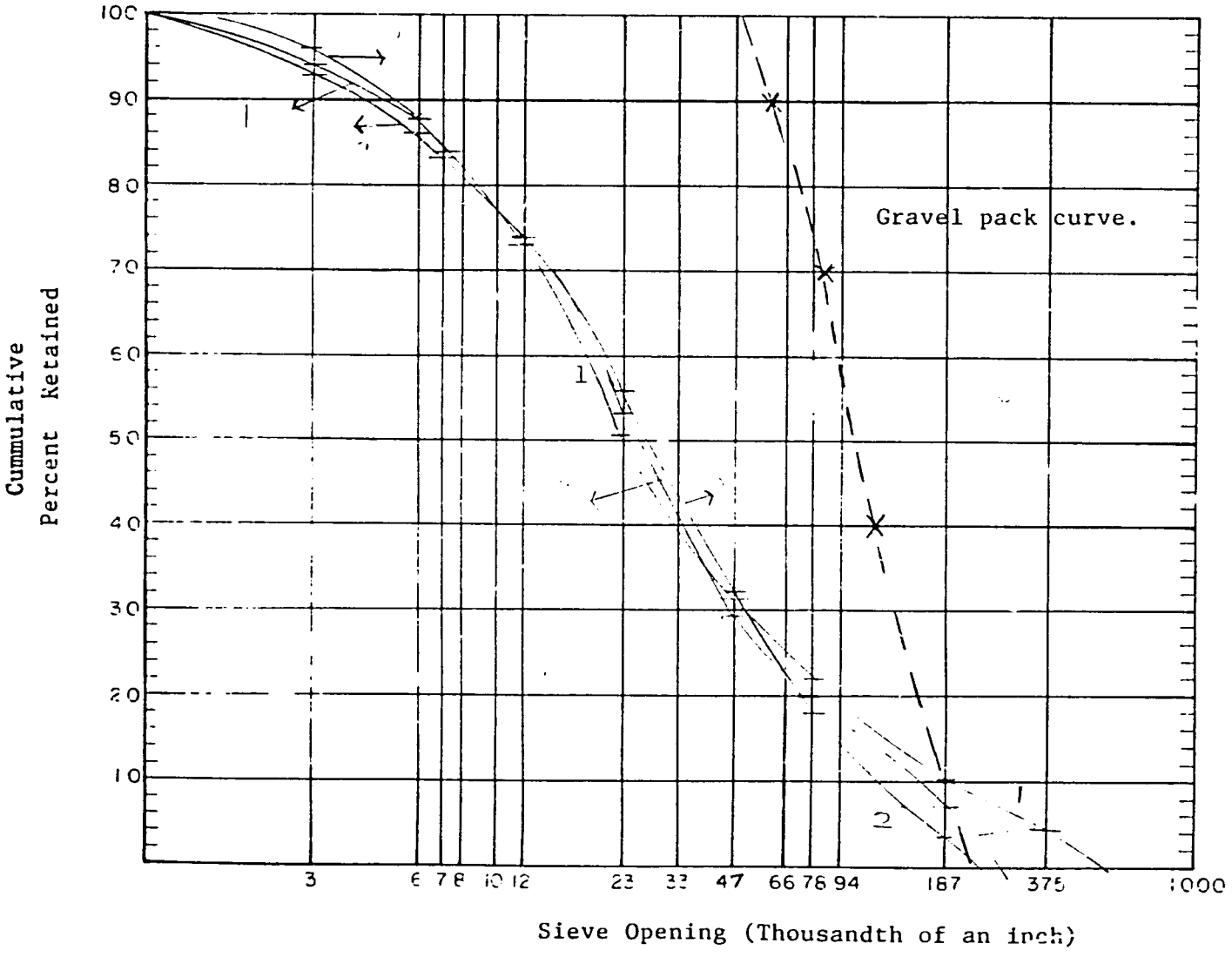
Analysis by Jamaica Bauxite Institute, Kingston)

SIEVE ANALYSIS CURVES

Location: Naggohead Corehole

Depth Range: (ft.)

1) 38-40 (2) 84-86 (3) 94-96



NAGGOHEAD COREHOLE

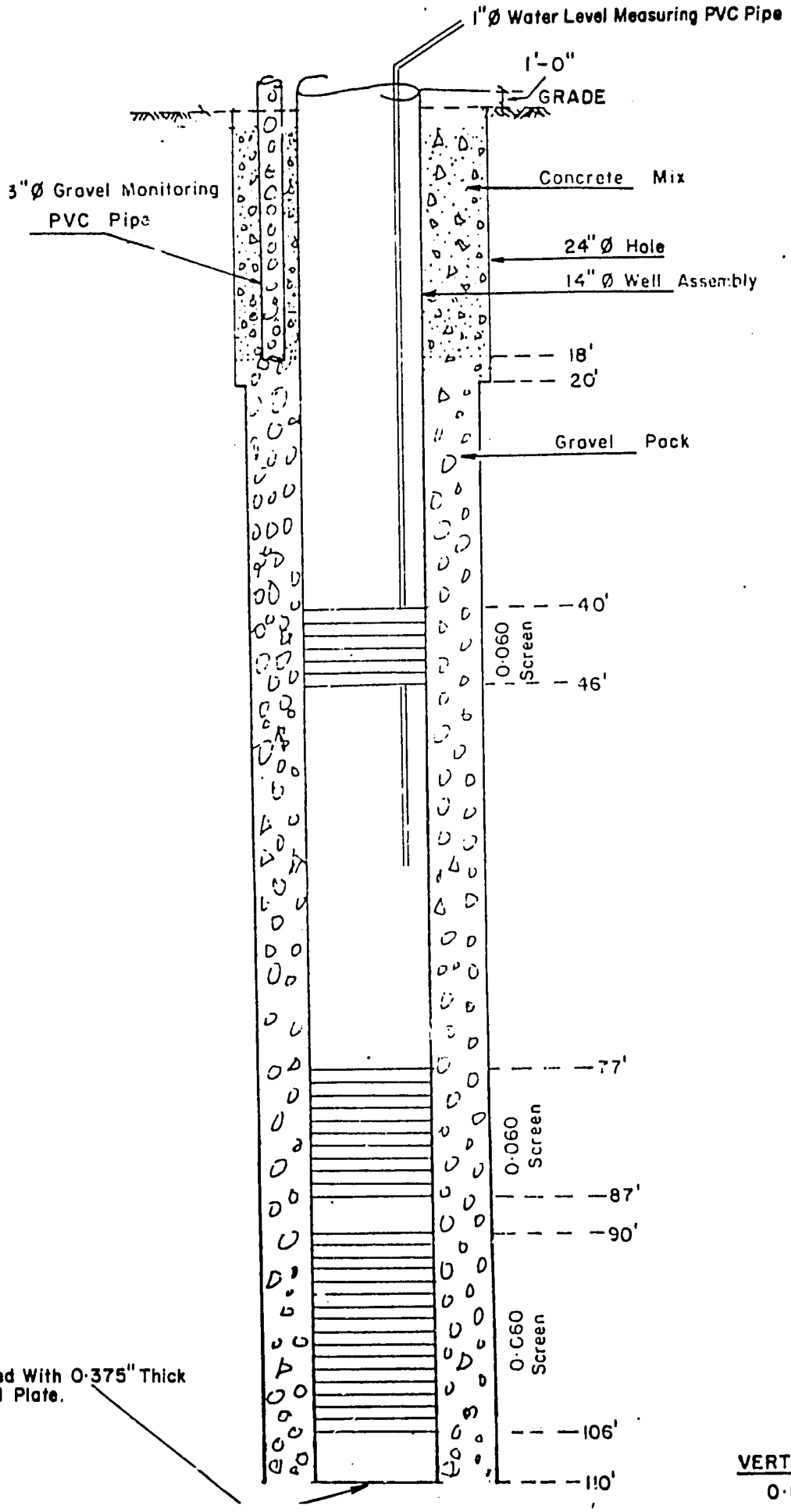
1. Finest sample is #1
2. 70% retention size of the sample = 0.014"
3. 70% retention size of the gravel pack material = 0.014" x 6 = 0.084"
4. Slot size of the screen (90% retention size of the gravel pack material) = 0.060"
5. Uniformity coefficient of the sample = 6.6

ST. CATHERINE PLAINS

Fig. 2

Caymanas Area – Project 'B'

Well Design – Naggo Head.



DATE : 14·3·86

DRAWING NO. A-053

BY : D. RAMANAMURTY

VERTICAL SCALE

0·8in = 10 ft.

Fig. 3

St. Catherine Plains

Naggo Head

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'

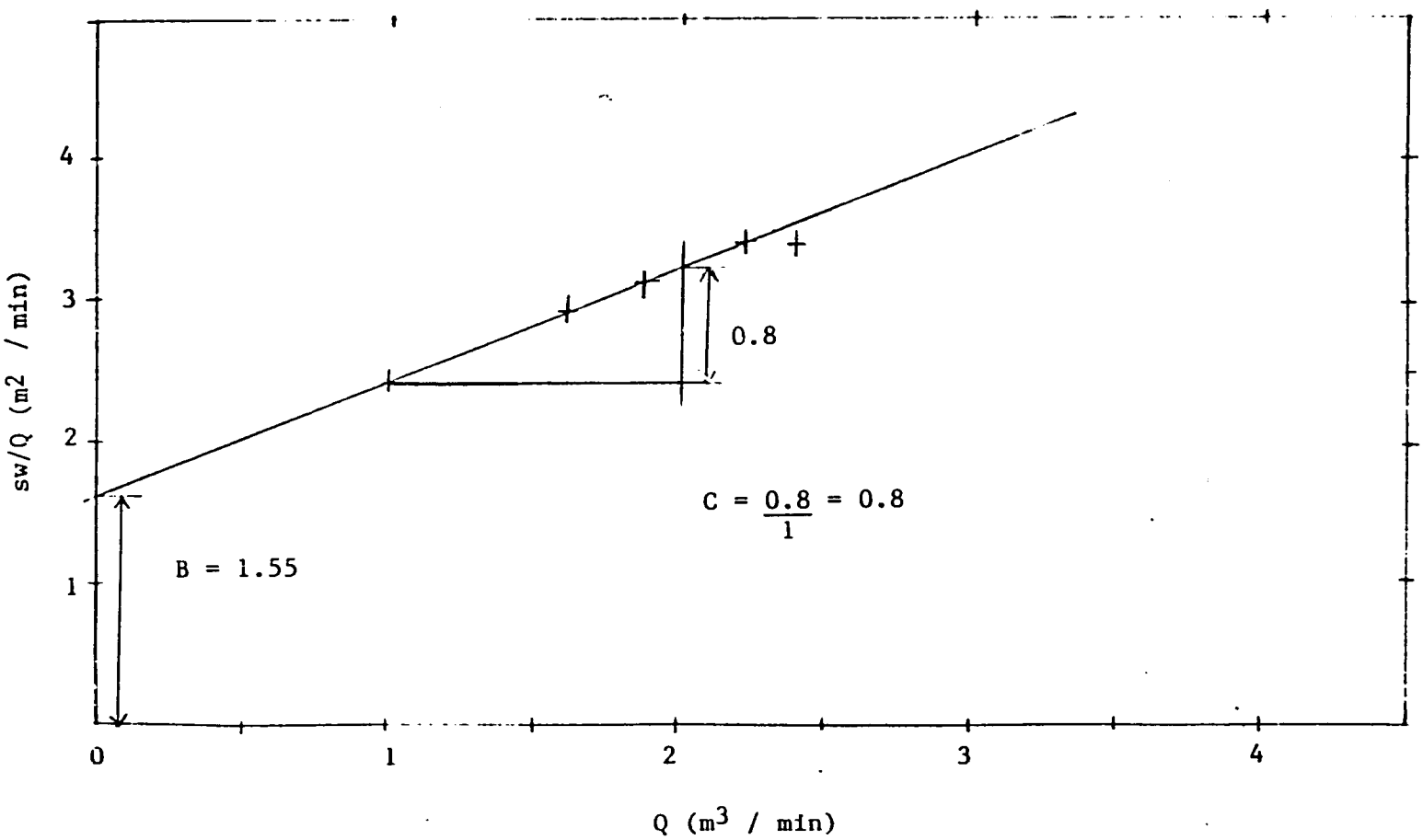


Fig. 4

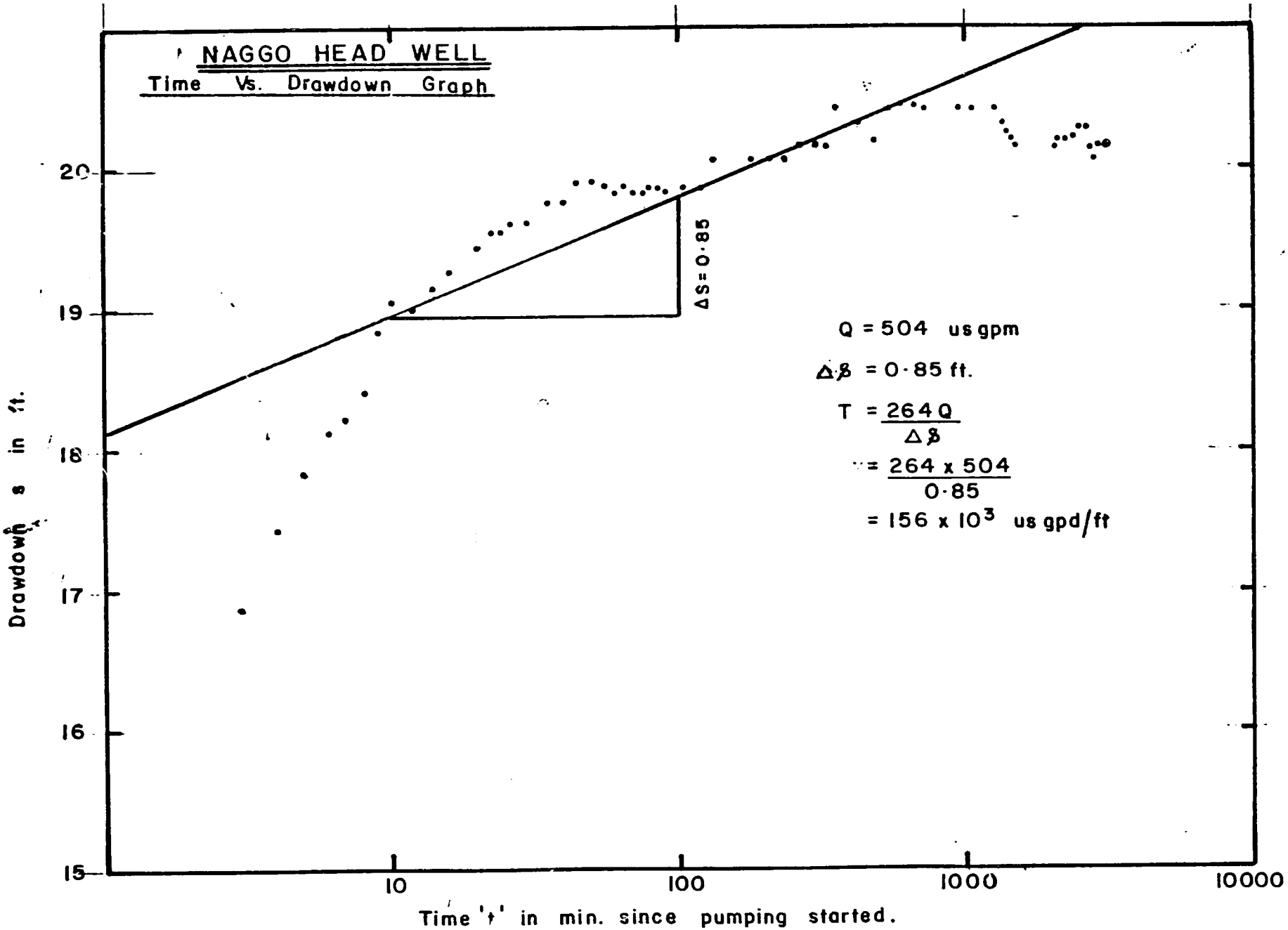
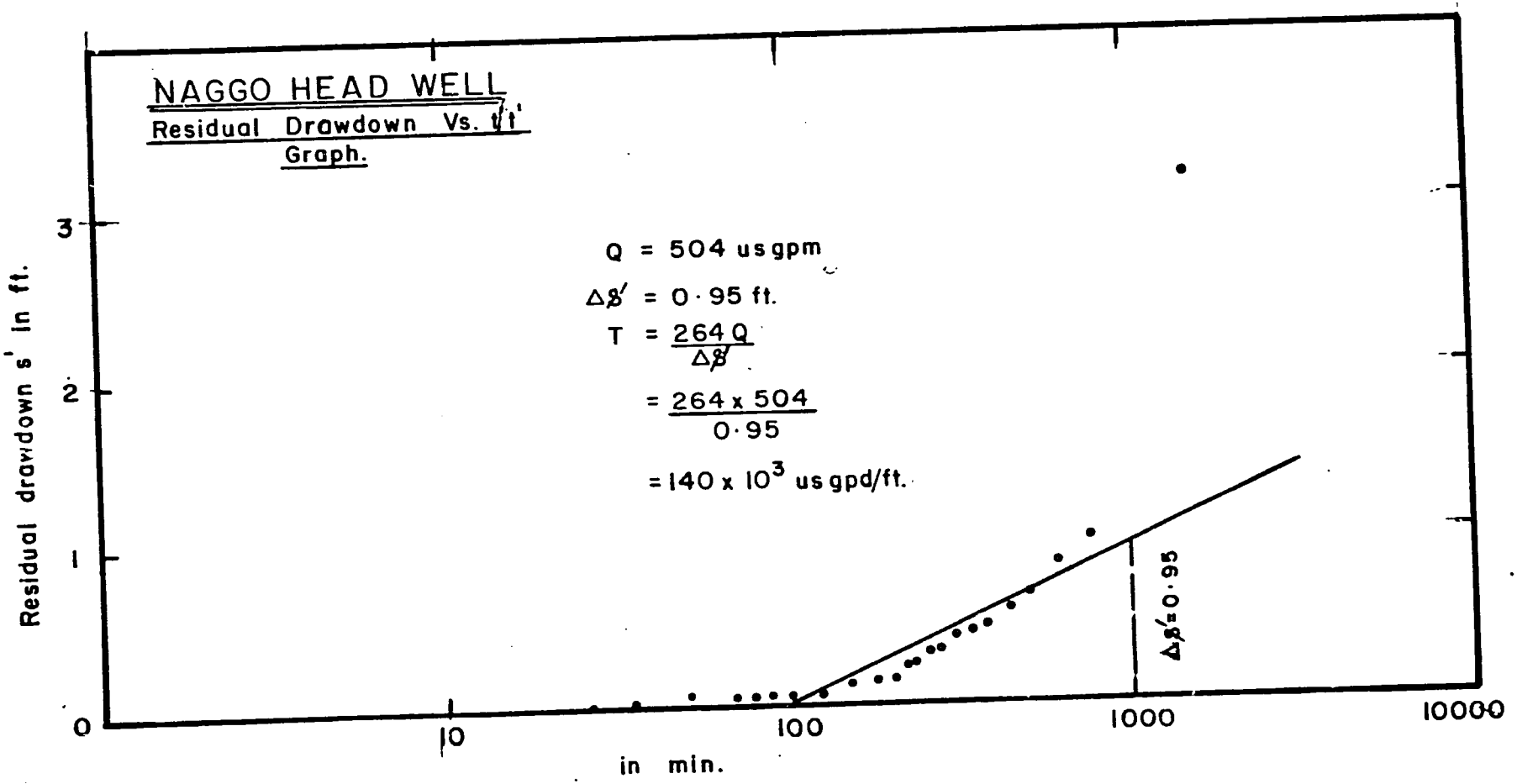

NAGGO HEAD WELL
Time Vs. Drawdown Graph
20
19
18
17
16
15
Drawdown s in ft.
ΔS=0·85
Q = 504 us gpm
Δs = 0·85 ft.
T = 264Q / Δs
= 264 x 504 / 0·85
= 156 x 10³ us gpd/ft
10
100
1000
10000
Time 't' in min. since pumping started.

