a large drawdown was confirmed using an air lift. After the development procedure, the static groundwater level was 7.52 m below the ground surface.

Consequently, the step drawdown test could not be carried out. The pumping test was carried out at 0.08 l/sec constant pumping discharge rate. The pumping time of the time drawdown test was 120 minutes, due to it's low permeability. The final drawdown of the test was 10.91 m. According to the analysis of the pumping test data, transmissivity of TW009 ranges from 0.04 to 0.1 m^2/day. The pumping test data suggest, that fresh olivine basalt has no potential for groundwater development.

2.10 TW010

Test well TW010 was drilled to confirm the water bearing fissured zones of basalt and basaltic breccia along the geological lineaments of Rabulu Road in the Rabulu Coastal Plain about 8 km east of Tavua town. The drilling operation was performed using mud water by a Model Top-200 drilling rig with a tricon rock bit to 70.2 m. The results of the test well drilling and pumping test are shown in Fig. C-1.3 (10). The operation time of the well drilling is shown in Table C-1.2.

According to the geological log and geophysical logging, the geological formation of TW010 consists of compacted basaltic rock of the Ba series, which are mainly weathered volcanics but also contain thick interbedded fresh olivine basalt between 31 and 41 m below the surface. These compacted volcanic rocks usually do not produce a large amount of groundwater. However, screens were installed at the lower weathered formation, and at the boundary of fresh rock and weathered rock to confirm the permeability of these rocks. An assembly of casing pipes and screens was installed to a depth of 70.2 m.

During the development, a very small quantity of water with a large drawdown was confirmed using an air lift. After the development procedure, the static groundwater level was 1.07 m below the ground surface.

Consequently, the step drawdown test could not be carried out. The pumping test was carried out at 0.005 l/sec constant pumping discharge rate. The pumping time of the time drawdown test was 120 minutes, due to its low permeability. The final drawdown of the test was 13.04 m. According to the analysis of the pumping test data, the transmissivity of TW010 is about 0.10 m^2/day. Therefore, groundwater development is not expected in the compacted basaltic rocks along Rabulu Road.

2.11 TW011

Test well TW011 was drilled at Wairuku in the west side of the Penang River Basin about 1 km west of Vaileka. The purposes of TW011 were to obtain hydrogeological data on fissured aquifers of chloritized tracky basaltic volcanics along the lineaments in Wairuku. The drilling operation was performed using mud water by a Model Top-200 drilling rig with a tricon rock bit to 76.5 m . The results of the test well drilling and pumping tests are shown in Fig. C-1.3 (11). The operation time of the well drilling is shown in Table C-1.2.

According to the drilling cuttings, the geological formations of TW011 are composed of weathered basaltic rocks and volcanic breccia, fresh hard basalt, volcanic ash, and olivine basalt. The possibility of water bearing zones in these formations is usually expected in fractured and weathered zones. However, distinct fractured zones were not found. Therefore, screens were installed mainly at the weathered and possible fractured zones.

During the development, a very small quantity of water with a large drawdown and the slow recovery of the water level were confirmed by air lift pumping. After the development procedure, the static groundwater level was 6.79 m below the ground surface.

Consequently, the step drawdown test could not be carried out. The pumping test was carried out at 0.03 l/sec constant pumping discharge rate. The pumping time of the time drawdown test was 120 minutes, due to its low permeability. The final drawdown of the test was 8.15 m. According to the analysis of the pumping test data, the transmissivity of TW011 ranges from 0.52 to 0.95 m^2/day. The pumping test results suggest that fresh olivine basalt and weathered zones have no potential for groundwater development.

2.12 TW0012

Test well TW012 was drilled 1km east of Vaileka in the Penang River Basin. This test well was selected from the alternative sites, because test Well TW007 at Qara-1, about 8 km southeast of Tavua town , was canceled due to land acquisition problems. The results of the test well drilling and pumping test are shown in Fig. C-1.3(12).

The drilling operation was performed using mud water by a Model Top-200 drilling rig with a tricon rock bit to 77 m. The operation time of the well drilling is shown in Table C-1.2. The assembly of casing pipes and screens was installed to a depth of 74.45 m. Screens were installed at the four water bearing beds which were determined by lithology and geophysical logging from 26 to 37 m and 61 to 69.25 m. The results of the drilling cuttings indicate that the water bearing beds are composed of basalt and weathered tuff breccia.

The step drawdown test was carried out in four steps from 0.73 l/sec to 1.43 l/sec. The depth to the water level in TW012 before the time drawdown test was 5.68 m. The time drawdown test was carried out for 48 hours at 0.98 l/sec constant pumping rate. The final drawdown of the test was 18.23 m. According to the analysis of the pumping test data, the transmissivity of TW008 is about 6.7 m^2/day.

The water quality analysis of the pumped water obtained from TW012 indicated a good potable water supply.

3. MRD EXISTING WELL

3.1 GW035

The existing MRD well, GW035 (MRD Reference No. 91/12), is located at Vatuyaka in the Ba Uplands about 7 km from Ba town. This well with a final depth of 45m and was completed by MRD in 1991. The assembly of casing pipes and screens was extended to 36.73 m. Screens with 200 mm geotext slits were installed from 8.4 m to 28.1 m, and with 150 mm geotext slit screens from 28.3 m to 36.73 m. According to the geological log, the water bearing beds of GW035 consist of weathered fractured basalt Ba volcanic.

The 24-hour time drawdown pumping test was carried out on August 10, 1994 to confirm the permeability and water level of GW035. The result of the pumping test is shown in Fig. C-3.1. The depth to the water level in GW035 before the time drawdown test was 7.52 m. The time drawdown test was carried out for 24 hours at 4.81 l/sec constant pumping rate. The final drawdown of the test was 11 m. According to the analysis of the pumping test data, the transmissivity of GW035 ranges from 98.8 to 138.3 m^2/day.

The water quality analysis of the pumped water obtained from GW035 indicated a good potable water supply.

3.2 GW254

The existing MRD well, GW254 (MRD Reference No.89/22) is located on the left bank of the lower reaches of the Yaqara river about 15 km from Tavua town. This well, with a diameter of 194 mm, was drilled, by MRD to a depth of 38.3 m in 1989. The assembly of casing pipes was extended to 3 m to protect the borehole from caving at the mouth. Casing pipes and screens were not further installed, due to the stiff geological condition of the borehole. According to the geological log, GW254 rocks chiefly consist of volcanic conglomerates, volcanic breccia, and agglomerate.

The 24-hour time drawdown pumping test was carried out on September 14, 1994 to confirm the permeability and water level of GW254. The result of the pumping test is shown in Fig. C-3.1. The depth to the water level before time drawdown test was 7.90 m. The time drawdown test was carried out for 24 hours at using a 15.81 l/sec constant pumping rate. The final drawdown of the test was

0.77 m. Consequently, the largest specific capacity (19.64 l/s/m) in the Study Area was confirmed by this test.

However, more attention will be paid to the evaluation of the groundwater potential because, according to the initial drawdown data collected during the pumping test of GW254, a large transmissivity (2,672 m^2/day) was obtained by the gradual decline of the water level. It is, however, noteworthy that the drawdown curve at a constant pumping rate becomes steeper 5 hours after pumping has started. As a result of the steeper decline, a smaller transmissivity of 829 m^2/day (Fig. C-3.1) occurred. This is suggested that a less pervious rock mass surrounds the pervious mass where the borehole was drilled. The results of the geophysical prospecting in this region also show a limited high permeability area.

It is impossible to detect the impervious boundary by using one observation well. But, the distance from the observation well to the image well can be calculated from the observation well data. Usually the impervious boundary is located between the observation well and the image well. According to the analysis of the observation well data (Fig. C-3.2), the distance from the observation well (GW014) to the image well is decided at about 565 m.

In addition, the water level recovery almost ceased at 20 cm below the original level, 6 hours after pumping stopped, due to the limited distribution of the aquifer and the poor recharge condition. This suggested that the discharge rate of the pumping test exceeded natural replenishment. In order to maintain a certain abstraction of groundwater for a long period, it is desirable to minimize the abstraction rate for GW254. On the other hand, in order to maintain the groundwater level, the possibility of artificial recharge should be considered. This is because the hydrological and geological properties of GW254 show a concentrated high porosity water bearing bed, and moreover, the annual water level fluctuation responds well the rainfall pattern. This is suggested that GW254's water bearing bed can be a possible storage space for artificially recharged water.

The water quality analysis of the ground water obtained from the boreholes in the Yaqara River Basin indicate a good potable waters supply. Monitoring of the water level and water quality of GW 254 has to be made in order to preserve the groundwater yield and to prevent possible sea water intrusion. This is because the well is located near the coast with a lower elevation static water level (about 7 m above sea level) and poor water recovery conditions.

TABLES

Table C-1.1 LIST OF TEST WELLS

Well No.	Location	Elevation (m)	Well Completed Date	Drilling Rig	Diameter (mm)	Depth (m)	Screen Position (m)	Screen Length (m)	Static Water Level (m)	Pumping Water Level (m)	Pumping Test Yeild (l/sec.)
TW001	Vutuni	62.20	21-7-94	Top300	150	76.00	43.1-69.35	23.25	23.03	34.23	3.20
TW002	Yalalevu	7.20	12-8-94	Top200	150	35.00	16.0-26.5	10.50	3.27	13.27	2.75
TW003	Nukuloa	44.45	6-8-94	Top300	150	74.55	37.6-53.35	15.75	41.19	44.95	0.05
							58.75-69.25	10.50			
TW004	Varadoli	17.76	10-2-94	Top200	150	75.30	10.3-37.8	27.50	8.12	18.37	2.89
TW005	Veisaru	40.92	15-3-94	Top200	150	72.00	16-21.5	5.50	9.81	23.45	2.35
							26.9-43.4	16.50			
							48.8-54.3	5.50			
TW006	Koronubu	26.52	2-7-94	Top300	150	76.00	6.1-18.8*	12.7*	+0.30	4.51	2.00
TW006A	Koronubu	26.52	5-7-94	Top300	150	21.35	5.35-15.85	10.50	+0.26	-	-
TW008	Kukunirewa	57.76	16-6-94	Top300	150	74.45	16-21.25	5.25	0.92	7.92	1.30
							32.05-37.3	15.25			
							48-53.25	5.25			
							64-69.25	5.25			
TW009	Drumasi	60.34	16-7-94	Top200	280	71.00	11-71*	60*	7.52	18.43	0.08
TW010	Rambulu	21.58	28-2-94	Top200	150	70.20	26.6-43.1	16.50	1.07	14.11	0.06
							48.5-65	16.50			
TW011	Wairuku	12.74	24--6-94	Top200	150	74.45	10.6-21.1	10.50	6.79	14.94	0.23
							48.1-53.35	5.25			
							58.75-69.25	10.50			
TW012	Vaileka	17.13	30-6-94	Top200	150	74.45	26.5-37.5	11.00	5.68	23.91	0.98
							64-69.25	5.25			