Fig 5


NAGGO HEAD WELL
Residual Drawdown Vs. t/t'
Graph.
Q = 504 us gpm
Δs' = 0·95 ft.
T = 264 Q / Δs'
= 264 x 504 / 0·95
= 140 x 10³ us gpd/ft.
Residual drawdown s' in ft.
3
2
1
0
10
100
1000
10000
in min.
Δs'=0·95

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
REPORT ON THE CONSTRUCTION OF WELL
NORTH SYNDICATE #2

Tables

Figures

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
REPORT ON THE CONSTRUCTION OF WELL
NORTH SYNDICATE #2 *

1. INTRODUCTION

North Syndicate well is at the extreme western end of the area. The well record was obtained from the Underground Water Authority (formerly Water Resources Division) and is given as Table-1. This well was constructed in July 1957, using perforated casing and coarse gravel. It used to pump sand and therefore the land surface around it collapsed in course of time forming a big depression. It was not in use for a long time and was filled below 34 ft.

In July 1985, attempts were made to clean the well and test it for the yield and water quality. Caribbean Boring and Diamond Drilling Limited, Kingston, carried out the cleaning operations from July 23 to 26, 1985, using a Mayhew-1500 direct rotary rig. The well could be cleaned down to 43 ft. with a 14" diameter drill bit. The diameter of the well appeared to have narrowed below 43 ft. and only a 6" dia. bit could be used to clean the well down to 54 ft. At this depth hard material was encountered which sounded like a metal. The well, therefore, could not be cleaned down to the original depth of 61 ft. The material which filled the well consisted of sand, gravel and small pieces of limestone and cement concrete. It was gathered from the cleaning operations that the well was not straight and therefore it was decided to abandon the well and construct a replacement well.

2. DRILLING OF COREHOLE #1

A corehole of 2" diameter was drilled down to 104 ft. at a location about 200 ft. to the south east of the well by Caribbean Boring and Diamond Drilling Limited, Kingston, from August 16 to 21, 1985, with a Boyles-37 rotary rig. Core samples were obtained at 2 ft. intervals, by split spoon sampling method. Lithological log of the corehole is given in Table-2. Two aquifer zones occur - one from 42 ft. to 57 ft. and the other from 84 ft. to 100 ft. The aquifer material consists mostly of medium to very coarse grained sand with angular to sub-rounded gravel upto 0.5" in size forming as much as 50% of the material.

---

* A replacement well for North Syndicate #1

In the lower zone there are some layers of finer materials. Six samples of aquifer material, three from each of the two zones were subjected to sieve analyses and the results are given in Table-3 and the sieve analyses curves are shown in Fig. 1.

3. DRILLING OF COREHOLE #2

As the location of corehole #1 was somewhat away from the underground pipeline, another corehole was drilled at about 1800 ft. southeast of corehole #1, close to the pipeline. The drilling was done by Caribbean Boring and Diamond Drilling Limited, Kingston, with a Boyles-37 rotary rig from June 19 to 27, 1986. Core samples were obtained at 2 ft. intervals by split-spoon sampling method. Lithological log of the corehole is given in Table-4. Two aquifer zones occur, one from 60 ft. to 80 ft. and the other from 88 ft. to 100 ft. The aquifer material is fairly uniform from top to bottom and consists mostly of fine to very coarse grained sand with 20% to 25% of angular to sub-rounded gravel upto 0.5" in size. The thickness of the aquifers is considerable and the aquifer material is fairly uniform.

4. SIEVE ANALYSES OF AQUIFER SAMPLES

Three samples of aquifer material from depth ranges 64-66 ft., 76-78 ft. and 92-94 ft. were subjected to sieve analyses and the results are given in Table-5. The sieve analyses curves are shown in Fig. 2.

5. WELL DESIGN

The slot size of the well screens and the composition of the gravel pack material were worked out using the sieve analyses curves. Six times the 70% retention size of the finest sample (sample #2) was taken as the 70% retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity co-efficient of less than 2.5 to represent the composition of the gravel pack material. The gravel pack curve is also shown in Fig. 2 and the composition of the gravel pack material is given below:

	Size	Percentage
(a)	0.047" - 0.094"	40
(b)	0.094" - 0.250"	60

Ninety percent retention size of the gravel pack material (0.060") was selected as the slot size of the well screen. The well assembly was of 14" diameter.

It consisted of 77 ft. of 0.375" thick steel seamless plain casing and 26 ft. of 304 stainless steel, non-clogging type well screens of slot size 0.060" (manufactured by Johnson Division, U.S.A.). The bottom of the assembly was sealed with a steel plate. The well design is shown in Fig. 3.

6. WELL CONSTRUCTION

The well was constructed by the Underground Water Authority, Hope Gardens, Kingston, using a Davey-1500 direct rotary rig. Drilling of a 24" diameter hole was started on August 7, 1986. The diameter of the hole was reduced to 22" below th depth of 20 ft. Drilling was completed on August 14, 1986, at the targeted depth of 102 ft. The well assembly was lowered into the hole on August 15, but it got stuck at 70 ft. probably due to the caving of the hole at depth. The assembly was therefore pulled out on the same day. The hole was redrilled and the assembly was lowered again on August 20, 1986. Twenty-six (26) cu. ft. of gravel was installed on that same day. Freshwater was circulated from August 21 to 27 to clear the well of drilling mud and another 130 cu. ft. of gravel was added from time to time during this period. A temporary casing of 24" diameter and 20 ft. length was lowered into the well (from one ft. above ground level to 19 ft. below ground level) on August 28, to prevent the collapse of that portion of the well which was not filled with gravel, during development and testing. The rig and equipment were moved from the site within 4 days to Kingston.

7. WELL DEVELOPMENT

The development and testing of the well were done by the Caribbean Wells and Diamond Coring Limited., 43 Burlington Avenue, Kingston 10. A Mayhew-1500 direct rotary rig was used for conducting these operations.

The well was developed for a total period of 179 hours from October 23 to November 19, 1986, by surging with a surge block and bailing, with an air compressor and with a turbine pump. Five thousand (5,000) gallons of water was circulated in the well before starting the development, to remove the drilling fluid from the well. Four (4) bags (each 100 lbs.) of sodium hexa-metaphosphate were used from time to time during the development to disperse the clay fractions.

An account of the development operations is given below:

	Date	Methods of Development	No. of hours
	1986		
(a)	Oct. 23-25	With an air compressor using a 4" eductor pipe and 1 1/4" air pipe, occasionally closing and opening the outlet pipe with the help of a valve so as to create air surging	22
(b)	Oct. 27-31	Surging with a surge block and bailing	40
(c)	Nov. 5-9	With an air compressor using an 8" eductor pipe and 1 1/4" air pipe	40
(d)	Nov. 10-12	As at (b)	22
(e)	Nov. 13-16	As at (c)	32
(f)	Nov. 17-19	With a turbine pump	23

At the end of these development operations, the yield from the well was around 1200 gpm for a pumping water level of 56-58 ft.

8. STEP-DRAWDOWN TEST

A step-drawdown test was conducted on November 20, 1986, with discharge rates of 800, 880, 1,000 and 1,200 gpm, the duration of each step being 2 hours. The test data is given in Table-6 and the data plot is given in Fig-4. Calculations of formation loss, well loss and well efficiency are shown in Table-7. It is seen from the Table that the calculated and observed drawdowns compare fairly. The well loss co-efficient of 0.25 min /m indicates that the well is properly designed and developed. The performance of the well was fairly steady throughout the test without any high fluctuations either in the yield or in the pumping water level in any of the steps.

9. TIME-DRAWDOWN TEST

A time-drawdown test was conducted from November 24 to 27, 1986, for a period of 72 hours and 50 minutes at an average discharge rate of 1000 gpm. The static water level was 18.29 ft. and the pumping water level stabilized around 52 ft. after 1000 minutes of pumping. The specific capacity works out to 29 gpm/ft. The test data is given in Table-8 and the time vs drawdown graph and the t/t' vs residual drawdown graph are shown in Fig-5. The transmissivity of the formation is calculated to be 406 x 10^3 gpd/ft. by drawdown method and 58 x 10^3 gpd/ft. by recovery method. As the water level recovered completely within 10 minutes after the pump was shut off, the transmissivity by the recovery method worked out low.

10. QUALITY OF WATER

Chemical analyses results of water samples collected from the well during the step-drawdown test and the time-drawdown test are given in Table-9.

11. SAND CONTENT IN WELL WATER

Sand content in well water was determined with the help of a 'Rossum' sand content tester. The tester was fitted to the discharge pipe, close to the discharge head and the sand collected in the test tube of the tester was weighed and the sand content in water in mg/l was determined. Results of the tests conducted are given below:

Date	Type of test	Pumping Rate (gpm)	Time of Sand Content Test	Quantity of water flown through tester (litres)	Weight of sand collected in tester (mg)	Sand Content in Water (mg/l)
20.11.86	SDT	800	90 mts.	170	4.9	0.028
	"	900	90 mts.	170	6.7	0.039
	"	1100	90 mts.	170	3.3	0.019
	"	1100	90 mts.	170	4.1	0.024
24.11.86 - 25.11.86	Time Test	1000	24 hrs.	2721	9.3	0.0034
25.11.86 -	"	1000	24 hrs.	2721	8.7	0.0032

The recommended rate of abstraction from the well is 800 gpm and therefore the sand content in the well discharge could be less than 0.003 mg/l.

12. RATE OF ABSTRACTION

It is seen from the time-drawdown test data that the well can yield steadily 1000 gpm for a pumping water level of about 50 ft. However, abstraction from the well may be limited to 800 gpm which is the licensed capacity of the well. The pumping water level at this rate of pumping is expected to be around 44 ft.

13. GROUTING OF THE WELL

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" diameter and the well assembly was maintained around 18 ft. After the time drawdown test was over, the temporary casing was pulled out and a 3" diameter pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The annular space was then grouted with cement concrete.

(The measure used is US gallons. The depths indicated are below ground level).

Table-1

WATER RESOURCES DIVISION — WELL RECORD

LOCATION: North Syndicate	WELL NUMBER: E5852 N3938
PARISH: St. Catherine	GRID REFERENCE: E5822 N3938
OWNER: Caymanas Est. Ltd.	ADDRESS: Spanish Town
DRILLER: Waterwell En. Co.	ADDRESS: Race Course
	DATE OF COMPLETION: July, 1957

HOLE SIZE	TYPE OF RIG USED	DEPTH OF WELL	ELEVATION OF SITE A.S.L.
24 INCHES TO 30 FEET 20 INCHES TO 61 FEET INCHES TO FEET	Cable Tool	61 FEET	40.15 FEET
	WATER STRUCK AT: FEET	PRINCIPAL AQUIFER: Alluvium	REST WATER LEVEL ON COMPLETION: 6 FEET

CASING

TYPE Plain	DIAMETER 24 INCHES	LENGTH 30	FEET FROM 0	FEET TO 30 FEET
TYPE Plain	DIAMETER 20 INCHES	LENGTH 41	FEET FROM 0	FEET TO 41 FEET
TYPE Perf.	DIAMETER 20 INCHES	LENGTH 20	FEET FROM 41	FEET TO 61 FEET

ORIGIN OF DATA	COMPILED BY	CHECKED BY
Well Logs.	D.S.	

REMARKS

S.W.L. - 14/10/63 - 1.74 ft

P.W.L. - 2/12/63 - 39.76 ft.

Yield - 1189 g.p.m.

14/08/84 - swl = 20.26 .ABGL (Top casing)

Blocked at 34 ft

TEST PUMPING — DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
0	6	
167	11	5
335	15.5	9.5
502	20	14.0
307	24.5	18.5
837	29	23.0
1005	33.5	27.5
1172	38.5	32.5

SKETCH PLAN OF LOCATION

SITED IN FIELD BY — DATE

Table-2

ST. CATHERINE PLAINS
CAYMANAS AREA PROJECT "B"

LITHOLOGICAL LOG OF COREHOLE-1
NORTH SYNDICATE #2

DEPTH RANGE (FT)	THICKNESS (FT)	DESCRIPTION
0 - 16	16	Top soil, brown fine silty sand and loam.
16 - 26	10	Fine to medium grained sand, occassionally silty and clayey.
26 - 30	4	Hard brown clay.
30 - 42	12	Brown silty clay with a little fine sand.
42 - 57	15	Dark brown medium to very coarse grained sand, with gravel, angular to subrounded and some silt and clay.
57 - 62	5	Brown silty clay and medium to fine grained sand and a little gravel.
62 - 72	10	Hard, brown silty clay.
72 - 77	5	Hard, brown silty clay with yellowish green clay patches and a little coarse, angular sand grains.
77 - 79	2	Fine brown silty sand.
79 - 84	5	Brown stiff silty sandy clay.
84 - 100	16	Brown medium to very coarse grained sand, with gravel, angular to subrounded, silty and clayey.
100 - 104	4	Tight brown silty sandy clay.

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: North Syndicate #2
Corehole #1

Area: Caymanas

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 42 - 44			48 - 50			54 - 56					
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	12.1	12.1	8.2	-		-	15.3	15.3	8.8			
2.	3/8"	0.375	8.2	20.3	13.8	9.9	9.9	6.9	6.9	22.2	12.7			
3.	4	0.187	26.0	46.3	31.5	24.3	34.2	23.8	22.3	44.5	25.5			
4.	10	0.078	30.2	76.5	52.0	49.7	83.9	58.4	35.7	80.2	46.0			
5.	16	0.047	20.9	97.5	66.3	23.2	107.1	74.6	24.9	105.1	60.2			
6.	30	0.023	22.5	119.9	81.6	17.3	124.4	86.6	35.0	140.1	80.3			
7.	50	0.012	14.2	134.1	91.2	7.7	132.1	92.0	20.0	160.1	91.7			
8.	80	0.007	6.8	140.9	95.8	4.5	136.6	95.1	7.5	167.6	96.0			
9.	100	0.006	1.8	142.7	97.1	2.0	138.6	96.5	1.9	169.5	97.1			
10.	200	0.003	2.9	145.6	99.0	3.5	142.1	99.0	3.8	173.3	99.3			
11.	PAN	--	1.4	147.0	100.0	1.5	143.6	100.0	1.2	174.5	100.0			

@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A - weight retained (grams)
B - cumulative weight retained (grams)
C - cumulative percentage retained

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: North Syndicate #2
Corehole #1

Area: Caymanas

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 84 - 86			90 - 92			98 - 100					
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	-	-	-	-	-	-	-	-	-			
2.	3/8"	0.375	-	-	-	-	-	-	-	-	-	13.3	13.3	8.3
3.	4	0.187				21.8	21.8	17.2	6.0	6.0	3.8	30.2	43.5	27.0
4.	10	0.078				28.2	50.0	39.5	11.1	17.1	10.8	45.0	88.5	55.0
5.	16	0.047				20.0	70.0	55.3	15.2	32.3	20.3	20.3	108.8	67.7
6.	30	0.023				23.1	93.1	73.5	45.0	77.3	48.7	22.5	131.3	81.6
7.	50	0.012				17.4	110.5	87.3	43.5	120.8	76.1	16.8	148.1	92.1
8.	80	0.007				1.5	112.0	88.5	18.0	138.8	87.4	7.1	155.2	96.5
9.	100	0.006				9.5	121.5	96.0	5.0	143.8	90.6	1.2	156.4	97.3
10.	200	0.003				3.0	124.5	98.4	9.5	153.3	96.5	3.0	159.4	99.1
11.	PAN	--				2.0	126.5	100.0	5.5	158.8	100.0	1.4	160.8	100.0

@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A - weight retained (grams)
B - cumulative weight retained (grams)
C - cumulative percentage retained

ST. CATHERINE PLAINS
CAYMANAS AREA PROJECT "B"

LITHOLOGICAL LOG OF COREHOLE-2
NORTH SYNDICATE #2

Depth Range (ft)	Thickness (ft)	Description
0-16	16	Top soil and light brown fine silty sand
16-20	4	Light brown fine silty clayey sand
20-33	13	Light brown to grey medium to coarse grained sand with gravel
33-38	5	Dark brown stiff sandy clay
38-49	11	Reddish brown soft silty sandy clay
49-60	11	Dark brown clayey, silty fine sand, with a little medium to coarse grained sand.
60-80	20	Dark brown fine to very coarse grained sand, silty and clayey, with some angular to subrounded gravel
80-82	2	No Sample
82-88	6	Fine to medium grained sand with layers of silty clay
88-100	12	Brown, fine to very coarse grained sand, silty and clayey, with some angular to subrounded gravel
100-102	2	Stiff dark brown clay

Table-5

ST. CATHERINE PLAINS

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

(CUMMULATIVE PERCENT RETAINED)

LOCATION: North Sydicate #2, Corehole #2

AREA: Caymanas Project 'B'

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE OF SAMPLE (FT.)		
			#1 (64-66')	#2 (76-78')	#3 (92-94')
1	3/8"	0.375	5.47	2.91	3.98
2	6	0.111	21.62	14.19	15.92
3	12	0.066	32.36	22.79	22.88
4	18	0.034	51.86	40.39	39.49
5	30	0.023	62.38	51.91	53.26
6	50	0.012	78.56	75.14	75.33
7	80	0.007			
8	100	0.006	87.91	86.18	86.50
9	200	0.003	93.61	92.55	92.54

CUMMULATIVE PERCENT RETAINED

@ - U.S.S. Sieve series except #6 and # 18 which are from Griffin and George Ltd. U.K.. series

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains **Table-6**

Step Test Data

Location: North Syndicate #2 **Area:** Caymanas - Project 'B'

Diameter- Discharge Pipe 8" **Orfice** 6"