Note:

Elevation data based on the leveling survey

*; Borehole without casing pipe and screen

Table C-1.2 OPERATION TIME OF WELL DRILLING

Well number	TW001	TW002	TW003	TW004	TW005	TW006	TW006A	TW008	TW009	TW010	TW011	TW012	Total	Total
Drilling depth (m)	76.00	36.40	77.00	75.30	72.00	76.00	21.35	75.00	71.00	70.20	76.50	77.00	days	%
Site preparation, transportation, and assembly of rig	2.5	2.0	3.0	6.5	3.0	2.5	0.5	3.0	3.0	4.5	3.0	2.5	36.0	13.0
Drilling operation	4.0	3.5	3.0	5.5	3.0	3.5	1.5	4.0	7.0	3.5	4.5	4.5	47.5	17.2
Electrical logging	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0	2.2
Installation of casing and screen, gravel packing and cementing	2.5	4.0	1.5	1.5	1.0	0*	0.5	1.5	0*	1.5	1.0	1.0	16.0	5.8
Development	4.5	12.5	4.5	2.0	6.5	2.5	1.0	8.5	3.0	2.0	12.0	4.0	63.0	22.8
Pumping test	5.0	6.0	1.0	10.0	6.0	5.0	0.0	5.0	1.0	1.0	1.0	5.0	46.0	16.7
Mechanical trouble	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	0.7
Disassembly of rig and transportation	1.0	0.5	1.5	1.5	2.0	0**	1.0	0.5	1.5	2.0	1.0	0.5	13.0	4.7
Holiday, etc.	5.0	4.5	2.0	3.0	3.0	8.0	1.0	8.0	2.0	3.0	5.0	2.0	46.5	16.8
Total	25.0	34.0	17.0	31.0	25.0	22.0	6.0	31.0	18.0	19.0	28.0	20.0	276.0	100.0

Note: *;No casing pipe installed
**; Transfer to TW006A

Table C-1.3 LIST OF CASINGS AND SCREENS FOR TEST WELLS

Item	Unit (m)	Outside diameter (mm)	Installed pieces	Installed total length (m)
11" Surface casing with thread	3	298.0	12	36.00
9" Work casing with thread	3	243.0	24	72.00
9" Work casing with thread	1	243.0	4	4.00
6"Steel casing with thread	5.4	165.2	83	448.20
6" Well screen with thread stainless wedged wire wound type slot size 1 mm	5.25	173.0	43	225.75

Table C-1.4 RESULTS OF THE PUMPING TESTS

Well No.	Test Type	Static Water Level (m)	Quantity (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Sw/Q (m/l/s)
TW001	C	23.03	3.20	11.20	0.29	3.5000
	S-1	23.29	2.59	5.29	0.49	2.0425
	S-2		2.99	7.75	0.39	2.5920
	S-3		3.45	9.31	0.37	2.6986
	S-4		3.73	10.16	0.37	2.7239
TW002	C	3.27	2.75	10.45	0.26	3.8000
	S-1	3.12	2.43	4.10	0.59	1.6872
	S-2		3.27	6.09	0.54	1.8624
	S-3		3.75	7.27	0.52	1.9387
	S-4		4.27	8.97	0.48	2.1007
TW003	C	41.19	0.05	3.76	0.01	75.2000
TW004	C	8.12	2.89	10.25	0.28	3.5467
	S-1	7.99	1.95	3.77	0.52	1.9333
	S-2		2.40	5.70	0.42	2.3750
	S-3		2.85	7.89	0.36	2.7684
	S-4		3.20	10.21	0.31	3.1906
TW005	C	9.81	2.35	13.64	0.17	5.8043
	S-1	9.81	2.01	8.53	0.24	4.2438
	S-2		2.38	12.05	0.20	5.0630
	S-3		2.89	16.97	0.17	5.8720
	S-4		3.43	29.87	0.11	8.7085
TW006	C	+0.26	2.00	4.81	0.42	2.4050
	S-1	+0.26	1.53	2.42	0.63	1.5817
	S-2		1.83	3.75	0.49	2.0492
	S-3		2.20	4.69	0.47	2.1318
	S-4		2.63	6.03	0.44	2.2928
TW008	C	0.92	1.30	7.00	0.19	5.3846
	S-1	0.92	0.83	3.56	0.23	4.2892
	S-2		1.13	5.57	0.20	4.9292
	S-3		1.48	8.48	0.17	5.7297
	S-4		1.78	11.42	0.16	6.4157
TW009	C	7.52	0.08	10.91	0.01	136.3750
TW010	C	1.07	0.06	13.04	0.005	217.3333
TW011	C	6.79	0.23	8.15	0.03	35.4348
TW012	C	5.68	0.98	18.23	0.05	18.6020
	S-1	5.53	0.73	9.82	0.07	13.4521
	S-2		0.95	15.62	0.06	16.4421
	S-3		1.20	21.88	0.05	18.2333
	S-4		1.43	29.01	0.05	20.2867
GW035*1	C	7.52	4.81	10.91	0.44	2.2682
GW254*2	C	7.90	15.12	0.77	19.64	0.0509

Note: *1: Vatuyak; *2: Yaqara

Table C-1.5 ESTIMATED WELL LOSS AND AQUIFER LOSS

Well No.	Quantity (l/s)	Aquifer loss (m)	Well loss (m)	Total drawdown (m)	Ratio of well loss
TW001	3.20	2.69	5.32	8.01	66.45%
	2.59	2.18	3.49	5.66	61.59%
	2.99	2.51	4.65	7.16	64.92%
	3.45	2.90	6.19	9.09	68.11%
	3.73	3.13	7.23	10.37	69.78%
TW002	2.75	3.38	1.36	4.74	28.70%
	2.43	2.99	1.06	4.05	26.23%
	3.27	4.02	1.92	5.95	32.37%
	3.75	4.61	2.53	7.14	35.43%
	4.27	5.25	3.28	8.53	38.46%
TW004	2.89	1.16	6.68	7.84	85.25%
	1.95	0.78	3.04	3.82	79.59%
	2.40	0.96	4.61	5.57	82.76%
	2.85	1.14	6.50	7.64	85.07%
	3.20	1.28	8.19	9.47	86.49%
TW005	2.35	2.47	9.11	11.58	78.69%
	2.01	2.11	6.67	8.78	75.95%
	2.38	2.50	9.35	11.85	78.90%
	2.89	3.03	13.78	16.82	81.95%
	3.43	3.60	19.41	23.01	84.35%
TW006	2.00	2.94	1.24	4.18	29.67%
	1.53	2.25	0.73	2.97	24.39%
	1.83	2.69	1.04	3.73	27.85%
	2.20	3.23	1.50	4.73	31.69%
	2.63	3.87	2.14	6.01	35.68%
TW008	1.30	3.19	3.80	6.99	54.42%
	0.83	2.03	1.55	3.58	43.25%
	1.13	2.77	2.87	5.64	50.93%
	1.48	3.63	4.93	8.55	57.61%
	1.78	4.36	7.13	11.49	62.04%
TW012	0.98	6.32	9.32	15.64	59.58%
	0.73	4.71	5.17	9.88	52.33%
	0.95	6.13	8.75	14.88	58.83%
	1.20	7.74	13.97	21.71	64.34%
	1.43	9.22	19.84	29.06	68.26%

Table C-1.6 RESULTS OF PUMPING TEST ANALYSIS

Well No.	Transmissivity (m2/day) Jacob/TimeDD	Transmissivity (m2/day) Recovery Test
TW001	46.0	49.1
TW002	20.8	19.9
TW003	0.12	-
TW004	57.1	101.5
TW005	21.2	16.9
TW006	45.8	57.5
TW006A	53.6	54.5
TW008	-	51.38
TW009	0.04	0.10
TW010	0.11	0.09
TW011	0.95	0.52
TW012	6.7	6.6
GW035	138.3	98.8
GW254	(S1) 2672	2004
GW254	(S2) 829	-

FIGURES

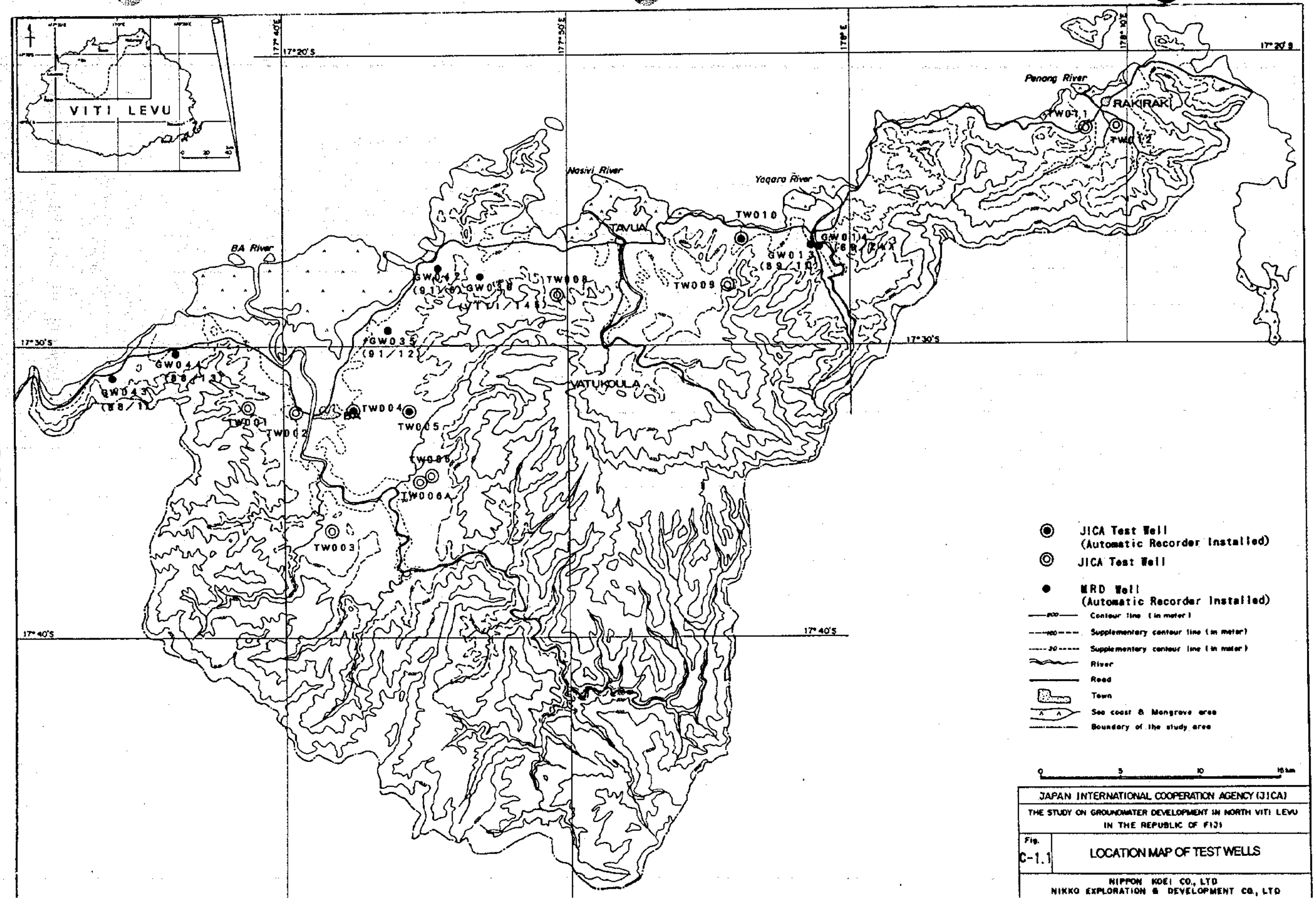

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Fig. C-1.1 LOCATION MAP OF TEST WELLS

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

DRILL-PROGRESS

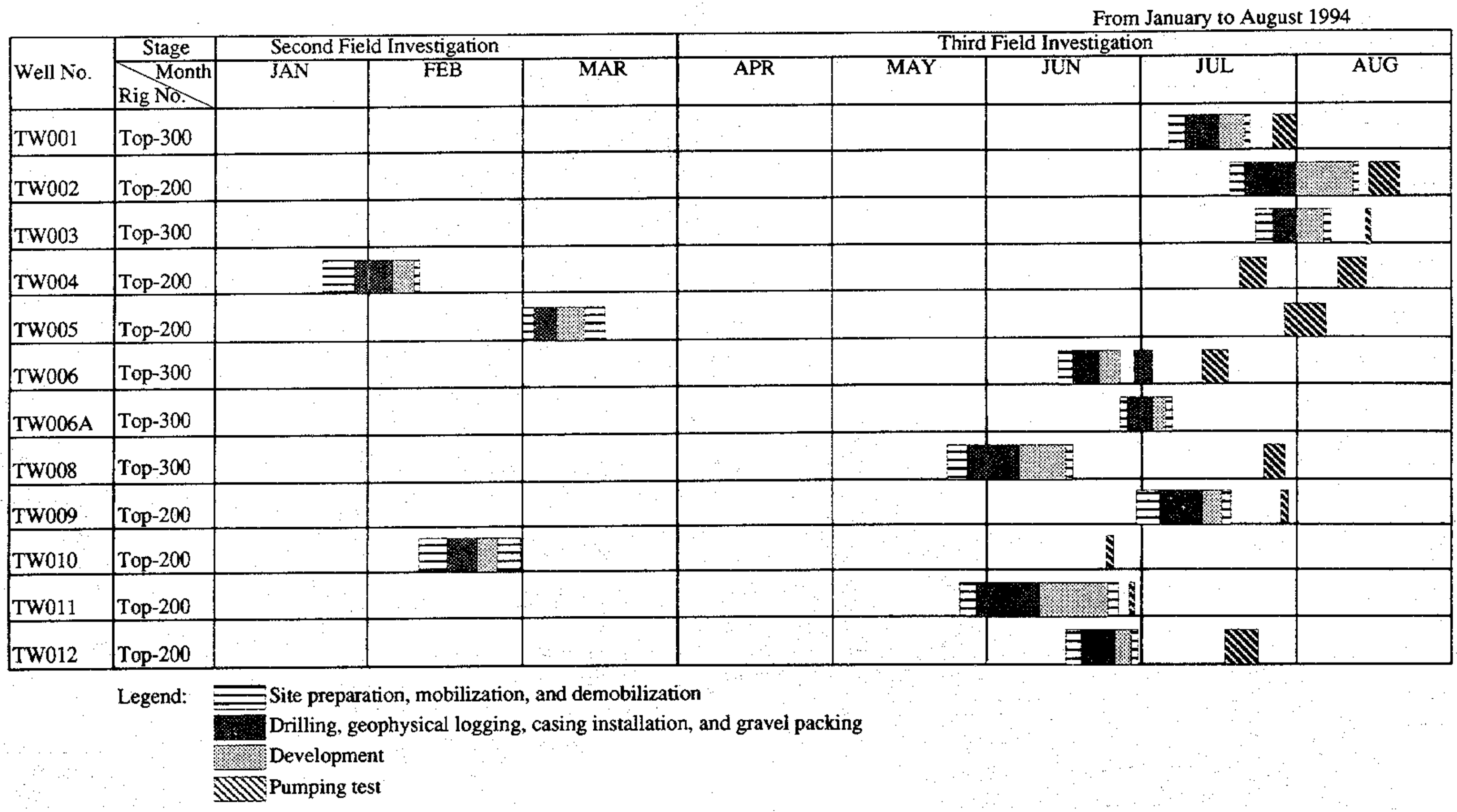

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Fig. C-1.2 DIAGRAM OF THE WELL DRILLING PROGRESS

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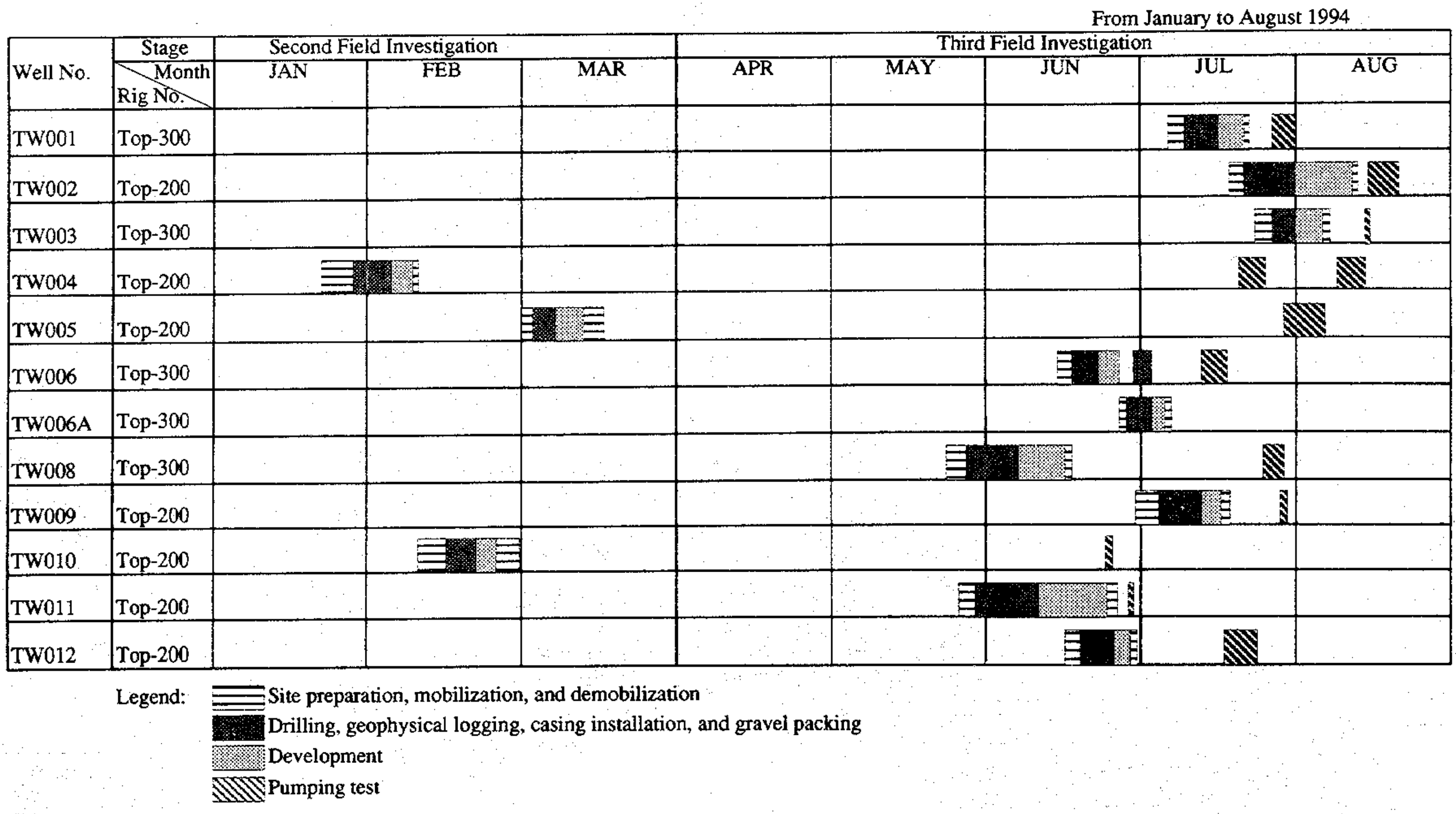
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

DRILL-PROGRESS



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THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1.2 DIAGRAM OF THE WELL DRILLING PROGRESS

NIPPON KOEI CO., LTD
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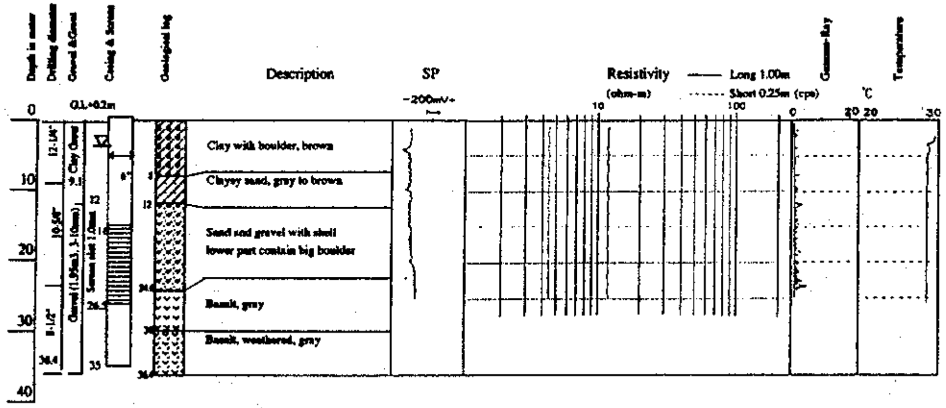
TW002 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