Static Water Level 20.33 ft. below M.P. which is 2 ft. above g.l.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
		Step 1					
20.11.86	0905	0	20.33				
		5	43.42	23.09	26	805	
		10	43.88	23.55			
		15	43.88	23.55			
		20	44.04	23.71			
		25	44.50	24.17	28	831	
		30	44.96	24.63			
		35	44.50	24.17	28		
		40	44.46	24.13			
		45	44.25	23.92			
		50	43.67	23.34	26	805	
		55	43.83	23.50			
	1005	60	43.75	23.42			
		65	43.75	23.42			
		70	43.67	23.34			
		75	44.42	24.09	26.5	812	
		80	44.75	24.42	27.5	828	
		85	44.50	24.17			
		90	44.33	24.00	26		
		95	44.42	24.09			

St. Catherine Plains 2

Step Test Data (Continued)

Location: North Syndicate #2

1	2	3	4	5	6	7	8
		100	44.40	24.07			
		105	44.42	24.09			
		110	44.58	24.25	26.5	812	812
		115	44.50	24.17			
	1104	119	44.54	24.21			
20.11.86	1110	Step - 2 5	47.83	27.50	34	907	907
		10	48.00	27.67			
		15	47.92	27.59	33	895	895
		20	47.83	27.50	33.5	901	901
		25	48.00	27.67			
		30	48.67	28.34			
		35	46.92	26.59	30	857	857
		40	47.00	26.67			
		45	47.75	27.42	31	869	869
		50	47.00	26.67			
		55	46.67	26.34	30		
	12:05	60	47.33	27.00			
		65	47.50	27.17	32		
		70	47.08	26.75			
		75	47.33	27.00			
		80	48.75	28.42	32	882	882
		85	48.75	28.42	32.5		889
		90	48.25	27.92			

St. Catherine Plains

Step Test Data (Continued)

Location: North Syndicate #2

1	2	3	4	5	6	7	8
		95	48.33	28.00	33		
		100	48.00	27.67			
		105	48.00	28.00			
		110	47.67	27.34	34	907	907
		115	48.00	27.67	31	869	869
20.11.86	1:04	119	47.67	27.34	32	882	882
		Step - 3					
	1:10	5	52.67	32.34			
		10	52.75	32.42	42	1001	1001
		15	51.91	31.58			
		20	51.71	31.38			
		25	52.33	32.00			
		30	52.29	31.96			
		35	52.17	31.84			
		40	52.25	31.92	42		
		45	52.00	31.67	43	1012	1012
		50	52.33	32.00			
		55	52.17	31.84			
	2:05	60	52.17	31.84			
		65	52.17	31.84	42		
		70	52.50	32.17			
		75	52.33	32.00			
		80	52.17	31.84			
		90	52.33	32.00	42		

St. Catherine Plains

Step Test Data (Continued)

Location: North Syndicate #2

1	2	3	4	5	6	7	8
		95	52.33	32.00	43		
		100	52.50	32.17			
		110	52.00	31.67			
		115	52.17	31.84	42		
20.11.86	3:04	119	52.50	32.17			
		Step - 4					
	3:10	5	54.92	34.59	51	1100	1100
		10	55.00	34.67			
		15	55.17	34.84			
		20	55.17	34.84			
		25	55.17	34.84			
		30	55.19	34.86			
		35	55.17	34.84	51		
		40	55.17	34.84			
		45	55.25	34.92			
		50	55.25	34.92			
		55	55.17	34.84	51		
	4:05	60	55.25	34.92			
		65	55.25	34.92			
		70	55.25	34.92			
		75	55.25	34.92			
		80	55.25	34.92			
		90	55.25	34.92			
		100	55.25	34.92			

St. Catherine Plains

Step Test Data (Continued)

Location: North Syndicate #2

1	2	3	4	5	6	7	8
		105	55.25	34.92			
		110	55.19	34.86			
		115	55.17	34.84			
20.11.86	5:05	120	55.25	34.92	51	1100	1100
		Test over at 5:05 p.m.					

TABLE 7

ST. CATHERINE PLAINS

North Syndicate #2

Calculation of Formation Loss, Well Loss and Well Efficiency
from Step-Drawdown Test Data

Step No.	Discharge (Q) USgpm	Discharge (Q) m3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m²/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
1	810	3.06	24.25	7.39	2.41	4.90	2.34	7.24	67	33.4
2	880	3.33	28.00	8.53	2.56	5.33	2.77	8.10	66	31.4
3	1000	3.78	32.17	9.80	2.59	6.05	3.57	9.62	63	31.1
4	1100	4.16	34.92	10.65	2.56	6.66	4.33	10.99	61	31.5

From the Graph (Figure 4)

Formation loss coefficient (B) 1.60
Well loss coefficient (C) 0.25

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Table 8

1

Location: North Syndicate #2 **Area:** Caymanas - Project "B"

Diameter- Discharge Pipe 8" **Orfice** 6"

Static Water Level 20.29 ft. below M.P. which is 2 ft. above g.l.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
24.11.86	10:00	0	20.29				
		1	49.42	29.13			
		2	50.63	30.34			
		3	51.46	31.17			Water clear
		4	52.33	32.04			
		5	52.96	32.67			
		6	52.12	31.83			
		12	50.58	30.29	41	990	
		14	51.08	30.79	42	1101	
		16	51.35	31.06			
		18	51.42	31.13			
		20	51.34	31.05			
		25	51.33	31.04			
		30	50.92	30.63	40	979	
		35	50.75	30.46			
		40	50.54	30.25			
		45	51.00	30.71	43	1012	
		50	51.33	31.04			
		55	--	--			
		60	51.58	31.29	42	1001	
		70	51.25	30.96			

St. Catherine Plains

Table 8

Pumping Test Data (Continued)

2

Location: North Syndicate #2

1	2	3	4	5	6	7	8
24.11.86		80	51.21	30.92	41	990	
	11:30	90	50.92	30.63	42	1001	
		100	50.83	30.54	40	979	
		110	51.75	31.46	42	1001	
	12:00	120	51.58	31.29	42.5	1007	
		135	51.29	31.00			
		150	51.08	30.79	41	990	
		165	51.08	30.79			
		180	51.00	30.71			
		210	51.25	30.96			
		240	51.25	30.96	42.5	1007	
		270	51.24	30.95			
	3:00	300	51.25	30.96	43	1012	
		360	51.33	31.04			
		420	51.08	30.79			
	6:00	480	51.12	30.83			
		540	51.33	31.04			
		600	51.00	30.71			
	9:00	660	51.50	31.21	42	1001	
		720	51.42	31.13			
		780	52.00	31.71	43	1012	
	12:00	840	52.50	32.21	42.5	1007	
25.11.86	1:00	900	52.42	32.13			

St. Catherine Plains

Pumping Test Data (Continued) Table 8

3

Location: North Syndicate #2

1	2	3	4	5	6	7	8
25.11.86	2:00	960	52.00	3171			
	3:00	1020	52.00	31.71			
	4:00	1080	52.33	32.04			
	5:00	1140	51.75	31.46	43.5	1018	
	6:00	1200	51.83	31.54			
	7:00	1260	52.17	31.88			
	8:00	1320	51.67	31.38			
	9:00	1380	51.75	31.46			
	10:00	1440	51.92	31.63	42.5	1007	
	11:00	1500	51.75	31.46	43.5	1018	
	12:00	1560	51.79	31.50			
	1:00	1620	51.83	31.54			
	2:00	1680	51.67	31.38			
	3:00	1740	51.75	31.46			
	4:00	1800	51.79	31.50	42		
	5:00	1860	51.75	31.46			
	6:00	1920	51.77	31.48			
	7:00	1980	51.79	31.50			
	8:00	2040	51.79	31.50			
	9:00	2100	51.75	31.46	41		
	10:00	2160	51.73	31.44			
	11:00	2220	51.72	31.43			
	12:00	2280	51.67	31.38			

St. Catherine Plains

Pumping Test Data (Continued) Table 8

4

Location: North Syndicate #2

1	2	3	4	5	6	7	8
26.11.86	1:00	2340	51.75	31.46			
	2:00	2400	51.75	31.46			
	3:00	2460	51.83	31.54			
	4:00	2520	51.79	31.50	43-44		
	5:00	2580	51.75	31.46			
	6:00	2640	51.83	31.54			
	7:00	2700	51.92	31.63			
	8:00	2760	51.75	31.46	41-42		
	9:00	2820	51.83	31.54			
	10:00	2880	51.79	31.50			
	11:00	2940	51.92	31.63			
	12:00	3000	51.75	31.46			
	1:00	3060	51.83	31.54	42		
	2:00	3120	51.83	31.54	43	1012	
	3:00	3180	51.79	31.50			
	4:00	3240	51.92	31.63	42	1001	
	5:00	3300	51.75	31.46	41.5	996	
	6:00	3360	51.67	31.38	42		
	7:00	3420	51.67	31.38	42.5	1007	
	8:00	3480	51.83	31.54			
	9:00	3540	51.75	31.46			
	10:00	3600	51.79	31.50			
	11:00	3660	51.83	31.54	41		

St. Catherine Plains

Pumping Test Data (Continued) Table 8

5

Location:

1	2	3	4	5	6	7	8
	12:00	3720	51.67	31.38	43		
	1:00	3780	51.67	31.38			
27.11.86	2:00	3840	51.71	31.42			
	3:00	3900	51.75	31.46			
	4:00	3960	51.83	31.54			
	5:00	4020	51.83	31.54			
	6:00	4080	51.79	31.50	42		
	7:00	4140	51.92	31.63			
	8:00	4200	51.83	31.54			
	9:00	4260	51.75	31.46			
	10:00	4320	51.83	31.54	42		
	10:29	4349	51.67	31.38		Fluctuating	
		Test over at 10:30 am					

Pumping Test Data (Continued)

Table 8

Location: North Syndicate-2 Recovery Data:

DATE (1)	TIME (HOUR) (2)	TIME SINCE PUMPING STARTED - t (MINUTES) (3)	TIME SINCE PUMPING STOPPED - t' (MINUTES) (4)	DEPTH TO WATER (FT) (5)	RESIDUAL DRAWDOWN (FT) (6)	t/t' (7)
		RECOVERY DATA				
'.11.86	1031	4351	1	24.42	4.13	4351
		4354	4	21.92	1.63	1088
		4355	5	21.38	1.09	871
		4356	6	21.00	0.71	726
		4357	7	20.77	0.48	622
		4358	8	20.54	0.25	544
		4359	9	20.42	0.13	484
		4360	10	20.29	-	436
		4362	12	20.16	+ 0.13	
		4364	14	20.04	+ 0.25	
		4366	16	19.98	+ 0.31	
		4368	18	19.92	+ 0.37	
	1100	4380	30	19.71	+ 0.58	
		4385	35	19.67	+ 0.62	
		4390	40	19.67	+ 0.62	
		4395	45	19.67	+ 0.62	
		4400	50	19.67	+ 0.62	
		4405	55	19.67	+ 0.62	
	1130	4410	60	19.67	+ 0.62	
		4420	70	19.67	+ 0.62	
		4430	80	19.67	+ 0.62	
		4440	90	19.67	+ 0.62	

Table-9

St. Catherine Plains

Chemical Analyses of Water Samples

Location: North Syndicate #2

Area: Caymanas Area - Project 'B'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
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

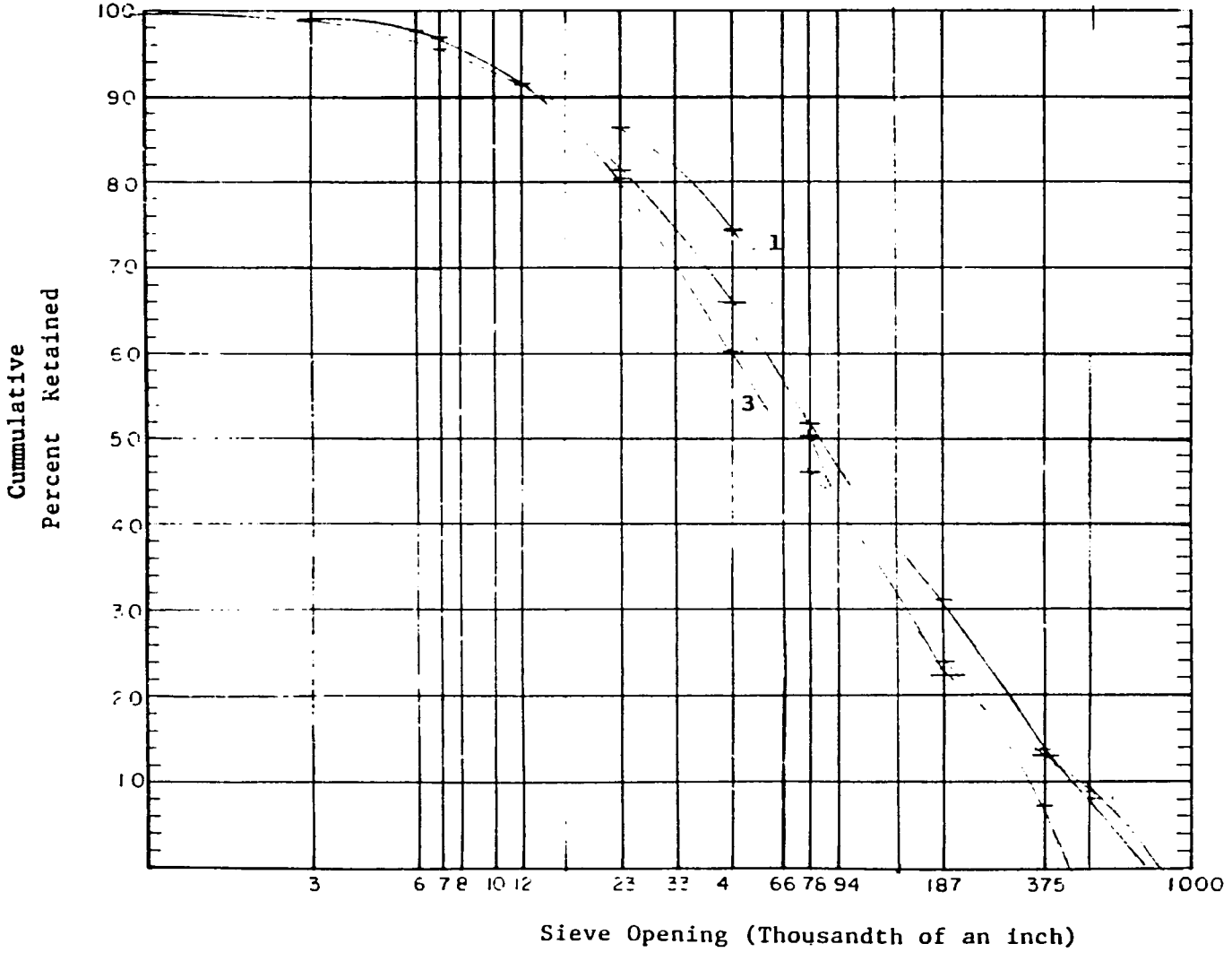
@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

SIEVE ANALYSES CURVES

Location: North Syndicate #2 (Corehole #1)

Depth Range: (ft.)(1) 42-44 (2) 48-50 (3) 54-56



SIEVE ANALYSES CURVES

Location: North Syndicate #2 (Corehole #1)

Depth Range: (ft.) (1) 84-86 (2) 90-92 (3) 98-100

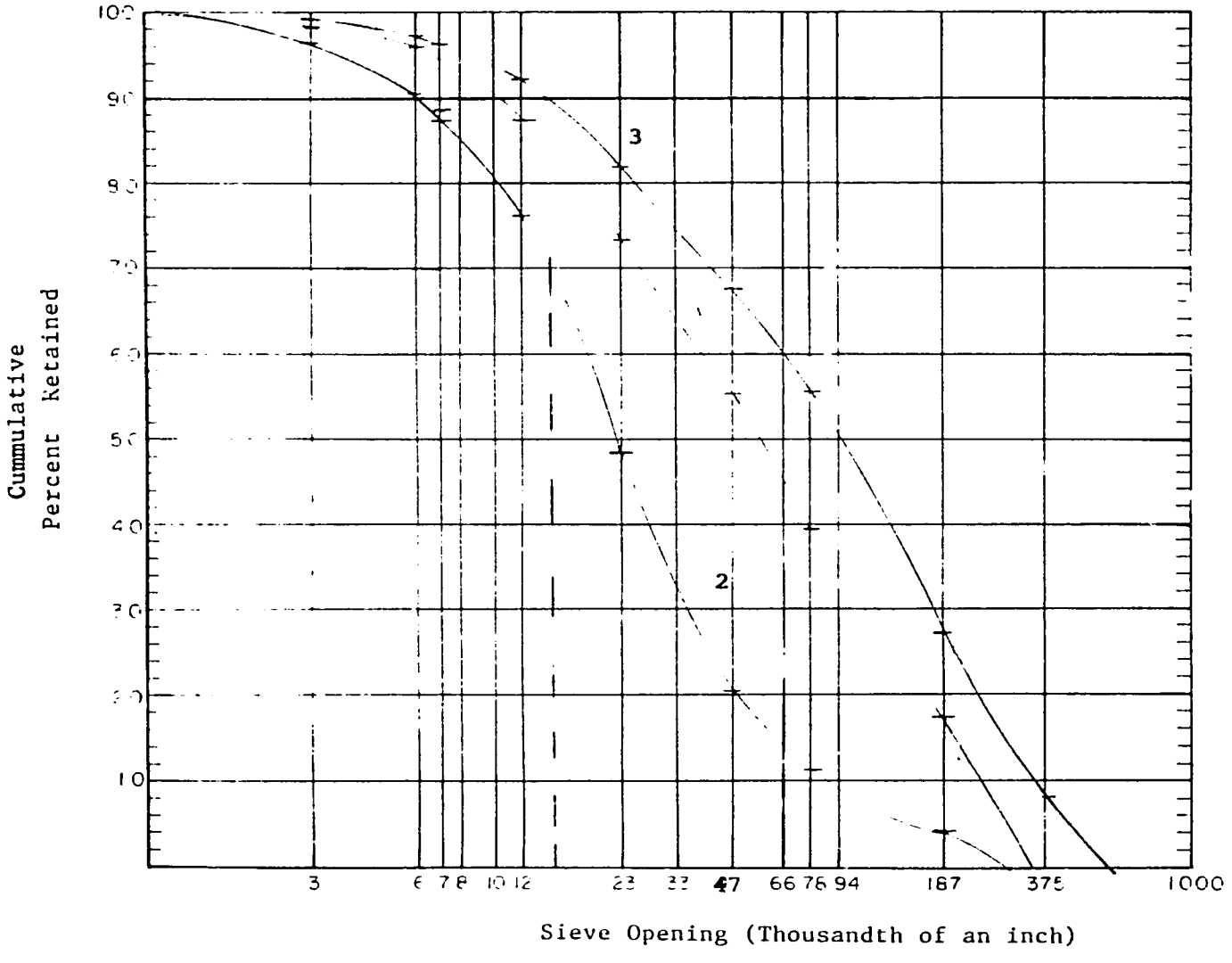
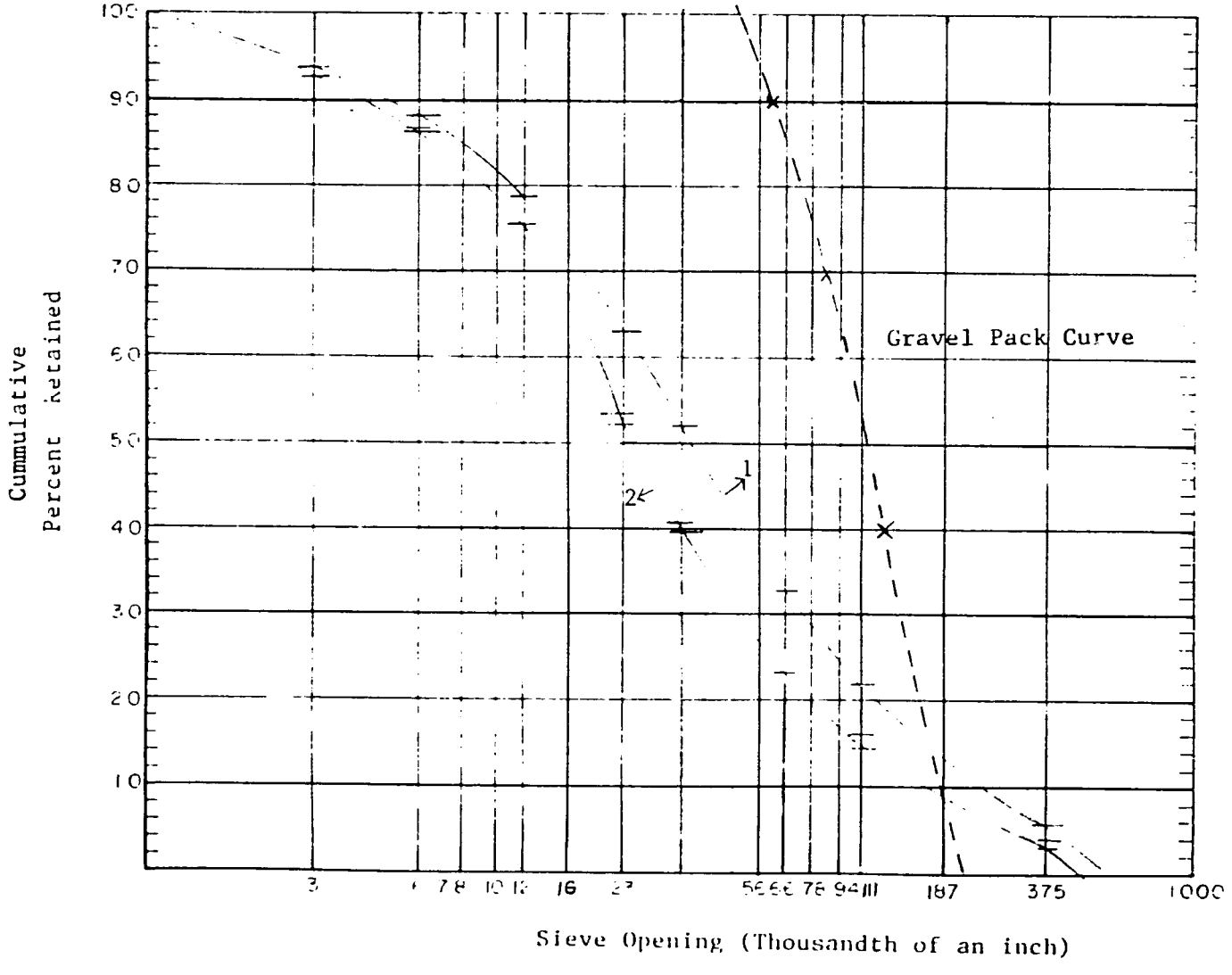


Fig. 2

SIEVE ANALYSES CURVES

Location: North Syndicate #2 Corehole (2)

Depth Range: (ft.) (1) 64'-66 (2) 76-78 (3) 92-94



1. Finest sample is #2.
2. 70% retention size of the sample = 0.014".
3. 70% retention size of the gravel pack material = 0.014" x 6 = 0.084"
4. Slot size of the screen = 0.060" (90% retention size of the gravel pack material).
5. Uniformity co-efficient of the sample = 8.5.

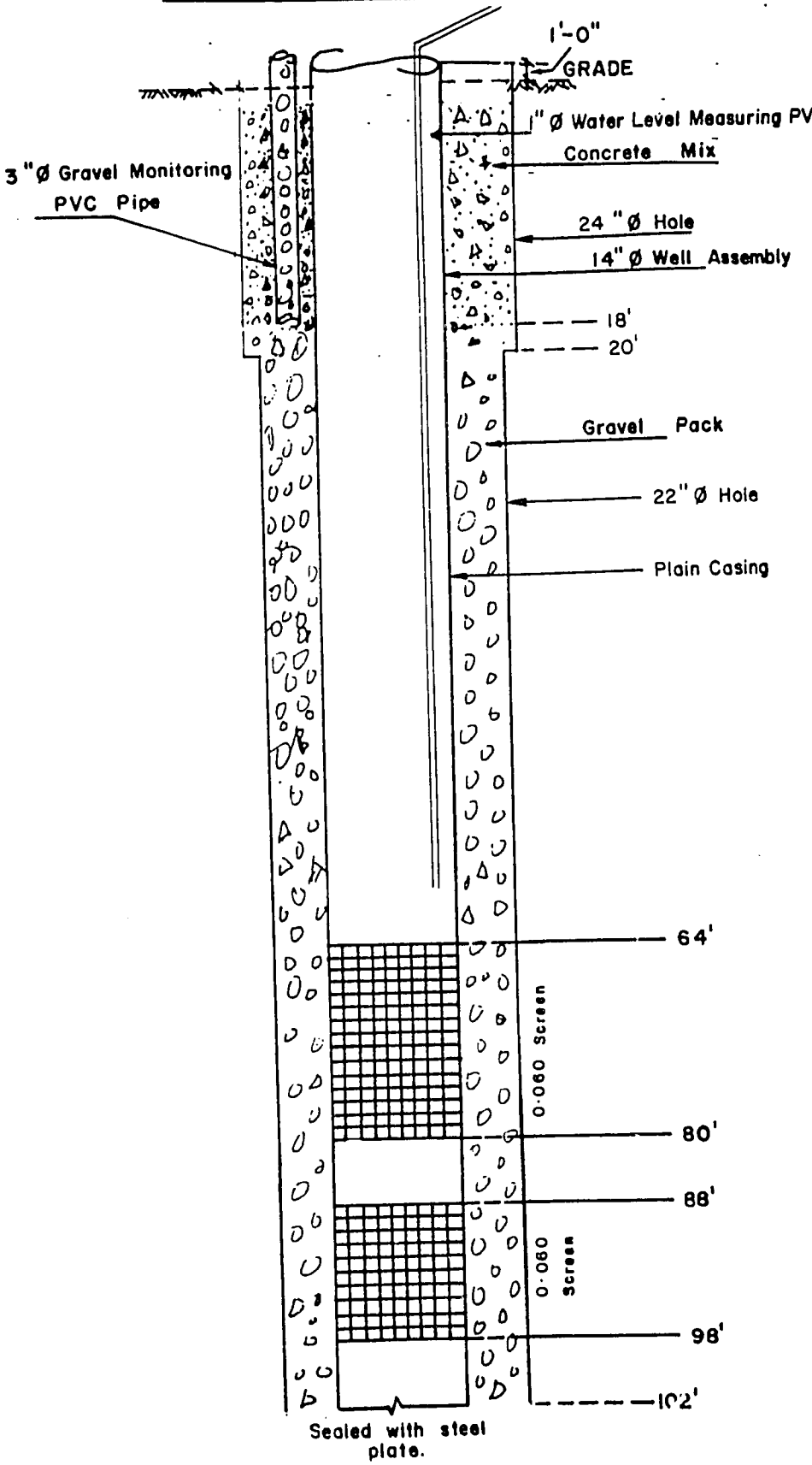
(Samples #2 and #3 are of similar composition).

ST. CATHERINE PLAINS

Fig. 3

Caymanas Area – Project 'B'

Well Design – North Syndicate 2.



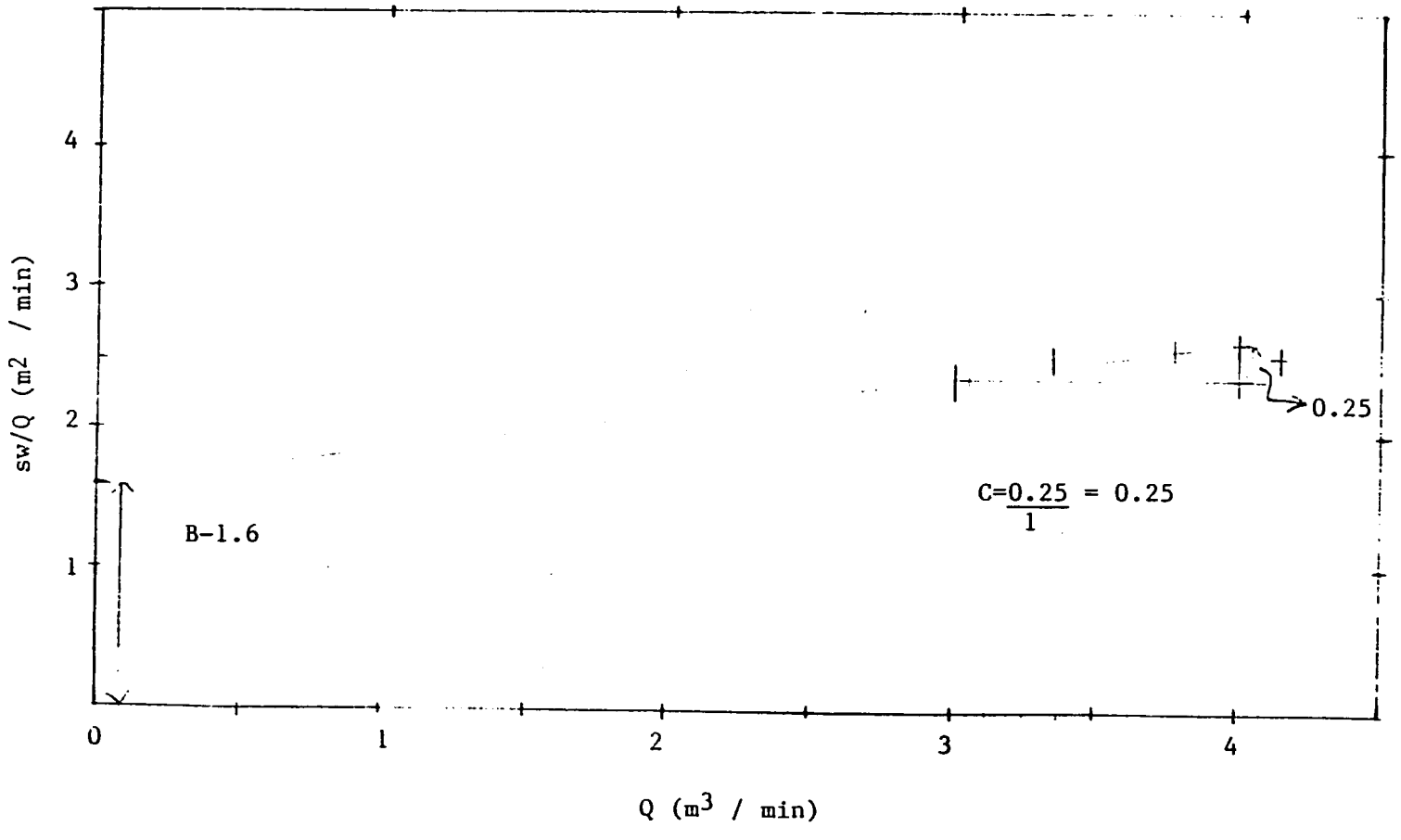
VERTICAL SCALE

ATE : 14·7·86

Fig. 4

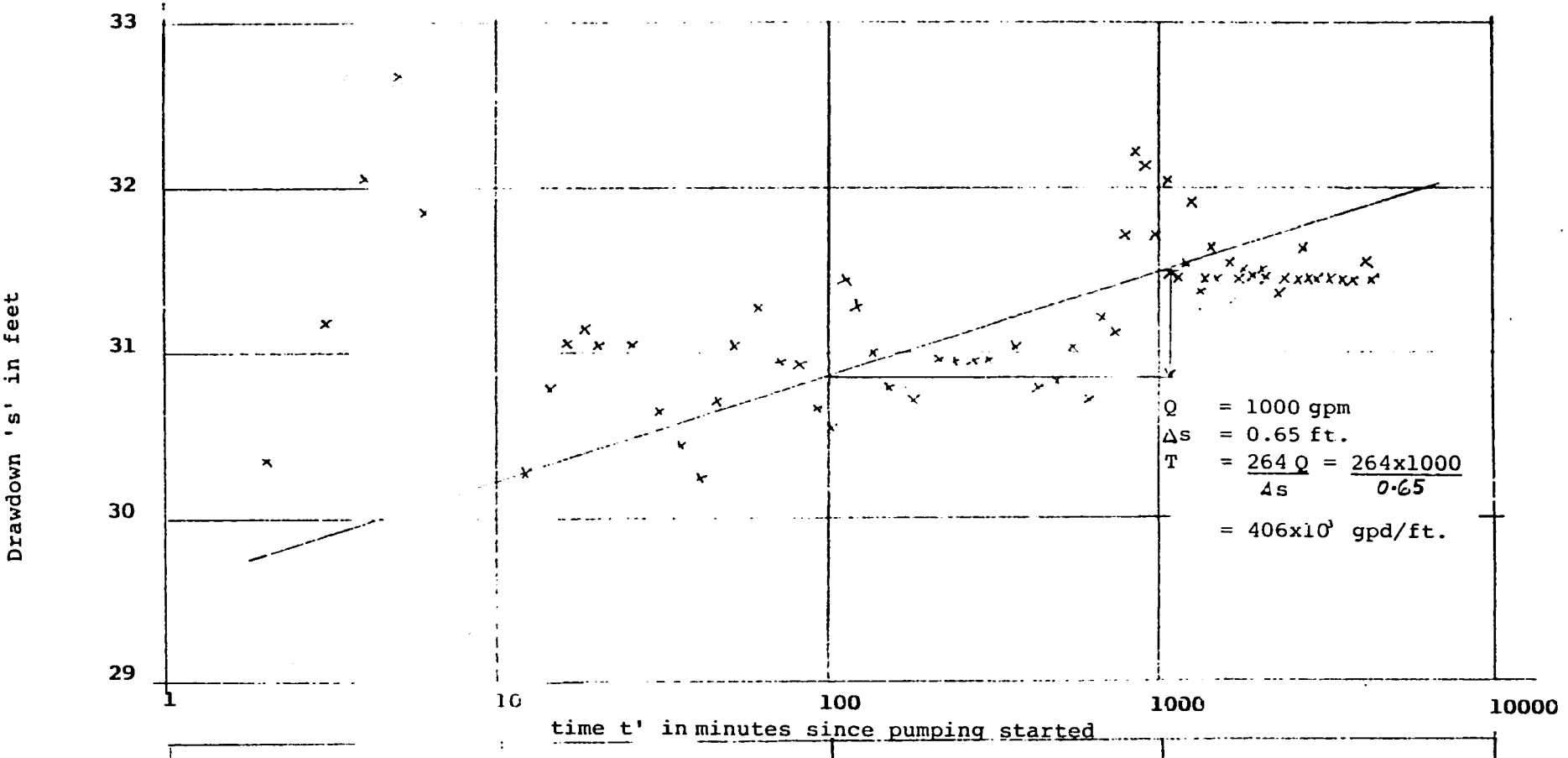
St. Catherine Plains

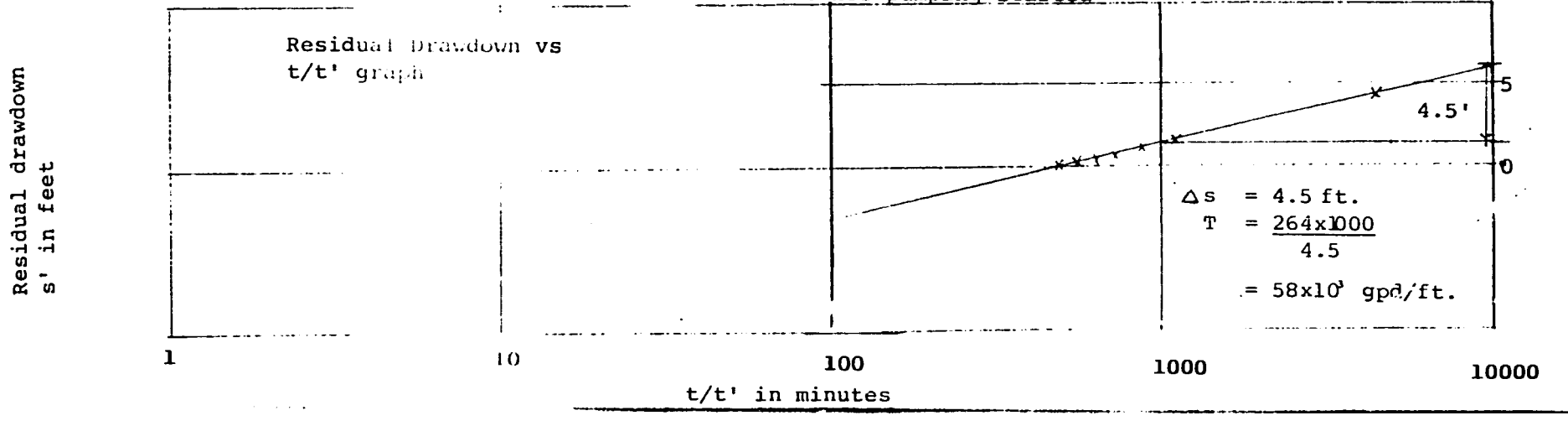
North Syndicate #2
Step - Drawdown Test Data Plot
Determination of 'B' and 'C'



St. Catherine Plains
North Syndicate #2 Well
Time vs Drawdown Graph

Fig. 5





ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
REPORT ON THE CONSTRUCTION OF WELL - SOUTH SYNDICATE #2

CONTENTS

Tables

Figures

1. Sieve Analyses Curves
2. Well Design
3. Step-Drawdown Test Data Plot
4. Time vs Drawdown Graph
5 t/t' vs Residual Drawdown Graph

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT-B
REPORT ON THE CONSTRUCTION OF WELL SOUTH SYNDICATE #2*

1. INTRODUCTION

South Syndicate #1 well is located in the southern part of the project area, just east of the Naggo Head spring channel. The well record was obtained from the Underground Water Authority (formerly Water Resources Division) and is given as Table-1. The well appears to have been constructed before January 1960. It was not in regular use for a long time. In August, 1984, it was found that the well was filled below 15 ft.