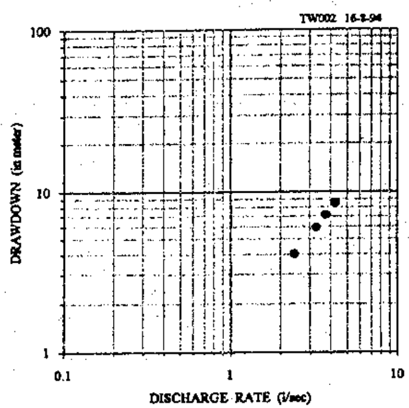
Date: 16/8/94

	Q (l/sec.)	Drawdown (m)
1	2.43	4.10
2	3.27	6.09
3	3.75	7.27
4	4.27	8.97

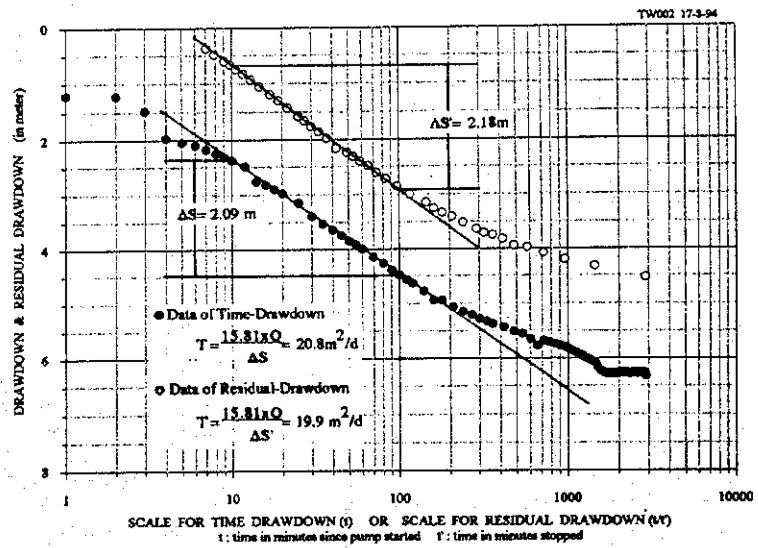
TIME DRAWDOWN TEST

Date:	17/8/94
Static water level:	3.27 m
Discharge rate (Q):	2.75 l/sec.
Drawdown:	10.45 m
Specific capacity:	0.26 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	18-7-94
Drilling finishes on:	25-7-94
Well completed:	12-8-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

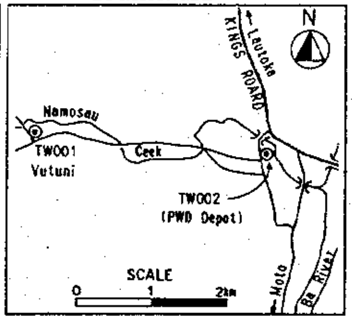
IN-SITU TEST

EC(MS/cm)	138	pH	7.11
Temperature	29.0 (℃)		

LABORATORY TEST Unit is mg/l

Na	8.0	K	1.3
Ca	9.6	Mg	5.1
Cl	6.0	SO4	23
HCO3	30.5	SiO2	28.0
NO2	0.02	NO3	1.00
Fe	0.42	Mn	0.20
NH4	0.20	TDS	75

LOCATION MAP



Well No.	TW002
Location:	Yalalevu
Coordinates:	1885560mE; 3940330mN
Elevation:	7.20m

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Fig. C-1. 3 COMPOSITE WELL LOG (2)

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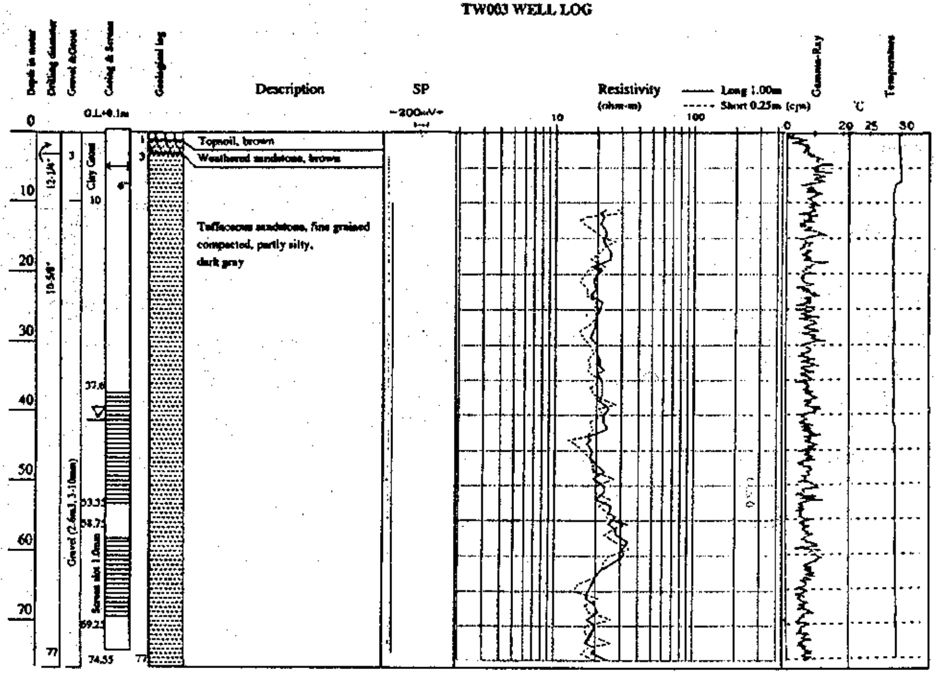
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW003 WELL LOG



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	22-7-94
Drilling finishes on:	28-7-94
Well completed:	6-8-94
Drilling rig:	Tone Top-300
Drilling method:	Direct Rotary
Driller:	Haga

WATER QUALITY

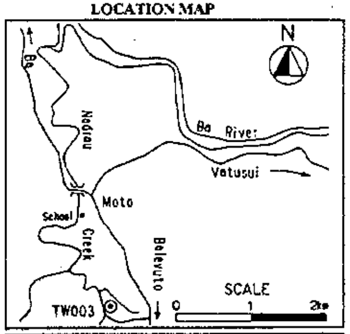
IN-SITU TEST

EC(MS/cm)	447	pH	9.08
Temperature	28.7	(°C)	

LABORATORY TEST Unit in mg/l

Na	14.0	K	2.1
Ca	27.2	Mg	14.6
Cl	65.0	SO4	15
HCO3	82.9	SiO2	10.6
NO2	2.09	NO3	1.00
Fe	1.4	Mn	0.1
NH4	0.06	TDS	300

LOCATION MAP



Well No. TW003

Location: Nukuloa

Coordinates: 1887600mE; 3932440mN

Elevation: 40m

PUMPING TEST

STEP DRAWDOWN TEST

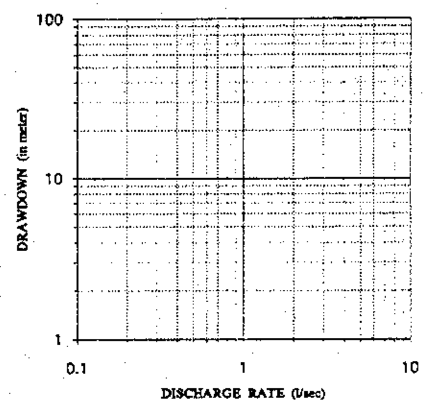
Date: No test

	Q (l/sec.)	Drawdown (m)
1		
2		
3		
4		

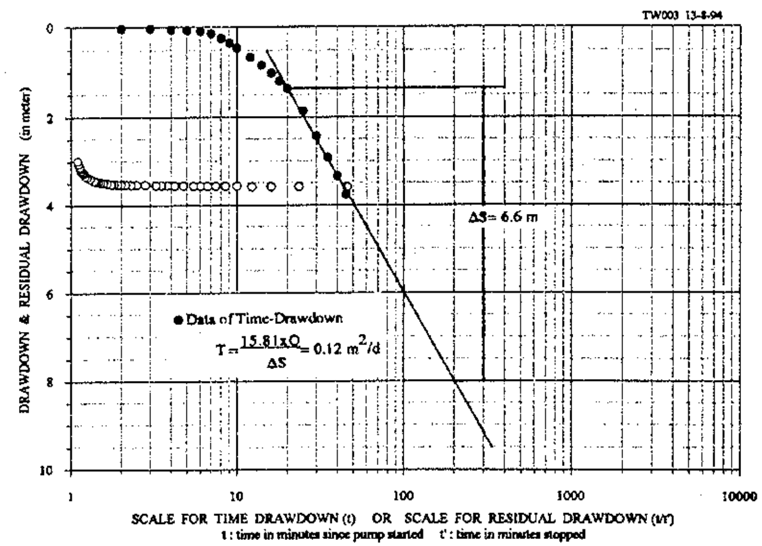
TIME DRAWDOWN TEST

Date:	13/8/94
Static water level:	41.19 m
Discharge rate (Q):	0.05 l/sec.
Drawdown:	3.76 m
Specific capacity:	0.01 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