In August, 1985, the well was cleaned and tested for its yield and quality of water. Caribbean Boring and Diamond Drilling Limited, Kingston carried out the cleaning and testing operations using a Davey-1500 direct rotary rig. The material which filled the well was first crushed with a roller-bit and then it was blown with the help of an air compressor. The well was then tested for the yield with a turbine pump for a period of 5 hours. The static water level was 17.5 ft. and the pumping water level was 51 ft. for a steady discharge of 595 gpm. However, the well discharge was accompanied by fine sand. To stop the sand pumping, the well is to be reconstructed by installing a smaller diameter well assembly in the well and gravel packing the annular space. Such a reconstructed well may not yield more than 300 gpm and therefore it was decided to abandon the well and construct another.

2. COREHOLE DRILLING

A corehole of 2" diameter was drilled down to a depth of 100 ft. at a location about 1000 ft. west of the old well by Caribbean Boring and Diamond Drilling Limited, Kingston, from October 23 to 29, 1985, with a Boyles-37 rotary rig. Core samples were obtained at 2 ft. intervals by split-spoon sampling method. Lithological log of the corehole is given in Table-2.

---

* A replacement well for South Syndicate #1

3. SIEVE ANALYSES OF AQUIFER SAMPLES

Two aquifer zones occur, one between 36 ft. and 50 ft. and the other between 84 ft. and 100ft. The aquifer material consists of brown, fine to very coarse grained sand with gravel constituting upto 30% of the material in the upper zone and 20% in the lower zone. The formation material of the lower aquifer is very coarse towards bottom.

Three samples of the aquifer material one from the upper zone and two from the lower zone were subjected to sieve analyses and the results are given in Table-3. The sieve analyses curves are shown in Fig-1.

4. WELL DESIGN

The slot size of the well screens and the composition of the gravel pack material were worked out using the sieve analyses curves. Six times the 70% retention size of the finest sample (the only sample for upper aquifer and sample from depth range of 86 ft. - 88 ft. for the lower aquifer) was taken as the 70% retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity co-efficient of less than 2.5 to represent the composition of the gravel pack material. The gravel pack curves are also shown in Fig-1 and the composition of the gravel pack material is given below:

	Size	Percentage
Upper aquifer	0.094" - 0.250"	50
	0.250" - 0.375"	30
	0.375" - 0.500"	20
Lower aquifer	0.047" - 0.094"	40
	0.094" - 0.250"	60

Ninety percent retention size of the gravel pack material, 0.150" for the upper aquifer material and 0.050" for the lower aquifer material was considered as the slot size of the well screen.

The well assembly was of 14" diameter and consisted of 81 ft. of 0.375 thick steel seamless plain casing and 22 ft. of 304 stainless steel, non-clogging type well screens of slot sizes 0.150" (10 ft.) and 0.050" (12 ft.) manufactured by Johnson Division, U.S.A. The bottom of the assembly was sealed with a steel plate. The well design is shown in Fig-2.

5. WELL CONSTRUCTION

The well was constructed by Caribbean Boring and Diamond Drilling Limited, Kingston, with a Mayhew-1500 direct rotary rig. Drilling operations were started on July 29, 1986, and completed on August 6, 1986 at the targeted depth of 102 ft. The diameter of the hole was 24" down to 20 ft. and 22" below that depth down to 102 ft. Well assembly was lowered into the hole on August 8, 1986. The hole was washed with water and gravel packing was done on August 11, 1986. The gravel level was kept at about 18 ft. below ground level. Construction casing of 24" diameter and 20 ft. length was then lowered into the well keeping 1 ft. of the casing above ground level. The purpose of the casing was to prevent the top section of the well that was not gravel packed, from collapsing during development and testing.

6. WELL DEVELOPMENT

The well was developed and tested by Caribbean Wells and Diamond Coring Limited, 43 Burlington Avenue, Kingston 10. A Mayhew-1500 direct rotary rig was used for conducting these operations.

The well was developed from September 3, 1986 to October 8, 1986, for a total period of 127 hours by surging with a surge block and bailing (26 hours) with an air compressor (77 hours) and with a turbine pump (24 hours). The well was washed with 2000 gallons of fresh water before starting development. One bag (100 lbs) of sodium hexa-metaphosphate was used during the development to disperse the clay fractions. An account of the development operations is given below:

Date	Method of Development	No. of hrs.
a) Sept. 3-4	Surging with a surge block and bailing	10
b) Sept. 8-10	With an compressor using a 4" eductor pipe and 1 1/4" air pipe, occasionally closing and opening the outlet pipe with the help of a valve, so as to create air surging	20
c) Sept. 11-19	With an air compressor using an 8" eductor pipe and 1 1/4" air pipe	34

	Date	Method of Development	No. of hrs.
d)	Sept. 22	as at (a)	4
e)	Sept. 24-26	as at (c)	23
f)	Sept. 29-30	as at (a)	12
g)	Oct. 1-4	With a turbine pump	24

At the end of these development operations, the yield of the well was around 800 gpm for a pumping water level of about 34 ft.

7. STEP DRAWDOWN TEST

A step drawdown test was conducted on October 8, 1986, with discharge rates of 495, 600, 700 and 818 gpm, the duration of each step being 2 hours. The test data is given in Table-4 and the data plot is given as Fig-3. Calculations of formation loss, well loss and well efficiency are shown in Table-5. It is seen from the Table that the calculated and observed drawdowns compare fairly. The well loss co-efficient of 0.16 min2/m5 indicates that the well is properly designed and developed. The performance of the well was steady throughout without any high fluctuations either in the yield or in the water levels.

8. TIME-DRAWDOWN TEST

A time drawdown test was conducted for a period of 48 hours, starting at 9:30 a.m. on October 9, 1986, at a discharge rate of 717 gpm. The static water level was 17.02 ft. and the pumping water level stabilized around 31 ft. after 30 hours of pumping. The specific capacity works out to 44 gpm/ft. The test data is given in Table-6 and the time vs drawdown graph and the t/t' vs residual drawdown graph are shown in Fig-4 and Fig-5 respectively. The transmissivity of the formation is calculated to be 172×10^3 gpd/ft. by the drawdown method and 252×10^3 gpd/ft. by the recovery method.

9. QUALITY OF WATER

Chemical analyses results of water samples collected from the well during the time drawdown test are given in Table-7.

10. SAND CONTENT IN WELL WATER

Sand content in well water was determined with the help of a 'Rossum' sand content tester. The tester was fitted to the discharge pipe close to the discharge head and the sand collected in the test tube of the tester for a particular time was weighed and the sand content in water in mg/l was determined. Results of the tests conducted are given below:

Date	Type of Test	Pumping Rate (USgpm)	Quantity of flow thru' tester (litres)	Sand Content In the tester (mg)	mg/l
7/6/86	Well development	600	170	33.8	0.2
9/10/86	Time-draw down test	700	189	3.6	0.019
10/10/86	Time-draw down test	700	216	0.1	negli-gible
11/10/86	Time-draw down test	700	160	0.1	negli-gible

It is seen from the results that the well was developed to an almost sand free condition.

11. RATE OF ABSTRACTION

It is seen from the time drawdown test data that the well can yield steadily 717 gpm for a pumping water level of about 31 ft. However, abstraction from the well may be limited to 600 gpm which is the licensed capacity of the well. The pumping water level at this rate of abstraction is expected to around 27 ft.

12. GROUTING OF THE WELL

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" diameter and the well assembly was maintained around 18 ft. After the time drawdown test was over, the temporary casing was pulled out and a 3" diameter pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The annular space was then grouted with cement concrete.

(The measure used is US gallons. The depths indicated are below ground level)

Table-1

GEOLOGICAL SURVEY DEPARTMENT — WELL RECORD

LOCATION: South Syndicate

WELL NUMBER: E5[illegible] N3917

PARISH: St. Catherine

GRID REFERENCE: E5871 N3917

OWNER: Caymanas Estates

ADDRESS: Spanish Town

DRILLER:

ADDRESS:

DATE OF COMPLETION:

HOLE SIZE: INCHES TO FEET / INCHES TO FEET / INCHES TO FEET

TYPE OF RIG USED: Percussion

WATER STRUCK AT: FEET

DEPTH OF WELL: 65 FEET

PRINCIPAL AQUIFER: Alluvium

ELEVATION OF SITE A.S.L.: 26.5 FEET

REST WATER LEVEL ON COMPLETION: FEET

CASING

TYPE steel	DIAMETER 16 INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO	FEET

ORIGIN OF DATA: G.S.D. Records.

COMPILED BY: B.F.

CHECKED BY:

REMARKS

P.W.L. - 8.28ft. (28.1.60)

S.W.L. - 1.14ft (14.10.63)

Used for Irrigation purposes.

Former Grid Reference

E5875 N3915

14/6/84 - Dia. → 16 inches with reduction Blanked above water table PL (15 A BGL)

TEST PUMPING

DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN

SKETCH PLAN OF LOCATION

PLOTTED IN FIELD BY

DATE

15A

ST CATHERINE PLAINS

CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE

SOUTH SYNDICATE 2

DEPTH RANGE (ft)	THICKNESS (ft)	DESCRIPTION
0- 8	8	Top soil and brown fine silty sand.
8-18	10	Brown fine silty sand with some clay.
18-20	2	Fine to coarse grained sand with silt, clay and some gravel.
20-22	2	Dark brown silty clay.
22-30	8	Brown fine silty sand with some clay.
30-36	6	Fine to coarse grained sand with some silt and clay.
36-50	14	Brown fine to very coarse grained sand with about 30 per cent of angular gravel (upto 0.375" in size) and a little silt and clay
50-56	6	Stiff dark brown silty clay.
56-58	2	A mixture of dark brown clay, coarse grained sand and gravel.
58-71	13	Stiff dark brown silty clay with some coarse grained sand and occasional gravel.
71-73	2	Fine grained silty sand and clay.
73-84	11	Stiff brown silty, sandy clay.
84-100	16	Brown fine to very coarse grained sand with about 20 per cent of gravel (upto 0.375" in size) in the upper part and a little silt; gravel content increases downwards (last 3" brown clay)

Table-3

St. Catherine Plains

Sieve Analyses Results of Aquifer Samples

Location: SOUTH SYNDICATE #2 CORE HOLE Area: BERNARD LODGE

SERIAL	@ SIEVE NO.	* MESH OPENING	DEPTH RANGE(FT.) 38'-40'			86'-88'			92'-94		
			A	B	C	A	B	C	A	B	C
1.	3/8"	375	4.70	4.70	2.60	3.20	3.20	1.8	40.70	40.7	20.3
2.	4	187	21.10	25.80	14.4	10.70	13.90	7.9	28.00	68.7	34.3
3.	8	94	26.60	52.40	29.3	15.7	29.60	16.9	26.60	95.3	47.6
4.	12	66	23.00	75.40	42.2	10.4	40.00	22.9	12.10	107.4	53.6
5.	16	47	19.60	95.00	53.1	10.6	50.60	28.9	13.50	120.9	60.3
6.	20	33	23.90	118.90	66.5	13.4	64.00	36.6	15.40	136.3	68.0
7.	30	23	22.60	141.50	79.1	10.5	74.50	42.6	16.30	152.6	76.1
8.	40	16	15.30	156.80	87.7	22.3	96.80	55.3	16.90	169.5	84.6
9.	50	12	8.00	164.80	92.2	20.10	116.90	66.8	10.50	180.0	89.8
10.	100	6	9.50	174.30	97.5	32.80	149.70	85.5	16.10	196.1	97.8
11.	PAN		4.50	178.80	100.0	25.30	175.00	100.0	4.30	200.4	100.0

* Thousandth of an Inch
@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd, Kingston)

A = Weight retained (grams)
B = Cummulate weight retained (")
C = Cummulative percentage retained

St. Catherine Plains

Step-Drawdown Test Data

Location: South Syndicate -2 Area: Caymanas

Diameter- Discharge Pipe 8" Orfice 6"

Static Water Level 19.00 ft. below M.P. which is about 2 ft. above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
10/8/86	1105	STEP I					
		5	28.33	4.83	10	508	
		10	23.90	4.90	10		
		15	23.92	4.92			
		20	23.96	4.96			
		25	23.96	4.96			
		30	24.08	5.08			
		35	24.04	5.04			
		45	24.67	5.67			
		55	25.92	6.92			
		65	26.25	7.25			
		75	26.92	7.92	9.5	495	
		85	26.90	7.90			
		95	26.92	7.92	9.5		
		105	26.92	7.92			
		115	26.92	7.92	9.5	495	
	1300	STEP II					
		5	28.00	9.00	14		
		10	28.79	9.79			
		15	28.83	9.83			
		20	28.83	9.83			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: South Syndicate #2

1	2	3	4	5	6	7	8
		25	28.83	9.83	14	600	
		30	28.83	9.83			
		35	28.83	9.83			
		40	28.83	9.83			
		50	28.83	9.83			
		60	28.83	9.83	14		
		70	28.83	9.83			
		80	28.83	9.83			
		90	28.83	9.83			
		100	28.83	9.83			
		120	28.83	9.83	14	600	
8 10/86	1300		STEP III				
		5	31.00	12.00	19.5	699	
		10	31.17	12.17			
		15	31.38	12.38			
		20	31.29	12.29			
		25	31.16	12.16			
		30	31.29	12.29			
		40	31.20	12.20			
		50	31.29	12.29			
		60	31.25	12.25			
		70	31.23	12.23			
		80	31.25	12.25			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: South Syndicate #2

1	2	3	4	5	6	7	8
		90	31.25	12.25			
		100	31.25	12.25			
		110	31.29	12.29			
		120	31.29	12.29			
$8\frac{10}{86}$	1700		STEP IV				
		5	33.63	14.63	26.5		
		10	34.00	15.00	27	818	
		15	33.90	14.90			
		20	33.92	14.92	27.5		
		25	34.20	15.20	28.5		
		30	34.08	15.08	27.5		
		40	34.12	15.12	27		
		50	34.12	15.12	28		
		60	34.00	15.00	27.5		
		70	34.15	15.15			
		80	34.04	15.04			
		90	34.08	15.08			
		100	34.08	15.08	27		
		110	34.08	15.08			
		120	34.04	15.04	27	818	

TABLE 5

ST. CATHERINE PLAINS

SOUTH SYNDICATE

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q) USgpm	Discharge (Q) m^3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
1	495	1.87	7.92	2.41	1.29	1.87	0.56	2.43	77	62.5
2	600	2.27	9.83	3.00	1.32	2.27	0.82	3.09	75	61.0
3	700	2.65	12.29	3.75	1.42	2.65	1.12	3.77	70	56.9
4	818	3.10	15.04	4.58	1.48	3.10	1.54	4.64	67	54.4

From the Graph (Figure 3)

Formation loss coefficient (B) = 1.00

Well loss coefficient (C) = 0.16

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Location: South Syndicate -2 Area: Caymanas - Project "B"

Diameter- Discharge Pipe 8" Orfice 6"

Static Water Level 19.02 ft. below M.P. which is about 2 ft. above G.L.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
9-10-86	9:30	0	19.02	PUMPING STARTED			
	9:31	1	30.59	11.57	20	708	
	9:32	2	30.66	11.64			
	9:33	3	30.70	11.68			
	9:34	4	30.75	11.73			
	9:35	5	30.80	11.78			
	9:36	6	30.92	11.90			
	9:37	7	30:95	11.93			
	9:38	8	30.95	11.93	20		
	9:39	9	30.96	11.94			
	9:40	10	30:96	11.94			
	9:42	12	30.98	11.96			
	9:44	14	31.08	12.06	20.5	717	
	9:46	16	31.16	12.14			
	9:48	18	31.23	12.21	20.5		
	9:50	20	31.25	12.23			
	9:55	25	31.29	12.27			
	10:00	30	31.29	12.27			
	10.05	35	31.30	12.28			
	10:10	40	31.29	12.27	20.5		
	10:15	45	31.31	12.29			

St. Catherine Plains

Pumping Test Data (Continued)

Location: South Syndicate #2

1	2	3	4	5	6	7	8
9-10-86	10:20	50	31.35	12.33			
	10:25	55	31.35	12.33			
	10:30	60	31.37	12.35			
	10:40	70	31.37	12.35			
	10:50	80	31.41	12.39	20.5		
	11:00	90	31.39	12.37			
	11:10	100	31.41	12.39	20.5		
	11:20	110	31.45	12.43	20.5	717	
	11:30	120	31.43	12.41			
	11:45	135	31.45	12.43			
	12:00	150	31.45	12.43	21	726	
	12:15	165	31.77	12.75	20.5		
	12:30	180	31.87	12.85	20.5	717	
	1 p.m.	210	31.83	12.81			
	1:30	240	31.62	12.60		717	
	2 p.m.	270	31.71	12.69			
	2:30	300	31.72	12.70			
	3:30	360	32.35	13.33	21.5	733	
	4:30	420	32.02	13.00	20.5		
	5:30	480	32.37	13.35	21		
	6:30	540	32.29	13.27	20	699	
	7:30	600	32.22	13.20	21	726	
	8:30	660	32.16	13.14			

St. Catherine Plains

Pumping Test Data (Continued)

Location: South Syndicate #2

1	2	3	4	5	6	7	8
9-10-86	9:30	720	32.29	13.27			
	10:30	780	32.29	13.27			
	11:30	840	32.37	13.35			
10-10-86	:30	900	32.41	13.39			
	1:30	960	32.29	13.27			
	2:30	1020	32.33	13.31	20	699	
	3:30	1080	32.37	13.35			
	4:30	1140	32.43	13.41			
	5:30	1200	32.45	13.43			
	6:30	1260	32.50	13.48	20	699	
	7:30	1320	32.67	13.65			
	8:30	1380	32.75	13.73	20	699	
	9:30	1440	32.81	13.79	20	699	
	10:30	1500	32.81	13.79	20		
	11:30	1560	33.00	13.98	20		
	12:30	1620	32.97	13.95	20		
	1:30p.m	1680	32.97	13.95	20.5	717	
	2:30	1740	33.12	14.10	21	726	
	3:30	1800	33.02	14.00	20.5	717	
	4:30	1860	33.06	14.04	20.5		
	5:30	1920	33.12	14.10	20.5		
	6:30	1980	33.06	14.04	20		
	7:30	2040	33.00	13.98	20.5		

St. Catherine Plains

Pumping Test Data (Continued)

Location: South Syndicate #2

1	2	3	4	5	6	7	8
10-10-86	8:30	2100	32.91	13.89			
	9:30	2160	32.84	13.82	20.5		
	10:30	2220	32.86	13.84	20		
	11:30	2280	33.02	14:00	20.5		
11-10-86	30	2340	33.00	13.98	20.5		
	1:30	2400	33.06	14.04	20		
	2:30	2460	32.91	13.89			
	3:30	2520	32.87	13.85			
	4:30	2580	33.08	14.06	20		
	5:30	2640	33.06	14.04	20.5		
	6:30	2700	33.08	14.06	20.5		
	7:30	2760	33.06	14.04	20		
	8:30	2820	33.02	14.00			
	9:30	2880	33.02	14.00	20		
			TEST OVER				