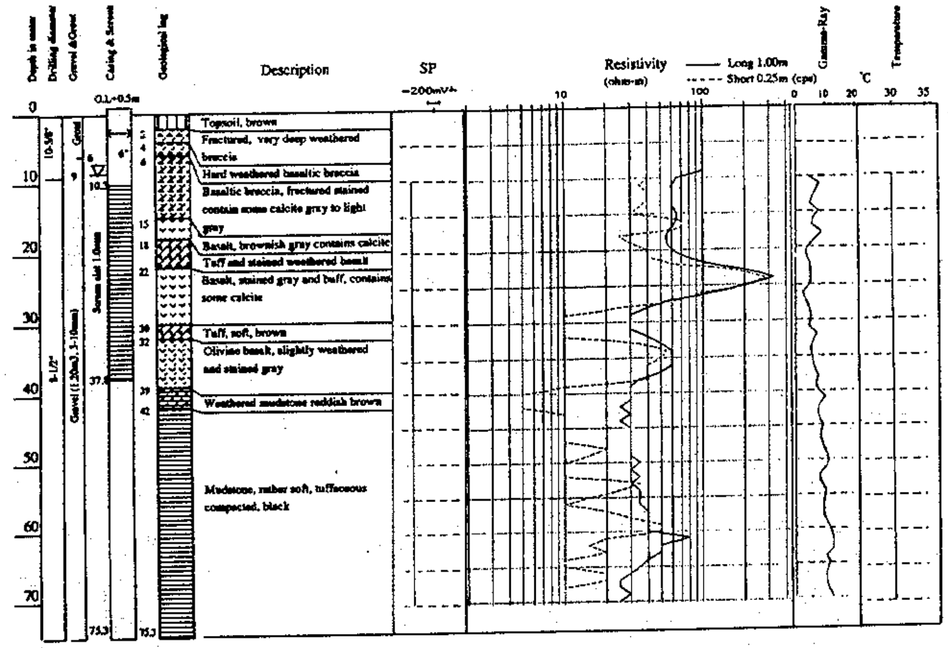
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C 1.3 COMPOSITE WELL LOG (3)

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW004 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

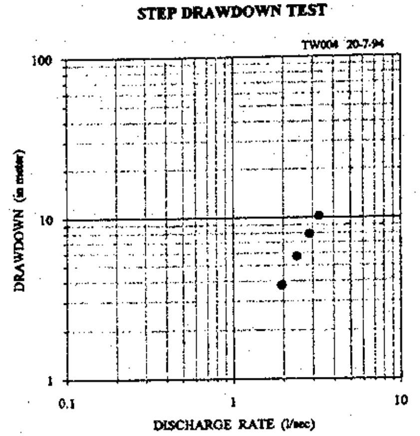
Date: 9/8/94

	Q (l/sec.)	Drawdown (m)
1	1.95	3.77
2	2.40	5.70
3	2.85	7.89
4	3.20	10.21

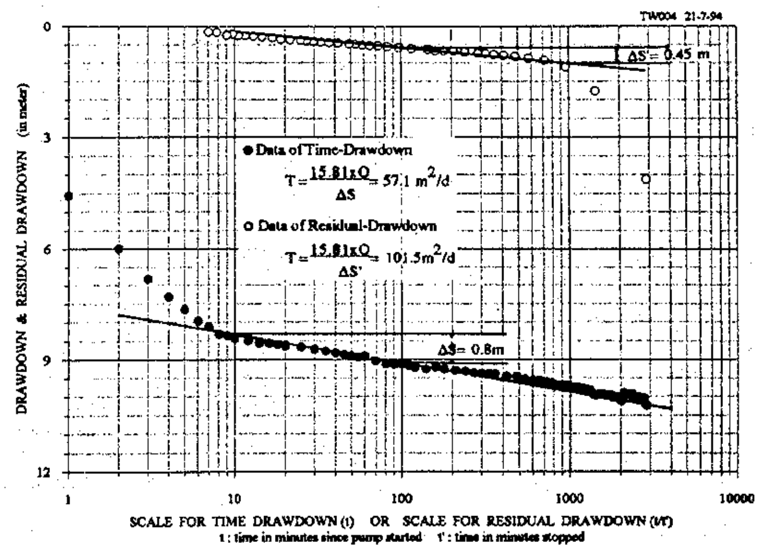
TIME DRAWDOWN TEST

Date:	10/8/94
Static water level:	8.12 m
Discharge rate (Q):	2.89 l/sec.
Drawdown:	10.25 m
Specific capacity:	0.28 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	28-1-94
Drilling finishes on:	4-2-94
Well completed:	10-2-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

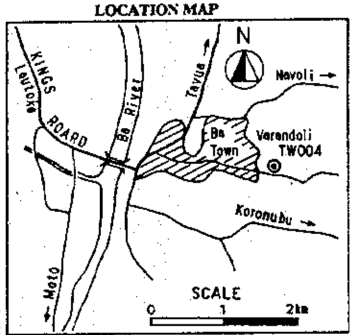
IN-SITU TEST

EC(MS/cm)	188	pH	6.68
Temperature	26.9	(°C)	

LABORATORY TEST Unit in mg/l

Na	10.0	K	1.8
Ca	16.0	Mg	6.1
Cl	6.0	SO4	49
HCO3	42.7	SiO2	46.0
NO2	0.06	NO3	2.00
Fe	0.2	Mn	<0.001
NH4	0.12	TDS	120

LOCATION MAP



Well No.	TW004
Location:	Varandoli
Coordinates:	1888700mE; 3940050mN
Elevation:	17.76m

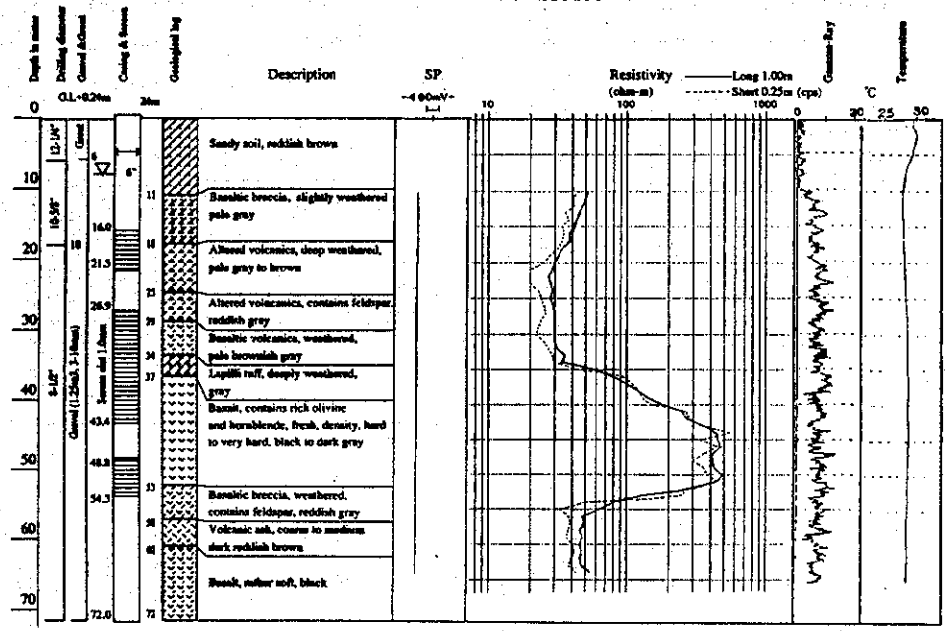
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

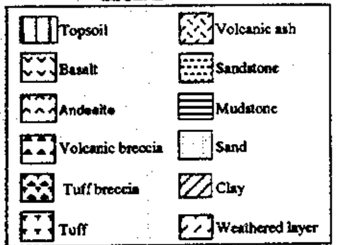
Fig. C-1.3 COMPOSITE WELL LOG (4)

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW005 WELL LOG



LEGEND



Drilling starts on:	2-3-94
Drilling finishes on:	7-3-94
Well completed:	15-3-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

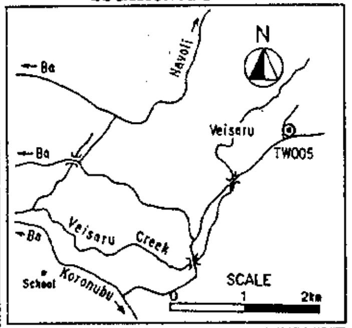
IN-SITU TEST

EC(MS/cm)	54	pH	5.88
Temperature	26.1	(°C)	

LABORATORY TEST Unit in mg/l

Na	4.0	K	0.9
Ca	2.4	Mg	2.9
Cl	6.0	SO4	17
HCO3	6.1	SiO2	4.9
NO2	0.51	NO3	3.00
Fe	0.5	Mn	0.25
NH4	0.50	TDS	78

LOCATION MAP



Well No.	TW005
Location:	Veisaru
Coordinates:	1892800mE; 3940500mN
Elevation:	40.92m

PUMPING TEST

STEP DRAWDOWN TEST

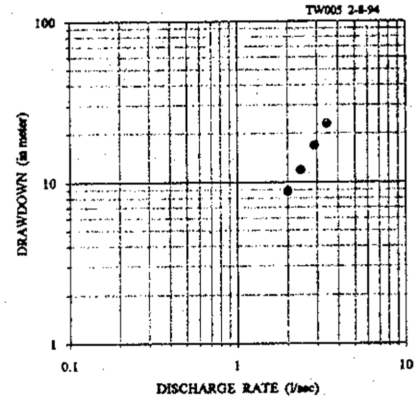
Date: 2/8/94

	Q (l/sec.)	Drawdown (m)
1	2.01	8.53
2	2.38	12.05
3	2.89	16.97
4	3.43	29.87

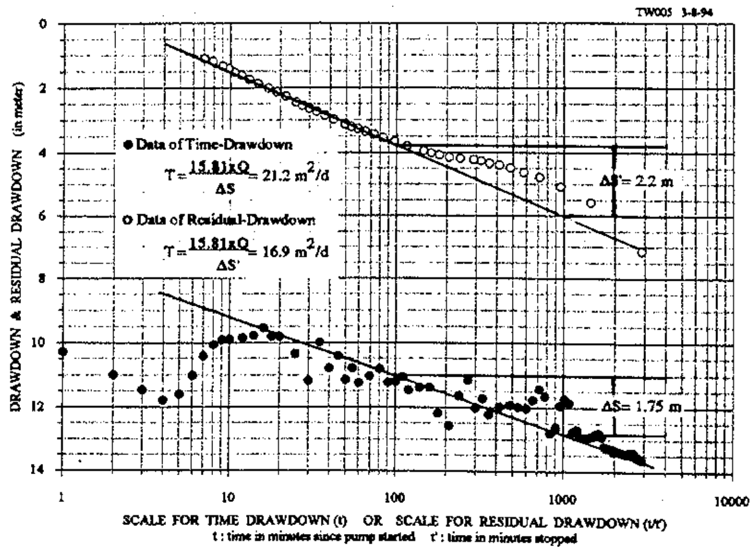
TIME DRAWDOWN TEST

Date:	3/8/94
Static water level:	9.81 m
Discharge rate (Q):	2.35 l/sec.
Drawdown:	13.64 m
Specific capacity:	0.17 l/s/m