Pumping Test Data (Continued)

Location: South Syndicate #2 Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
11-10-86						
	9:32	2882	2	20.94	1.92	1441
		2883	3	21.45	2.43	961
		2884	4	21.41	2.39	721
	9:35	2885	5	21.36	2.34	577
		2886	6	21.33	2.31	481
		2887	7	21.29	2.27	412
		2888	8	21.27	2.25	361
		2889	9	21.27	2.25	321
	9:40	2890	10	21.27	2.25	289
		2892	12	21.19	2.17	241
		2894	14	21.19	2.17	206
		2896	16	21.16	2.14	181
		2898	18	21.14	2.12	161
	9:50	2900	20	21.12	2.10	145
		2905	25	21.08	2.06	116
	10:00	2910	30	21.04	2.02	97
		2915	35	21,04	2.02	83
		2920	40	21.02	2.00	73
		2925	45	21.00	1.98	65
	10:20	2930	50	20.93	1.91	58
		2935	55	20.87	1.85	53
	10:30	2940	60	20.87	1.85	49

Pumping Test Data (Continued)

Location: South Syndicate #2 Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
11-10-86	10:30	2950	70	20.85	1.83	42
		2960	80	20.81	1.79	37
	11:00	2970	90	20.67	1.65	33
	11:10	2980	100	20.67	1.65	30
	11:20	2990	1 0	20.67	1.65	27
	11:30	3000	120	20.64	1.62	25
	11:45	3015	135	20.58	1.56	22
	12:00	3030	150	20.58	1.56	20
	12:15	3045	165	20.54	1.52	18
	12:30	3060	180	20.41	1.39	17
		3090	210	20.41	1.39	14
		3120	240	20.39	1.37	13
		3150	270	20.37	1.35	11
		3180	300	20.37	1.35	10
		3300	420	18.82	+0.20	7

Table-7

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_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
				←						mg/l									→	
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	19.20	35.50	2.80		22.99	50.01					286.01	22.16	308.17	242.00	1.0/2.6

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

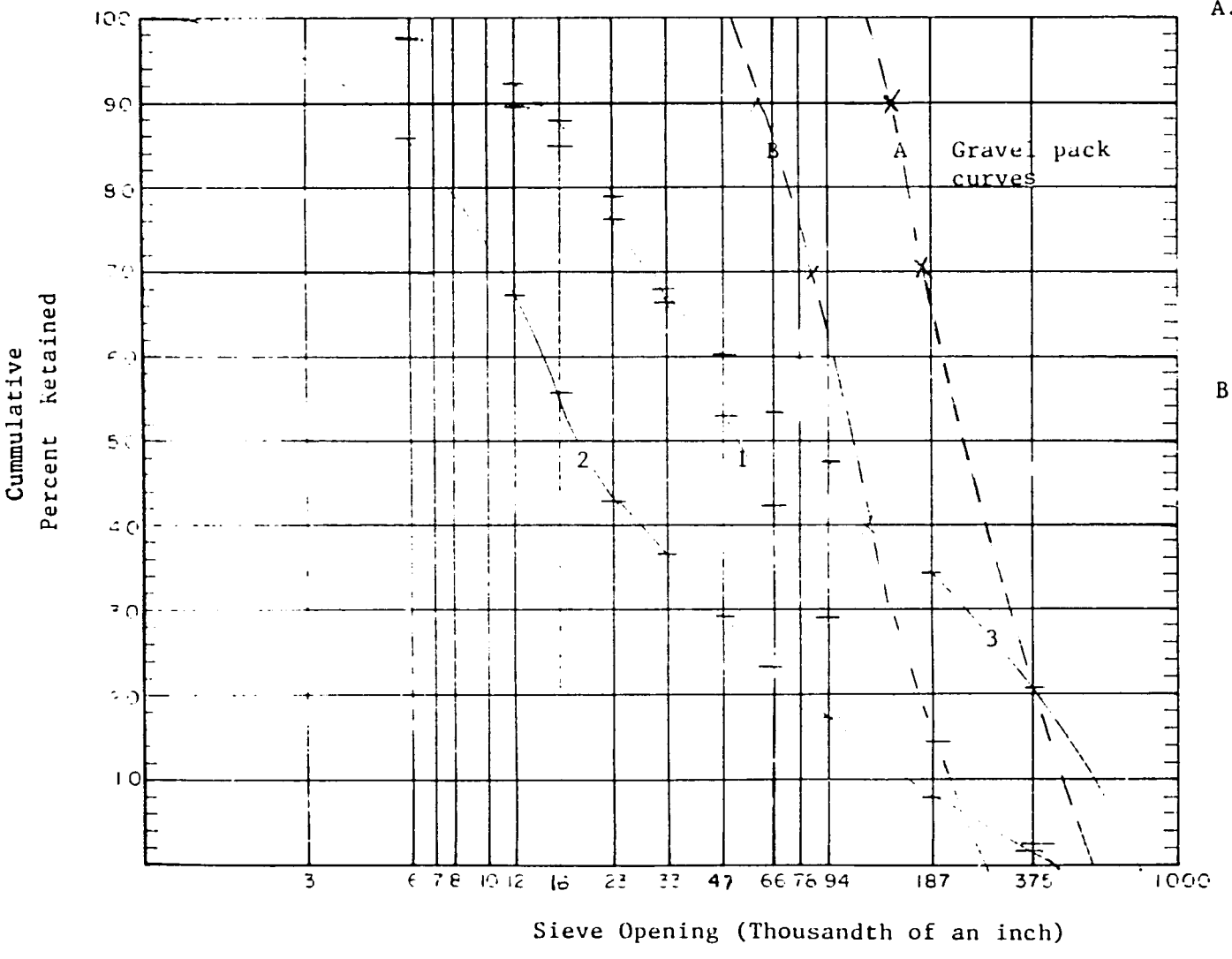
SIEVE ANALYSES CURVES

Fig. 1

Location: South Syndicate #2 Corehole

Depth Range: (ft.)

1) 38-40 (Upper Aquifer)
2) 86-88 (3) 92-94 (Lower Aquifer)



A. UPPER AQUIFER

1. 70% retention size of the sample = 0.030"
2. 70% retention size of the gravel pack meterial = 0.030" x 6 = 0.180"
3. Slot size of the screen (90% retention size of the gravel pack material) = 0.150"
4. Uniformity coefficient of the sample. = 5

B. LOWER AQUIFER

Finest sample is #2

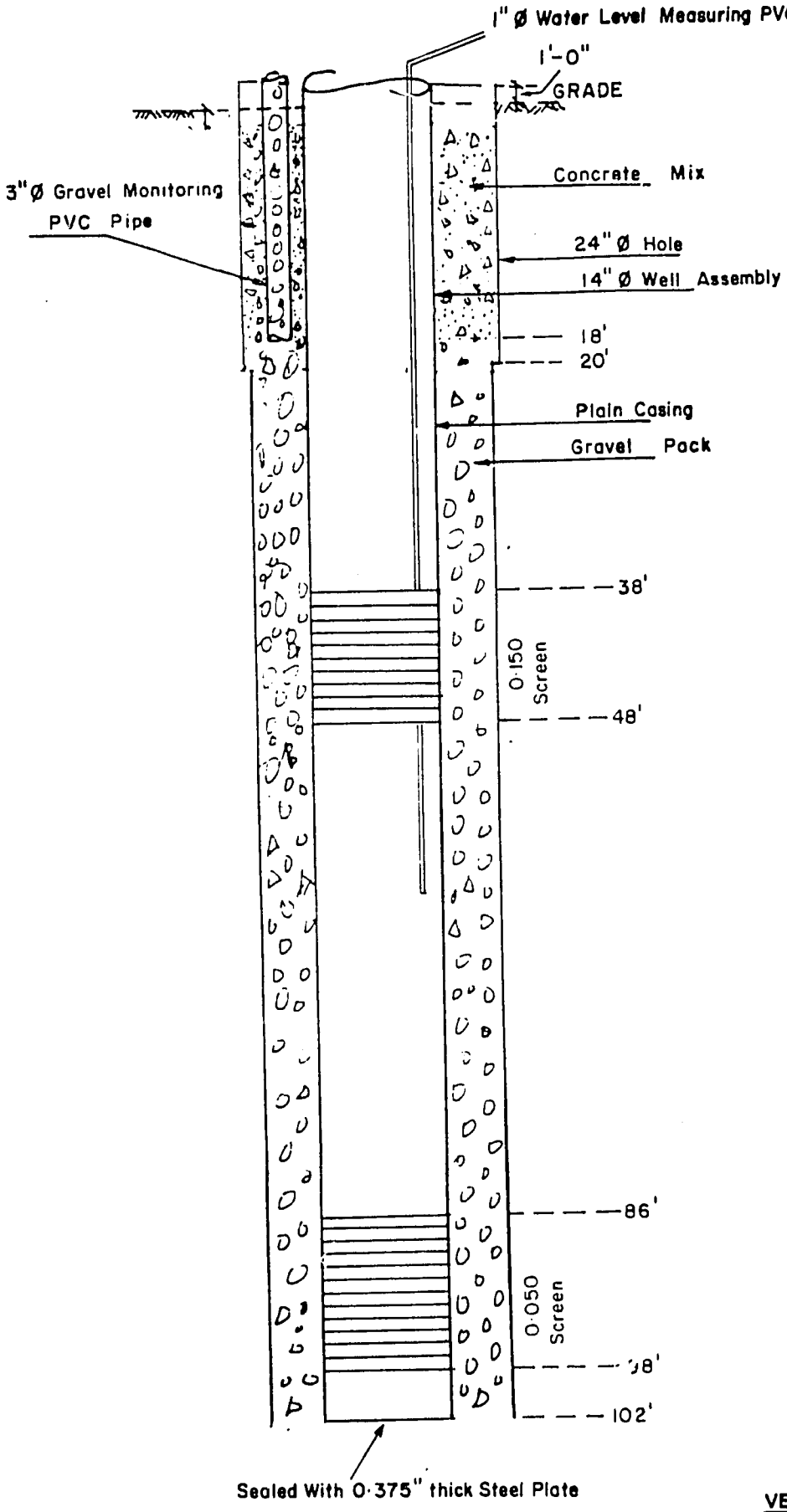
1. 70% retention size of the sample. = 0.010"
2. 70% retention size of the gravel pack materia = 0.010" x 6 = 0.060"
3. Slot size of the screen (90% retention size of the gravel pack material) = 0.050"
4. Uniformity coefficient of the sample. = 6.5

ST. CATHERINE PLAINS

Fig. 2

Caymanas Area – Project 'B'

Well Design – South Syndicate 2.



DATE : 14 · 3 · 86
DRAWING NO. A-050
BY : D. RAMANAMURTY

VERTICAL SCALE
0·8 in = 10 ft.

Fig. 3

St. Catherine Plains

South Syndicate #2

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'

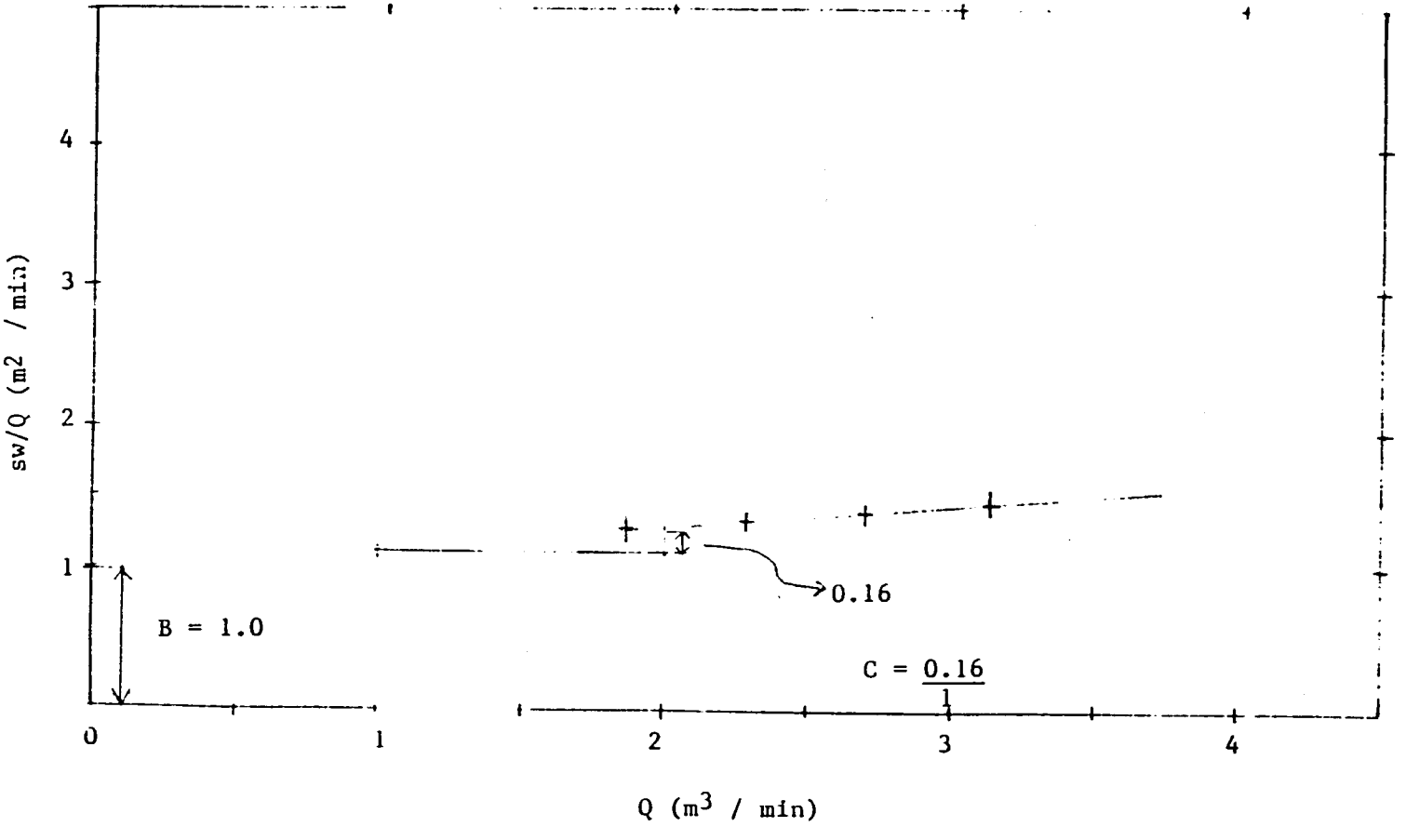


Fig. 4

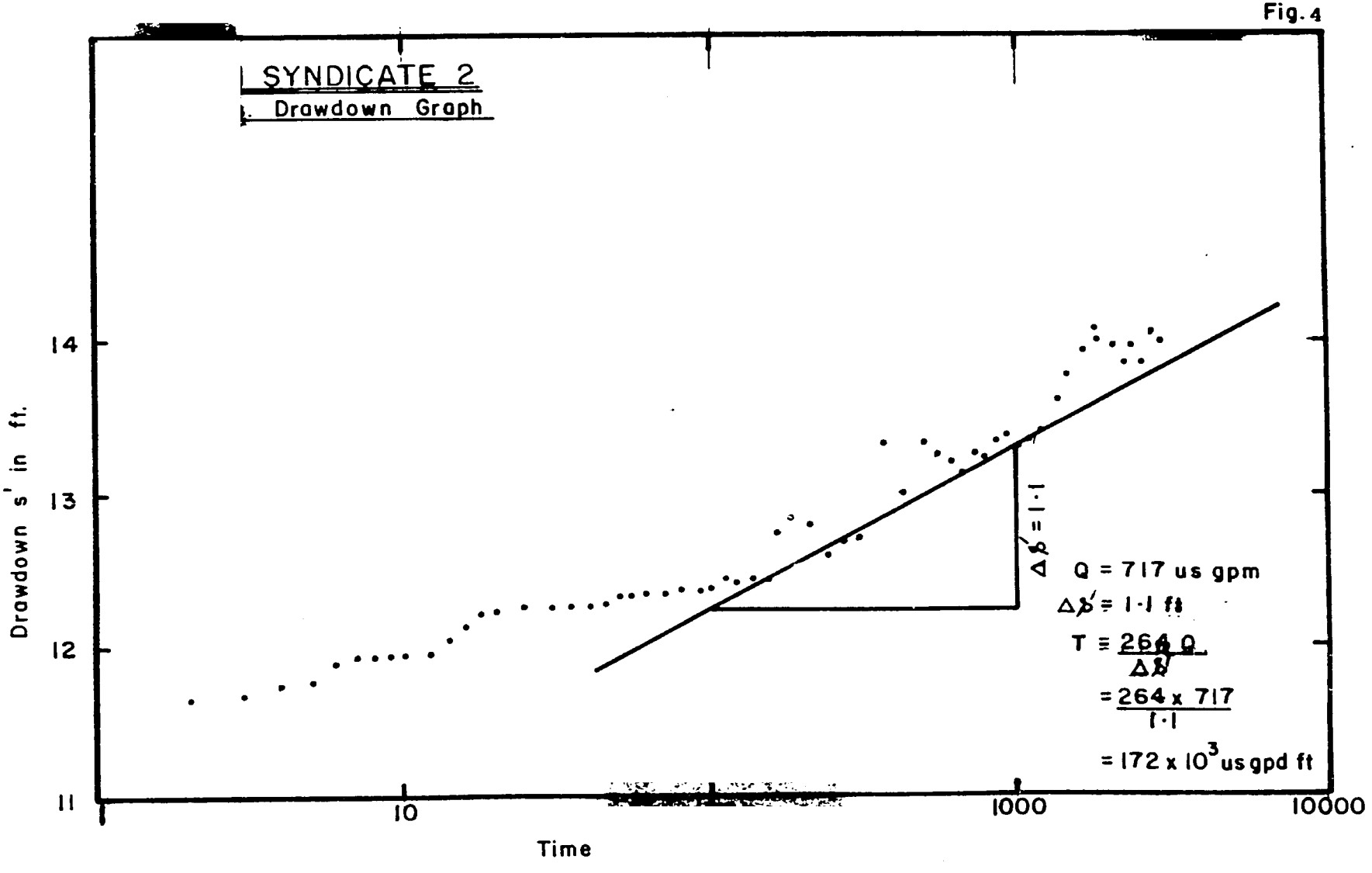
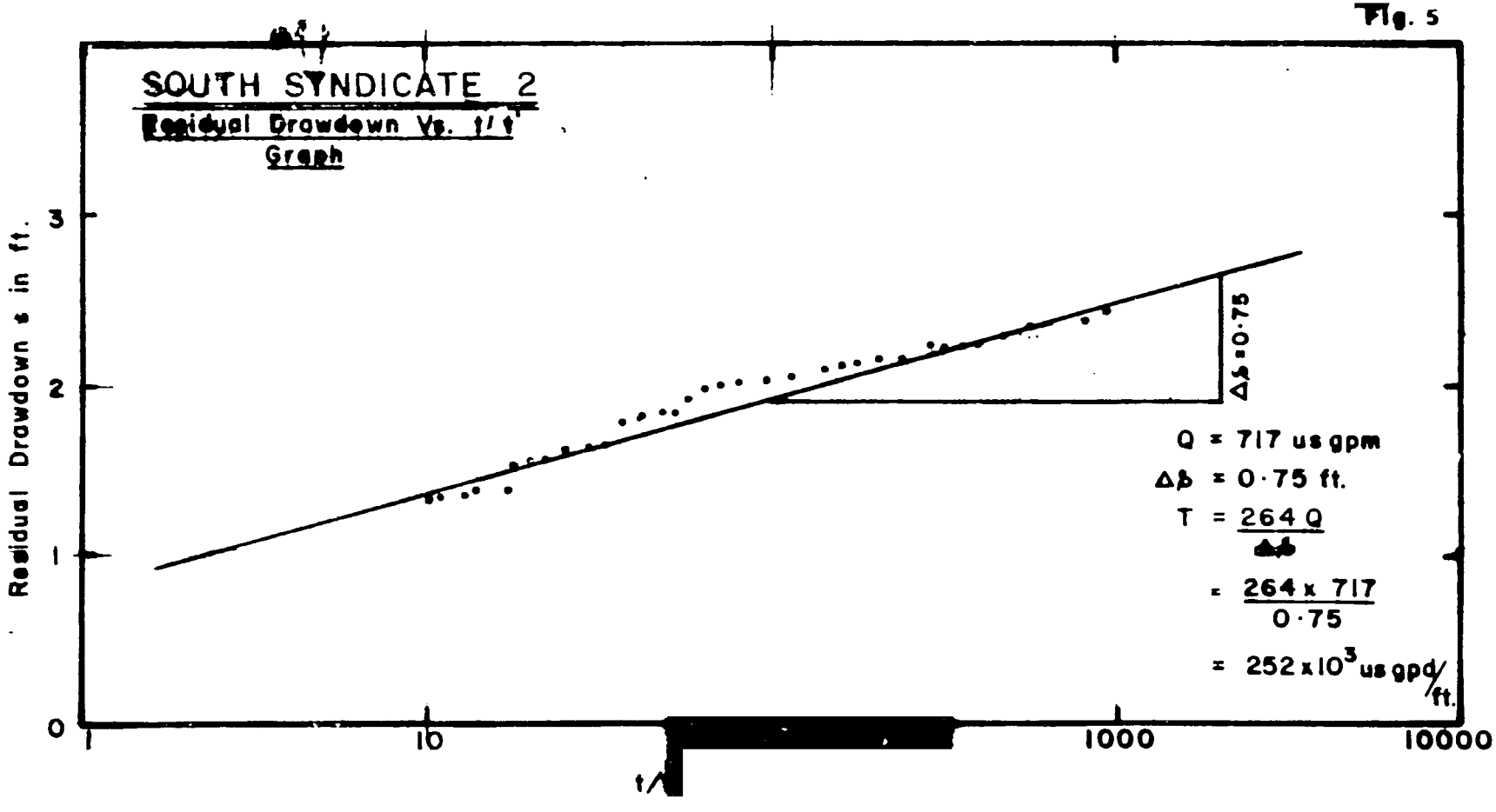

SYNDICATE 2
Drawdown Graph
Drawdown s' in ft.
14
13
12
11
10
1000
10000
Time
Δs' = 1·1
Q = 717 us gpm
Δs' = 1·1 ft
T = 264 Q / Δs'
= 264 x 717 / 1·1
= 172 x 10³ us gpd ft

Fig. 5


SOUTH SYNDICATE 2
Residual Drawdown Vs. t/t'
Graph
Residual Drawdown s in ft.
0
1
2
3
1
10
1000
10000
t/t'
Δs = 0·75
Q = 717 us gpm
Δs = 0·75 ft.
T = 264 Q / Δs
= 264 x 717 / 0·75
= 252 x 10³ us gpd/ft.

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
PERFORMANCE OF CEDAR GROVE #2 WELL

This well is located at the extreme eastern end of Project-B area. It is an old well constructed long ago. It has not been in use for a long time. A copy of the well record, obtained from the records of the Underground Water Authority (formerly Water Resources Division) is given as Table-1.

In July-September, 1985, when the well rehabilitation programme was taken up, this well was cleaned and tested for yield by Caribbean Boring and Diamond Drilling Limited, Kingston. The well was clear down to about 87 ft. The very little fill at the bottom was cleaned with the help of an air compressor. The well was then tested with a turbine pump at three different rates of discharge - 320, 604 and 991 USgpm on August 2, 1985. The test data is given in Table-2. The test results indicate that the well can yield 991 USgpm for a pumping water level of 31.17 ft. which is about 9 ft. above sea level. However, the well discharge was accompanied by the fine to medium grained sand. If the well is reconstructed by installing a smaller diameter well assembly in the well and packing the annular space with proper size gravel to stop sand pumping, the yield may be around 500 USgpm. It was therefore decided to use the well in the same condition with a sand separator installed on the well to eliminate sand from the well water. The recommended rate of discharge from the well is 800 USgpm.

WATER RESOURCES DIVISION — WELL RECORD

LOCATION: Cedar Grove #2	WELL NUMBER: E5893 N3942
PARISH: St. Catherine	GRID REFERENCE: E58980 N39420
OWNER: United Fruit (Ja. Co. Ltd.	ADDRESS: Spanish Town
DRILLER: Waterwell Eng. Con,	ADDRESS: Race Course
	DATE OF COMPLETION:

HOLE SIZE	TYPE OF RIG USED	DEPTH OF WELL	ELEVATION OF SITE A.S.L.
INCHES TO FEET / INCHES TO FEET / INCHES TO FEET	Cable Tool	88 FEET	40.05 FEET
	WATER STRUCK AT FEET	PRINCIPAL AQUIFER: Alluvium	REST WATER LEVEL ON COMPLETION FEET

CASING

TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET

ORIGIN OF DATA	COMPILED BY	CHECKED BY
G.S.D. Records	B.F.	

REMARKS

Water quality - Good

S.W.L. - 14/10/63 - 4.59 ft.

P.W.L. - 24/9/63 - 19.08 ft.

Yield - 365 G.P.M.

Used for Irrigation

Former Grid Reference

E5859 N3955

Was once called Pumpkin Ground #2

14/08/84 - swl 22.02 ft bgl (casing)

Depth 88 ft. soft mud at bottom

Dia. 18 inches (with perfor.)

TEST PUMPING — DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
365		4.38

SKETCH PLAN OF LOCATION

SITED IN FIELD BY — DATE

St. Catherine Plains

Step-Drawdown Test Data

Location: Cedar Grove #2 Area: Caymanas - Project 'B'

Diameter- Discharge Pipe 10" Orfice 6"

Static Water Level 23.00 ft.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
2.8.85	10.15	0	23.00	-			
		1	25.83	2.83	5		
		2	25.92	2.92		320	
		3	26.08	3.08			
		4	26.13	3.13			
		5	26.17	3.17			
		6	26.17	3.17			
		7	26.21	3.21			
		8	26.25	3.25			
		9	26.25	3.25			
		10	26.29	3.29			
		12	26.29	3.29			
		14	26.33	3.33			
		16	26.38	3.38			
		18	26.42	3.42			
		20	26.42	3.42			
		25	26.42	3.42		320	
		30	26.42	3.42			
		35	26.42	3.42			
		40	26.46	3.46			
		45	26.46	3.46			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		50	26.50	3.50			
		55	26.50	3.50			
	11:15	60	26.50	3.50			
		90	26.58	3.58			
	12:15	120	26.67	3.67			
		150	26.70	3.70			
	1:15 p.m.	180	26.70	3.70			
			STEP 2				
	1:17 p.m.	2	30.08	7.08			
		3	30.79	7.79	18	604	
		4	30.79	7.79			
		5	30.79	7.79			
		6	30.87	7.87			
		7	30.87	7.87			
		8	30.92	7.92			
		9	30.92	7.92			
		10	30.92	7.92			
		12	30.92	7.92			
		14	30.92	7.92			
		16	30.92	7.92			
		18	30.92	7.92			
		20	30.92	7.92			

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		25	30.92	7.92			
		30	30.92	7.92			
		35	30.92	7.92			
		40	30.92	7.92			
		45	30.92	7.92	18	604	
		50	30.92	7.92			
		55	30.92	7.92			
	2:15 p.m.	60	30.92	7.92			
				STEP 3			
	2:18 p.m.	3	31.17	8.17			
		4	31.17	8.17	51	991	
		5	31.21	8.21			
		6	31.25	8.25			
		7	31.25	8.25			
		8	31.25	8.25			
		9	31.17	8.17			
		10	31.21	8.21			
		12	31.17	8.17			
		14	31.21	8.21			
		16	31.25	8.25			
		18	31.17	8.17			
	2:35 p.m.	20	31.17	8.17			
		25	31.17	8.17			

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		30	31.25	8.21			
		35	31.25	8.25			
		40	31.25	8.25			
		45	31.17	8.17			
		50	31.17	8.17			
		55	31.17	8.17			
	3:15 p.m.	60	31.17	8.17			
		70	31.17	8.17			
		80	31.17	8.17	51	991	
	3:45 p.m.	90	31.17	8.17			

Pumping Test Data (Continued)

Location: South Syndicate #2 Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
11-10-86						
	9:32	2882	2	20.94	1.92	1441
		2883	3	21.45	2.43	961
		2884	4	21.41	2.39	721
	9:35	2885	5	21.36	2.34	577
		2886	6	21.33	2.31	481
		2887	7	21.29	2.27	412
		2888	8	21.27	2.25	361
		2889	9	21.27	2.25	321
	9:40	2890	10	21.27	2.25	289
		2892	12	21.19	2.17	241
		2894	14	21.19	2.17	206
		2896	16	21.16	2.14	181
		2898	18	21.14	2.12	161
	9:50	2900	20	21.12	2.10	145
		2905	25	21.08	2.06	116
	10:00	2910	30	21.04	2.02	97
		2915	35	21,04	2.02	83
		2920	40	21.02	2.00	73
		2925	45	21.00	1.98	65
	10:20	2930	50	20.93	1.91	58
		2935	55	20.87	1.85	53
	10:30	2940	60	20.87	1.85	49

Pumping Test Data (Continued)

Location: South Syndicate #2 Recovery Data:

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (ft.)	RESIDUAL DRAWDOWN (ft.)	t/t'
11-10-86	10:30	2950	70	20.85	1.83	42
		2960	80	20.81	1.79	37
	11:00	2970	90	20.67	1.65	33
	11:10	2980	100	20.67	1.65	30
	11:20	2990	110	20.67	1.65	27
	11:30	3000	120	20.64	1.62	25
	11:45	3015	135	20.58	1.56	22
	12:00	3030	150	20.58	1.56	20
	12:15	3045	165	20.54	1.52	18
	12:30	3060	180	20.41	1.39	17
		3090	210	20.41	1.39	14
		3120	240	20.39	1.37	13
		3150	270	20.37	1.35	11
		3180	300	20.37	1.35	10
		3300	420	18.82	+0.20	7

Chemical Analyses of Water Samples

Location: South Syndicate-2

Area: Caymanas Area - Project 'I

SL NO.	DATE	pH	@ Sp. Conduct-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
				←						mg/l									→	
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	19.20	35.50	2.80		22.99	50.01					286.01	22.16	308.17	242.00	1.0/2.6

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

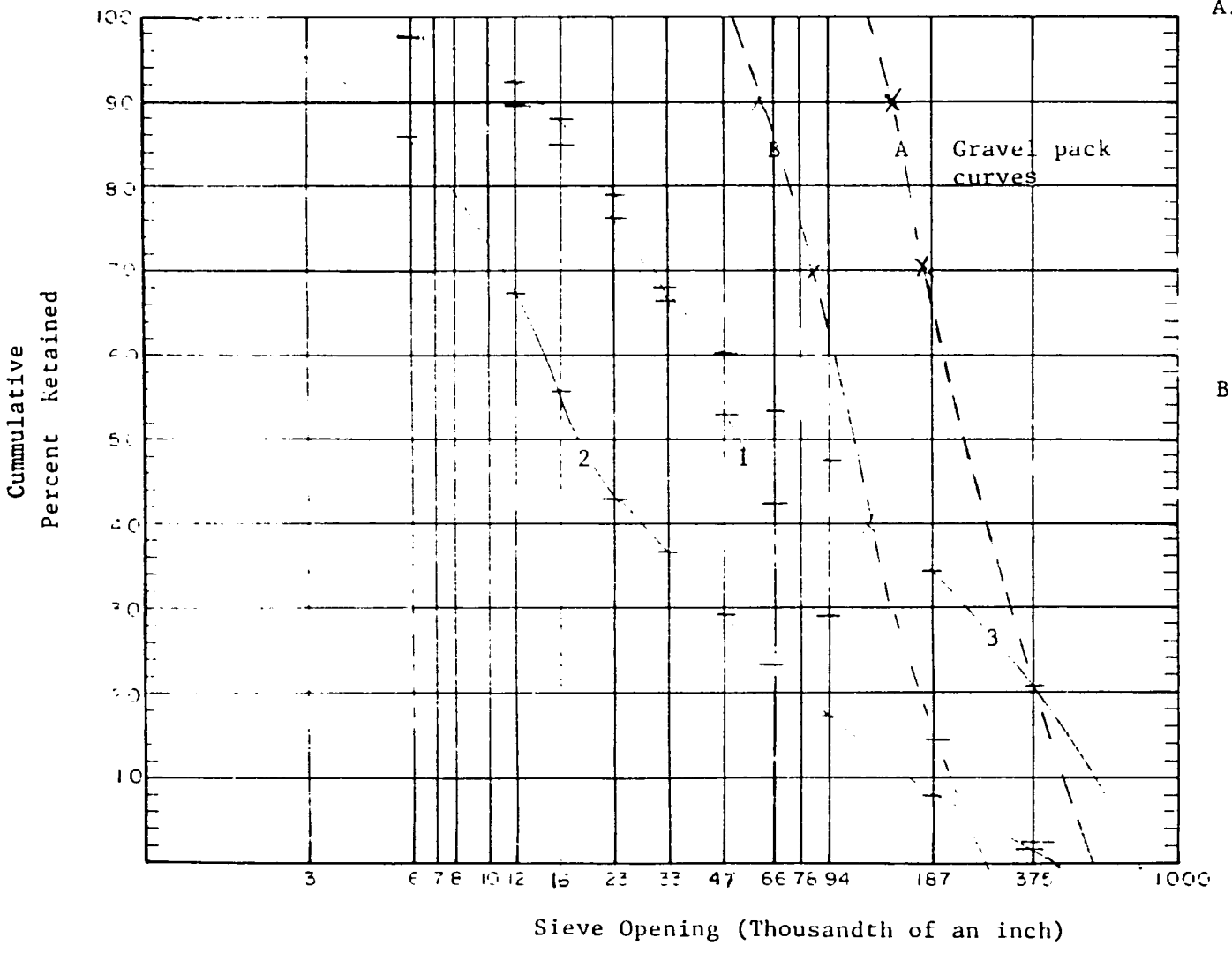
SIEVE ANALYSES CURVES

Fig. 1

Location: South Syndicate #2 Corehole

Depth Range: (ft.)

1) 38-40 (Upper Aquifer)
2) 86-88 (3) 92-94 (Lower Aquifer)



A. UPPER AQUIFER

1. 70% retention size of the sample = 0.030"
2. 70% retention size of the gravel pack meterial = 0.030" x 6 = 0.180"
3. Slot size of the screen (90% retention size of the gravel pack material) = 0.150"
4. Uniformity coefficient of the sample. = 5

B. LOWER AQUIFER

Finest sample is #2

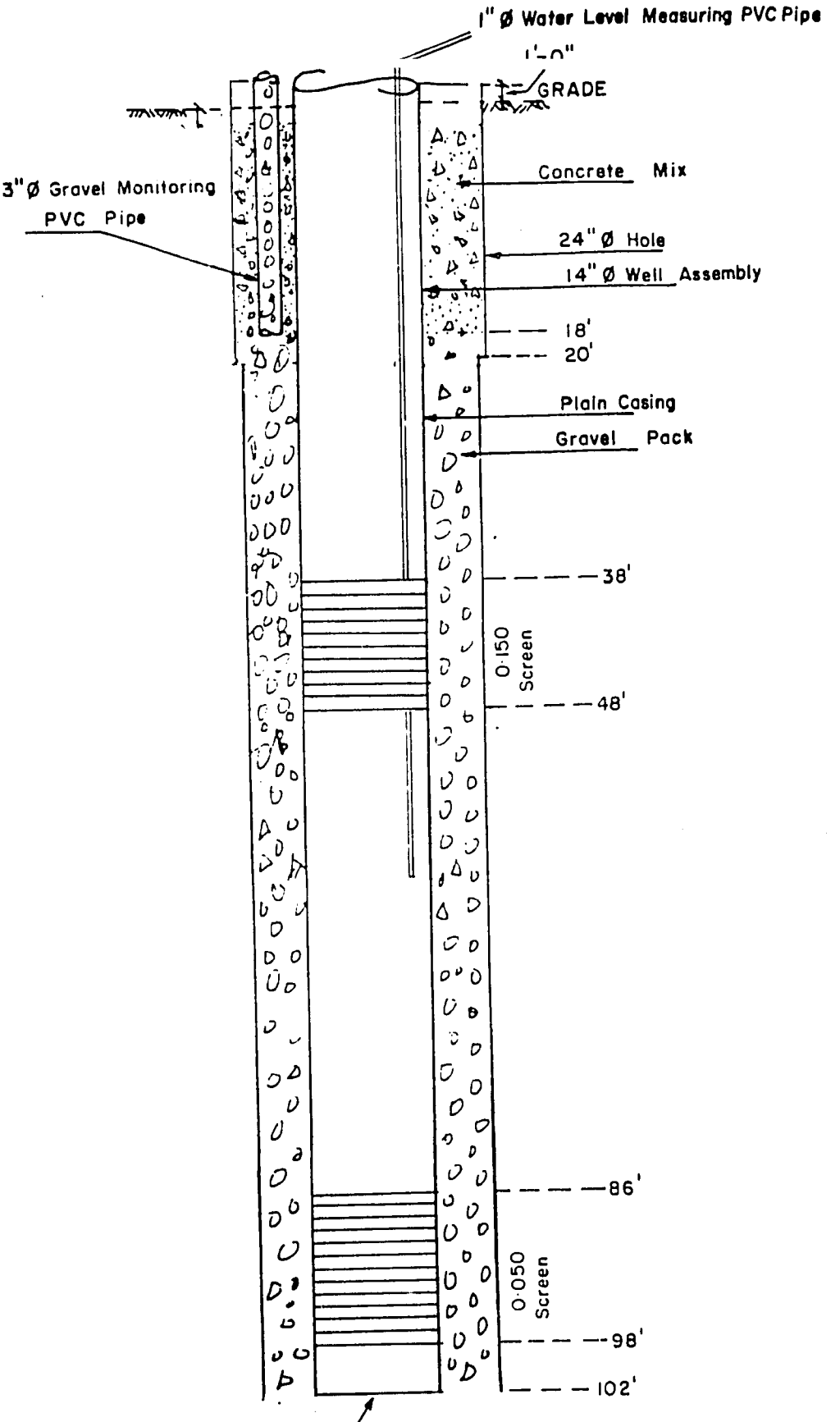
1. 70% retention size of the sample. = 0.010"
2. 70% retention size of the gravel pack materia = 0.010" x 6 = 0.060"
3. Slot size of the screen (90% retention size of the gravel pack material) = 0.050"
4. Uniformity coefficient of the sample. = 6.5

ST. CATHERINE PLAINS

Fig. 2

Caymanas Area – Project 'B'

Well Design – South Syndicate 2.