STEP DRAWDOWN TEST

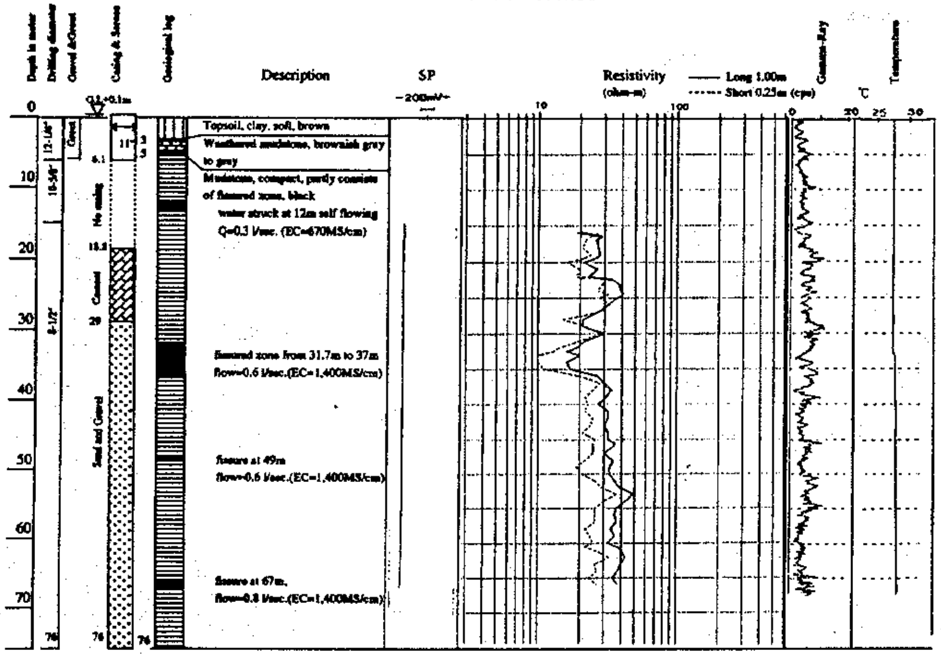


TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	
THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI	
Fig. C-1. 3	COMPOSITE WELL LOG (5)
NIPPON KOEI CO., LTD NIKKO EXPLORATION & DEVELOPMENT CO., LTD	

TW006 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

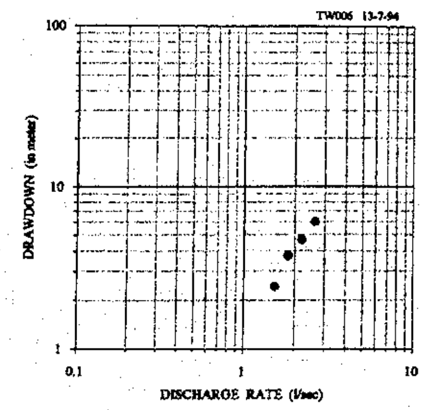
Date: 13/7/94

	Q (l/sec.)	Drawdown (m)
1	1.53	2.42
2	1.83	3.75
3	2.20	4.69
4	2.63	6.03

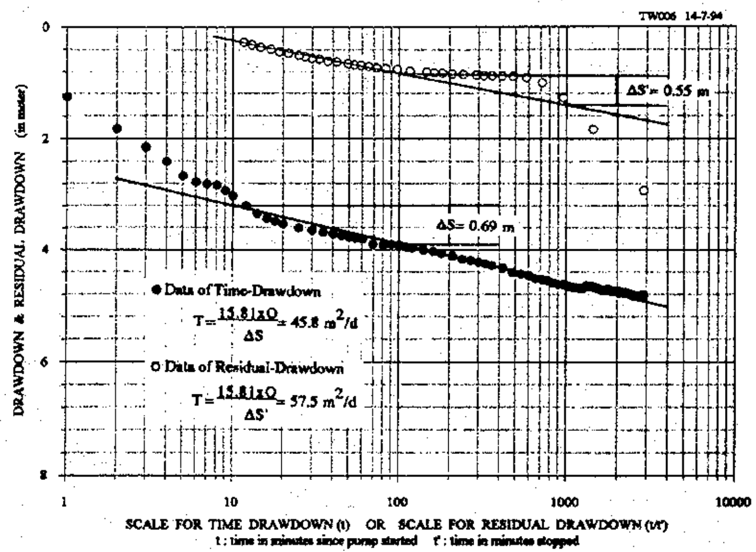
TIME DRAWDOWN TEST

Date:	14/7/94
Static water level:	+0.26 m
Discharge rate (Q):	2.00 l/sec.
Drawdown:	4.81 m
Specific capacity:	0.42 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	14-6-94
Drilling finishes on:	21-6-94
Well completed:	2-7-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

IN-SITU TEST

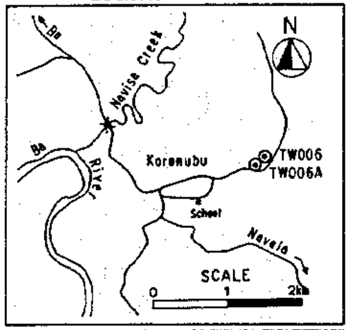
EC(MS/cm)	590	pH	7.8
Temperature	26.7	(℃)	

LABORATORY TEST Unit is mg/l

Na	35.5	K	2.1
Ca	46.0	Mg	13.4
Cl	53.0	SO4	91
HCO3	112.2	SiO2	49.4
NO2	<0.01	NO3	<0.01
Fe	0.03	Mn	<0.001
NH4	<0.02	TDS	380

*Depth of sampling between 6 and 18.8m

LOCATION MAP



Well No.	TW006
Location:	Koronubu
Coordinates:	1894400mE; 3935380mN
Elevation:	35m

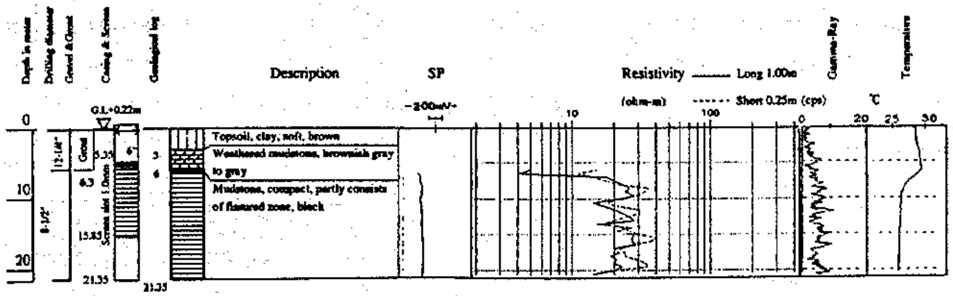
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C 1.3 **COMPOSITE WELL LOG (6)**

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW006A WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

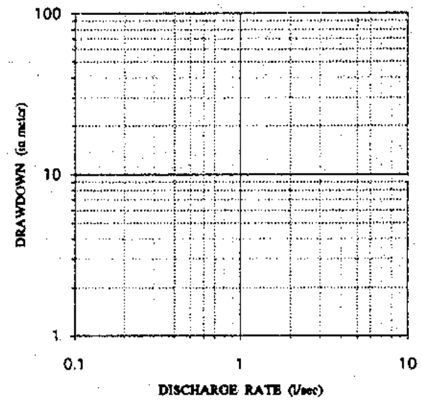
Date: No test

	Q (l/sec.)	Drawdown (m)
1		
2		
3		
4		

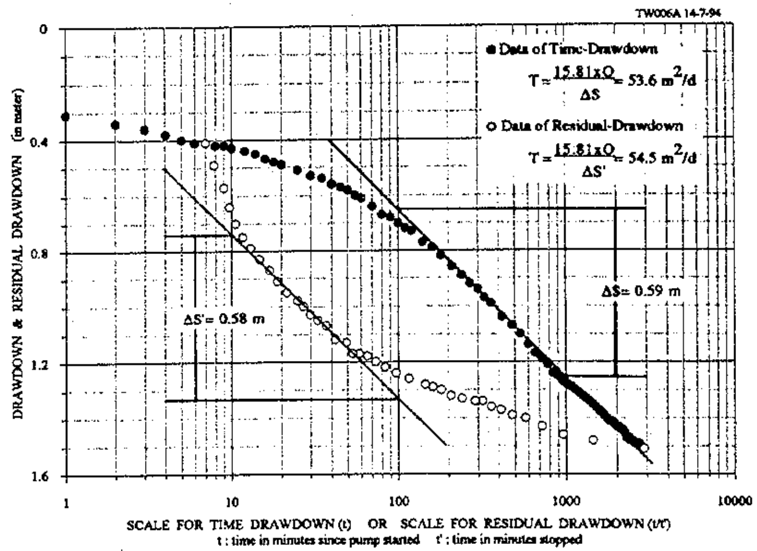
TIME DRAWDOWN TEST

Date:	14/7/94
Static water level:	+0.26 m
Discharge rate (Q):	(2.00) l/sec.
Drawdown:	(1.51) m
Specific capacity:	- l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	27-6-94
Drilling finishes on:	28-6-94
Well completed:	5-7-94
Drilling rig:	Tone Top-300
Drilling method:	Direct Rotary
Driller:	Haga

WATER QUALITY

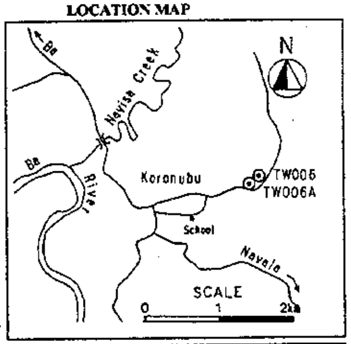
IN-SITU TEST

EC(MS/cm)	784	pH	7.87
Temperature	27.6	(°C)	

LABORATORY TEST Unit in mg/l

Na	74.0	K	2.3
Ca	56.5	Mg	7.0
Cl	110.0	SO4	90
HCO3	110.9	SiO2	42.8
NO2	0.13	NO3	2.46
Fe	0.02	Mn	<0.001
NH4	1.02	TDS	490