DATE : 14 · 3 · 86
DRAWING NO. A-050
BY: D. RAMANAMURTY

VERTICAL SCALE
0·8 in = 10 ft.

141

Fig. 3

St. Catherine Plains

South Syndicate #2

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'

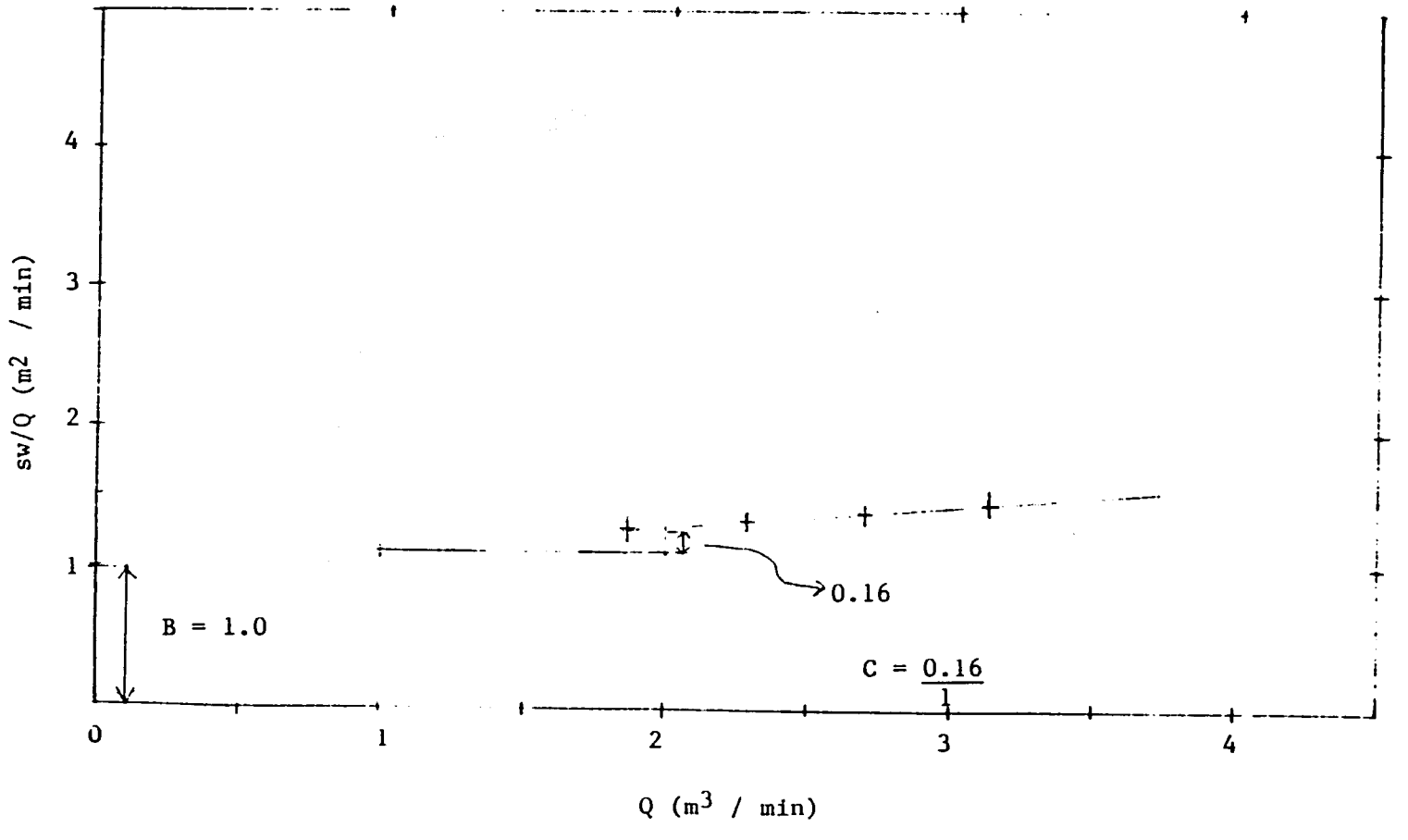


Fig. 4

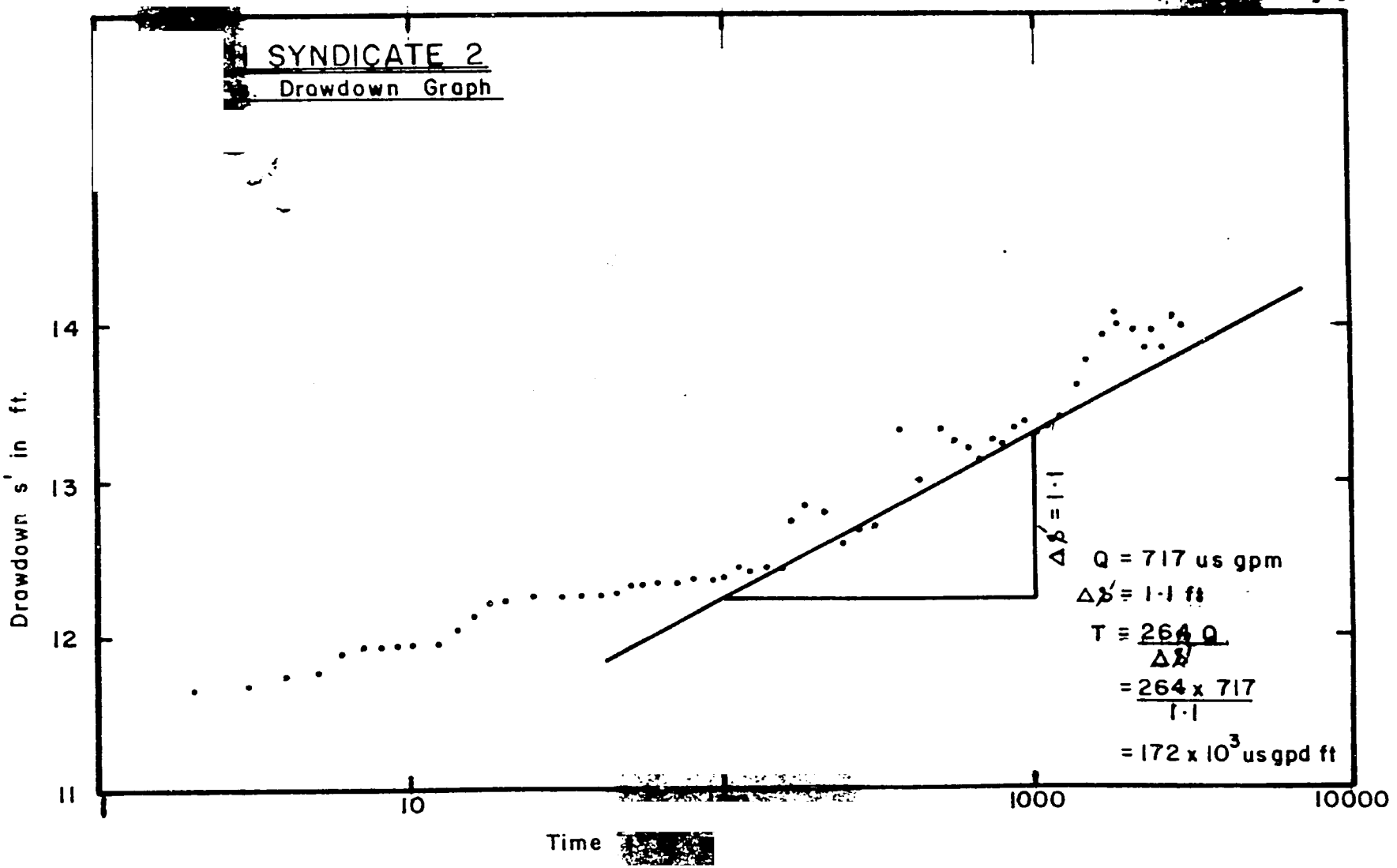
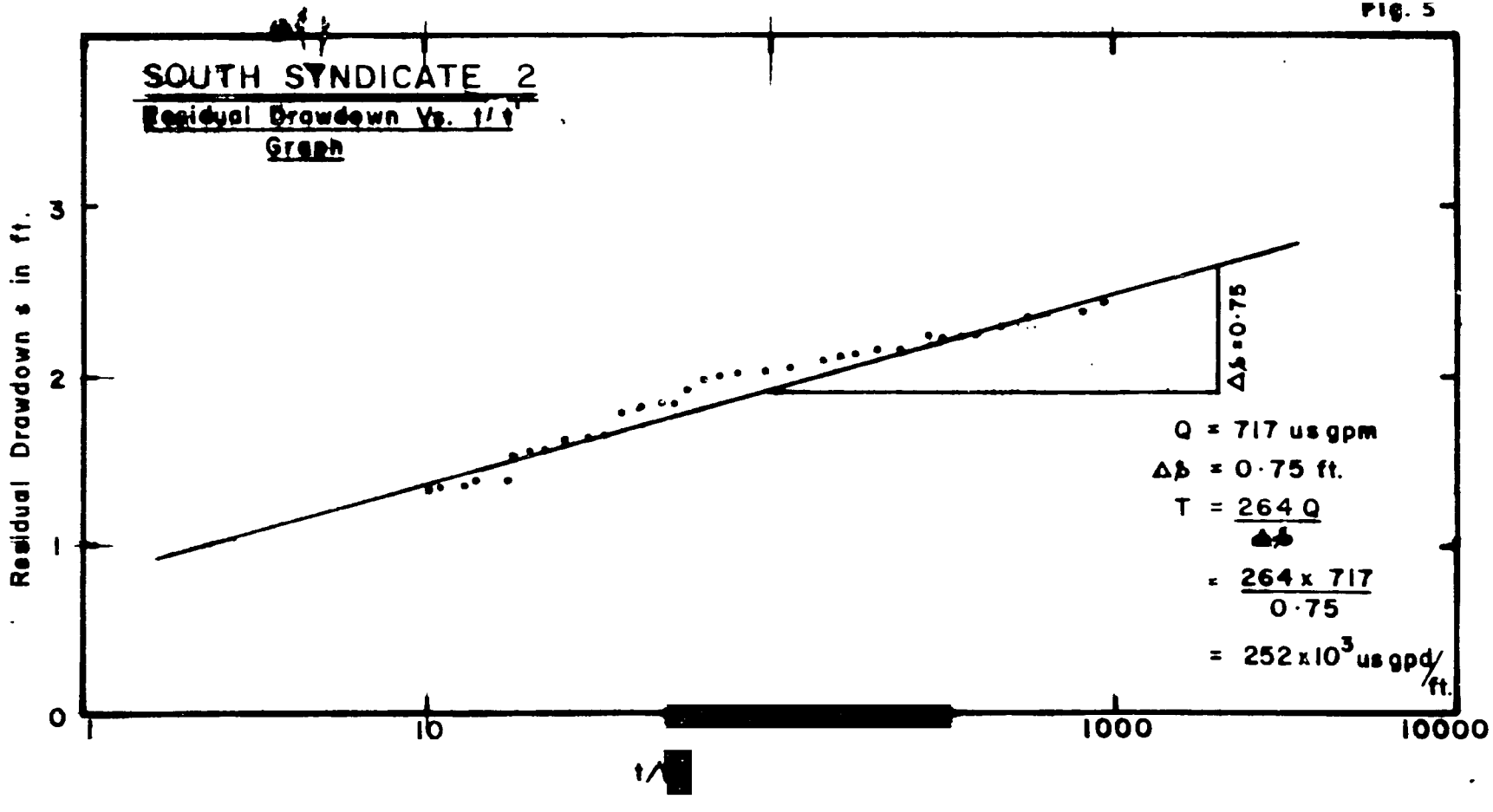

SYNDICATE 2
Drawdown Graph
Drawdown s' in ft.
14
13
12
11
10
1000
10000
Time
Δs' = 1·1
Q = 717 us gpm
Δs' = 1·1 ft
T = 264 Q / Δs'
= 264 x 717 / 1·1
= 172 x 10³ us gpd ft

FIG. 5


SOUTH SYNDICATE 2
Residual Drawdown Vs. t/t'
Graph
Residual Drawdown s in ft.
0
1
2
3
1
10
1000
10000
t/t'
Δs=0·75
Q = 717 us gpm
Δs = 0·75 ft.
T = 264 Q / Δs
= 264 x 717 / 0·75
= 252 x 10³ us gpd/ft.

ST. CATHERINE PLAINS
CAYMANAS AREA - PROJECT 'B'
PERFORMANCE OF CEDAR GROVE #2 WELL

This well is located at the extreme eastern end of Project-B area. It is an old well constructed long ago. It has not been in use for a long time. A copy of the well record, obtained from the records of the Underground Water Authority (formerly Water Resources Division) is given as Table-1.

In July-September, 1985, when the well rehabilitation programme was taken up, this well was cleaned and tested for yield by Caribbean Boring and Diamond Drilling Limited, Kingston. The well was clear down to about 87 ft. The very little fill at the bottom was cleaned with the help of an air compressor. The well was then tested with a turbine pump at three different rates of discharge - 320, 604 and 991 USgpm on August 2, 1985. The test data is given in Table-2. The test results indicate that the well can yield 991 USgpm for a pumping water level of 31.17 ft. which is about 9 ft. above sea level. However, the well discharge was accompanied by the fine to medium grained sand. If the well is reconstructed by installing a smaller diameter well assembly in the well and packing the annular space with proper size gravel to stop sand pumping, the yield may be around 500 USgpm. It was therefore decided to use the well in the same condition with a sand separator installed on the well to eliminate sand from the well water. The recommended rate of discharge from the well is 800 USgpm.

WATER RESOURCES DIVISION — WELL RECORD

LOCATION: Cedar Grove #2	WELL NUMBER: E5858 N3942
PARISH: St. Catherine	GRID REFERENCE: E58980 N39420
OWNER: United Fruit (Ja. Co. Ltd.	ADDRESS: Spanish Town
DRILLER: Waterwell Eng. Con,	ADDRESS: Race Course
	DATE OF COMPLETION:

HOLE SIZE	TYPE OF RIG USED	DEPTH OF WELL	ELEVATION OF SITE A.S.L.
INCHES TO FEET INCHES TO FEET INCHES TO FEET	Cable Tool	38 FEET	40.05 FEET
	WATER STRUCK AT: FEET	PRINCIPAL AQUIFER: Alluvium	REST WATER LEVEL ON COMPLETION: FEET

CASING

TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET

ORIGIN OF DATA	COMPILED BY	CHECKED BY
G.S.D. Records	B.F.	

REMARKS

Water quality - Good

S.W.L. - 14/10/63 - 4.59 ft.

P.W.L. - 24/9/63 - 19.08 ft.

Yield - 365 G.P.M.

Used for Irrigation

Former Grid Reference

E5859 N3955

Was once called Pumpkin Ground #2

14/08/84 - swl 22.02 ft bgl (casing)

Depth 88 ft. soft mud at bottom

Dia. 18 inches (with perfor.)

TEST PUMPING — DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
365		4.38

SKETCH PLAN OF LOCATION

SITED IN FIELD BY — DATE

St. Catherine Plains

Step-Drawdown Test Data

Location: Cedar Grove #2 Area: Caymanas - Project 'B'

Diameter- Discharge Pipe 10" Orfice 6"

Static Water Level 23.00 ft.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
2.8.85	10.15	0	23.00	-			
		1	25.83	2.83	5		
		2	25.92	2.92		320	
		3	26.08	3.08			
		4	26.13	3.13			
		5	26.17	3.17			
		6	26.17	3.17			
		7	26.21	3.21			
		8	26.25	3.25			
		9	26.25	3.25			
		10	26.29	3.29			
		12	26.29	3.29			
		14	26.33	3.33			
		16	26.38	3.38			
		18	26.42	3.42			
		20	26.42	3.42			
		25	26.42	3.42		320	
		30	26.42	3.42			
		35	26.42	3.42			
		40	26.46	3.46			
		45	26.46	3.46			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		50	26.50	3.50			
		55	26.50	3.50			
	11:15	60	26.50	3.50			
		90	26.58	3.58			
	12:15	120	26.67	3.67			
		150	26.70	3.70			
	1:15 p.m.	180	26.70	3.70			
			STEP 2				
	1:17 p.m.	2	30.08	7.08			
		3	30.79	7.79	18	604	
		4	30.79	7.79			
		5	30.79	7.79			
		6	30.87	7.87			
		7	30.87	7.87			
		8	30.92	7.92			
		9	30.92	7.92			
		10	30.92	7.92			
		12	30.92	7.92			
		14	30.92	7.92			
		16	30.92	7.92			
		18	30.92	7.92			
		20	30.92	7.92			

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		25	30.92	7.92			
		30	30.92	7.92			
		35	30.92	7.92			
		40	30.92	7.92			
		45	30.92	7.92	18	604	
		50	30.92	7.92			
		55	30.92	7.92			
	2:15 p.m.	60	30.92	7.92			
				STEP 3			
	2:18 p.m.	3	31.17	8.17			
		4	31.17	8.17	51	991	
		5	31.21	8.21			
		6	31.25	8.25			
		7	31.25	8.25			
		8	31.25	8.25			
		9	31.17	8.17			
		10	31.21	8.21			
		12	31.17	8.17			
		14	31.21	8.21			
		16	31.25	8.25			
		18	31.17	8.17			
	2:35 p.m.	20	31.17	8.17			
		25	31.17	8.17			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Cedar Grove #2

1	2	3	4	5	6	7	8
		30	31.25	8.21			
		35	31.25	8.25			
		40	31.25	8.25			
		45	31.17	8.17			
		50	31.17	8.17			
		55	31.17	8.17			
	3:15 p.m.	60	31.17	8.17			
		70	31.17	8.17			
		80	31.17	8.17	51	991	
	3:45 p.m.	90	31.17	8.17			