LOCATION MAP



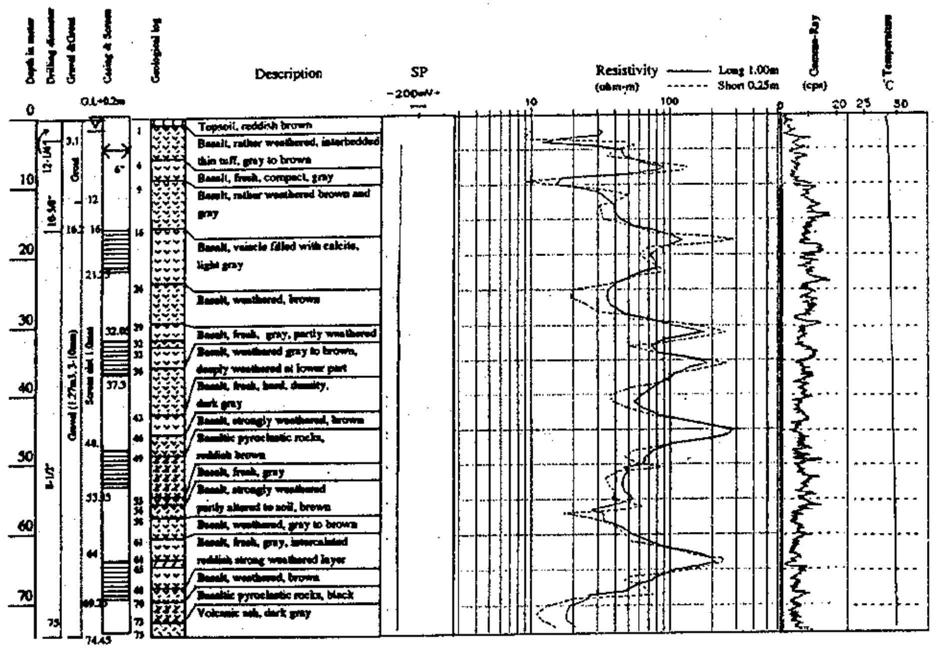
Well No.	TW006A
Location:	Koronubu
Coordinates:	1894400mE; 3935380mN
Elevation:	35m

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C 1.3 COMPOSITE WELL LOG (7)

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW008 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

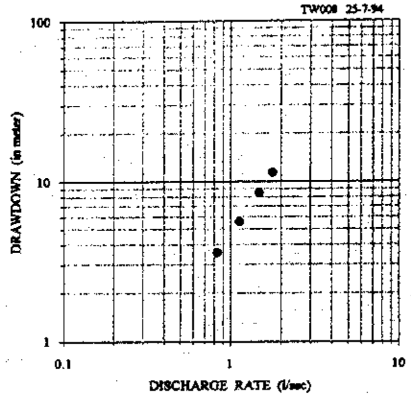
Date: 25/7/94

	Q (l/sec.)	Drawdown (m)
1	0.83	3.56
2	1.13	5.57
3	1.48	8.48
4	1.78	11.42

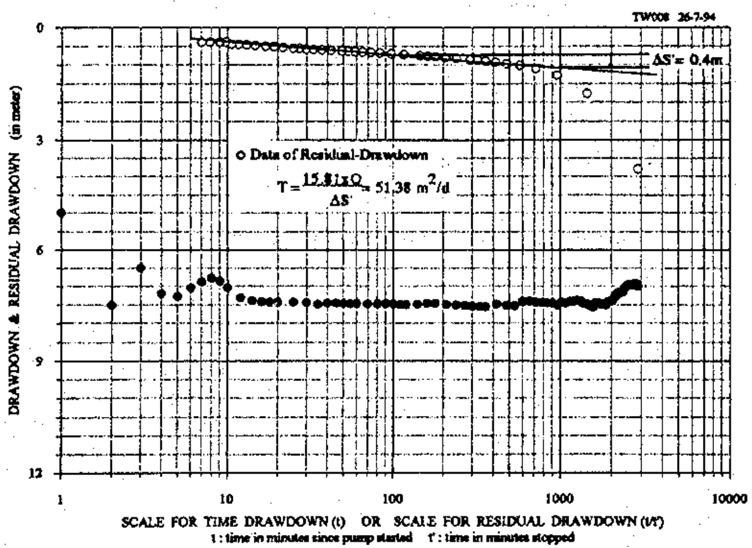
TIME DRAWDOWN TEST

Date:	26/7/94
Static water level:	0.92 m
Discharge rate (Q):	1.30 l/sec.
Drawdown:	7.00 m
Specific capacity:	0.19 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	23-5-94
Drilling finishes on:	1-6-94
Well completed:	16-6-94
Drilling rig:	Tone Top-300
Drilling method:	Direct Rotary
Driller:	Haga

WATER QUALITY

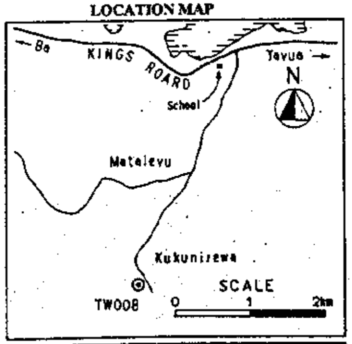
IN-SITU TEST

EC(MS/cm)	320	pH	7.03
Temperature	27.7	(°C)	

LABORATORY TEST Unit in mg/l

Na	4.6	K	0.7
Ca	66.1	Mg	26.7
Cl	7.0	SO4	97
HCO3	203.6	SiO2	77.6
NO2	<0.01	NO3	2.00
Fe	0.29	Mn	<0.001
NH4	<0.01	TDS	220

LOCATION MAP

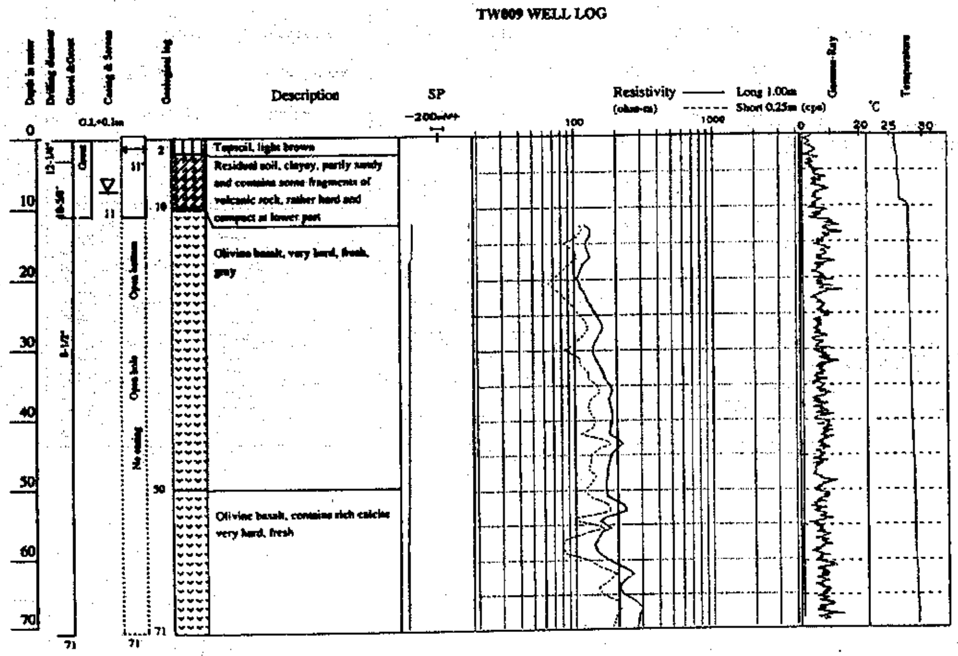


Well No.	TW008
Location:	Kukunirewa
Coordinates:	1901780mE, 3947660mN
Elevation:	60m

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1. 3 **COMPOSITE WELL LOG (8)**

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD



PUMPING TEST

STEP DRAWDOWN TEST

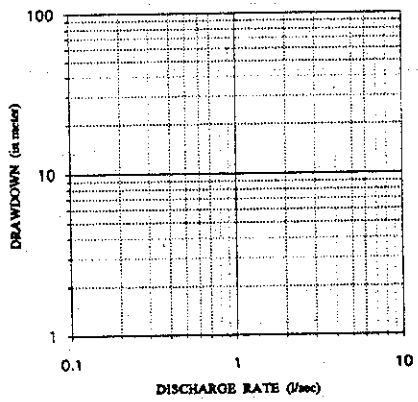
Date: No test

	Q (l/sec.)	Drawdown (m)
1		
2		
3		
4		

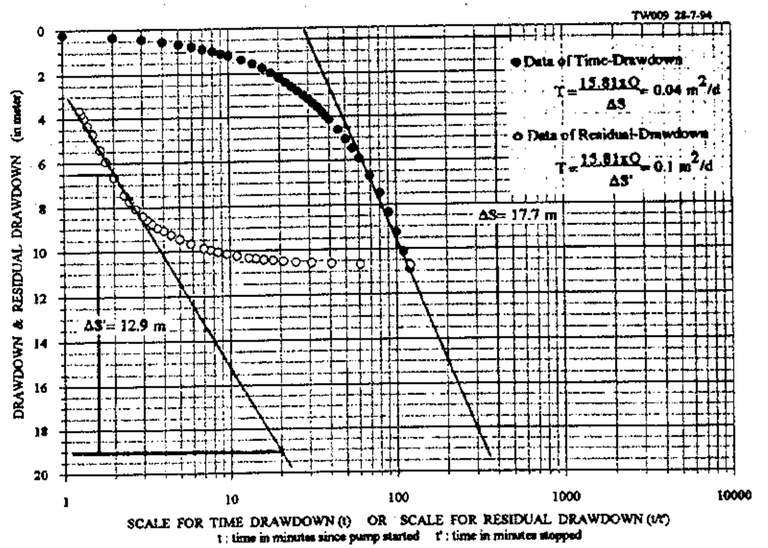
TIME DRAWDOWN TEST

Date:	28/7/94
Static water level:	7.52 m
Discharge rate (Q):	0.08 l/sec.
Drawdown:	10.91 m
Specific capacity:	0.01 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	30-6-94
Drilling finishes on:	11-7-94
Well completed:	16-7-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

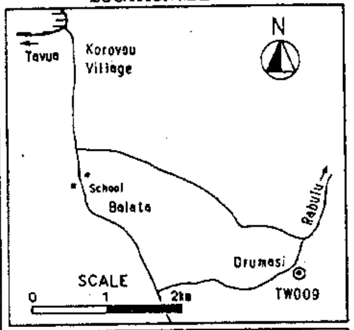
IN-SITU TEST

EC(MS/cm)	548	pH	7.12
Temperature	29.6	(°C)	

LABORATORY TEST Unit in mg/l

Na	43.0	K	3.7
Ca	54.5	Mg	10.4
Cl	70.0	SO4	100
HCO3	123.1	SiO2	33.4
NO2	1.04	NO3	1.43
Fe	0.35	Mn	0.11
NH4	2.45	TDS	320

LOCATION MAP



Well No.	TW009
Location:	Drumasi
Coordinates:	1911800mE; 3947560mN
Elevation:	60m

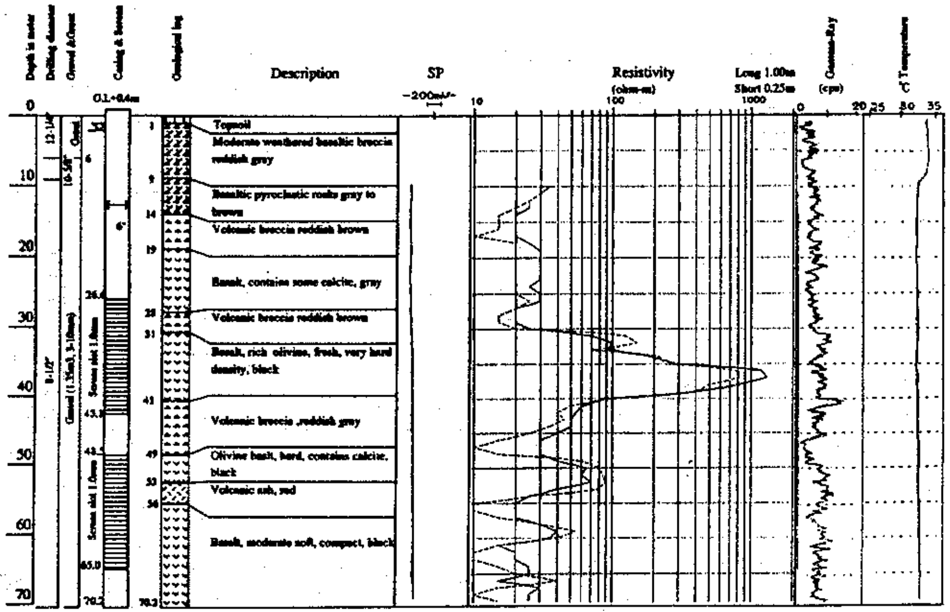
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1.3 COMPOSITE WELL LOG (9)

NIPPON KOEI CO., LTD
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

TW010 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

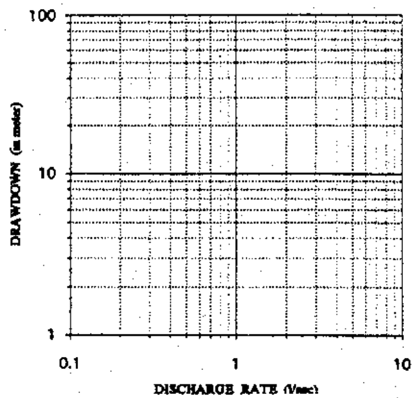
Date: No test

	Q (l/sec.)	Drawdown (m)
1		
2		
3		
4		

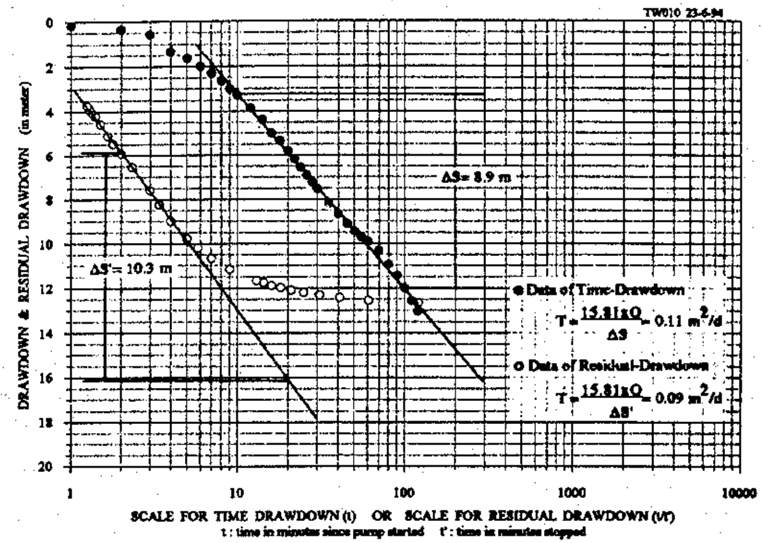
TIME DRAWDOWN TEST

Date:	23/6/94
Static water level:	1.07 m
Discharge rate (Q):	0.06 l/sec.
Drawdown:	13.04 m
Specific capacity:	0.005 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

- Topsoil
- Basalt
- Andesite
- Volcanic breccia
- Tuff breccia
- Tuff
- Volcanic ash
- Sandstone
- Mudstone
- Sand
- Clay
- Weathered layer

Drilling starts on:	16-2-94
Drilling finishes on:	21-2-94
Well completed:	28-2-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

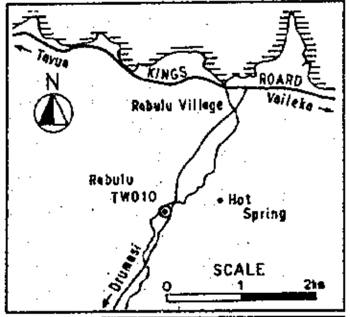
IN-SITU TEST

EC(MS/cm)	320	pH	8.41
Temperature	30.0	(°C)	

LABORATORY TEST Unit in mg/l

Na	7.0	K	0.8
Ca	30.8	Mg	10.2
Cl	9.5	SO4	66
HCO3	81.7	SiO2	52.1
NO2	<0.01	NO3	<0.01
Fe	0.17	Mn	<0.001
NH4	0.80	TDS	200

LOCATION MAP



Well No.	TW010
Location:	Rambuhu
Coordinates:	1913050mE; 3950250mN
Elevation:	20m

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1.3 COMPOSITE WELL LOG (10)

NIPPON KOEI CO., LTD
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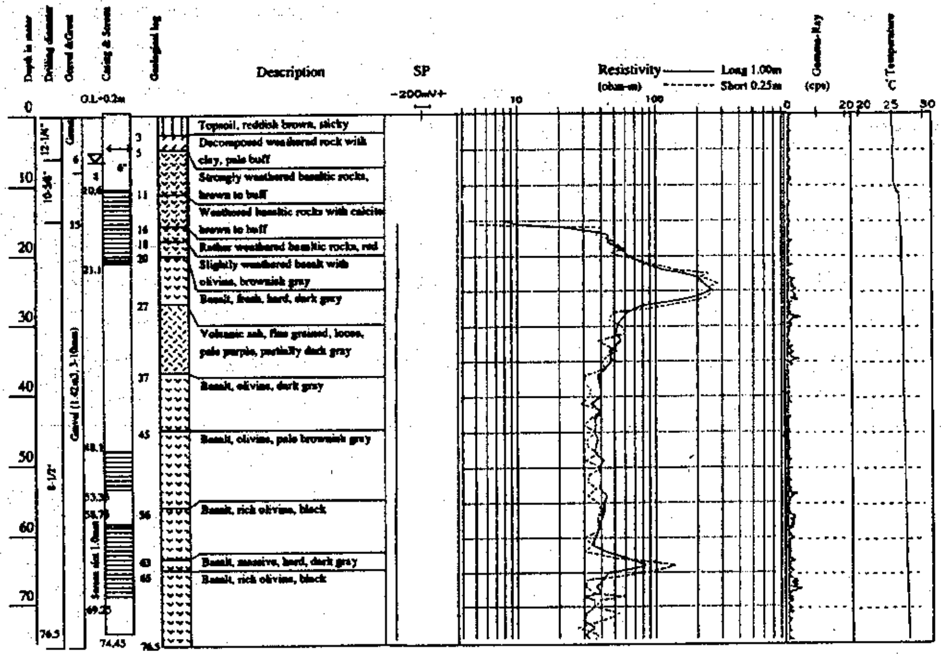
TW011 WELL LOG



PUMPING TEST

STEP DRAWDOWN TEST

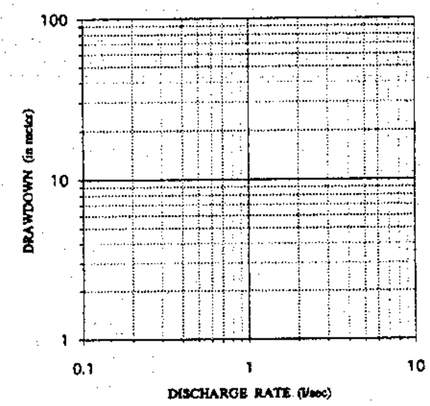
Date: No test

	Q (l/sec.)	Drawdown (m)
1		
2		
3		
4		

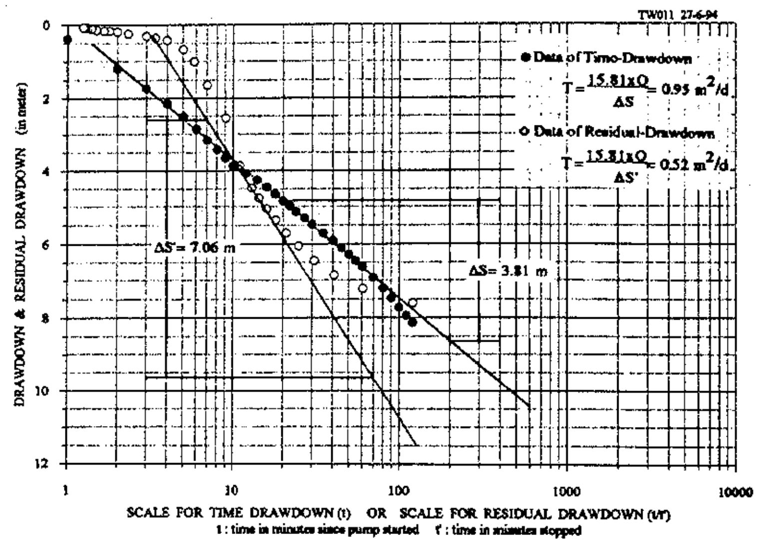
TIME DRAWDOWN TEST

Date:	27/6/94
Static water level:	6.79 m
Discharge rate (Q):	0.23 l/sec.
Drawdown:	8.15 m
Specific capacity:	0.03 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	25-5-94
Drilling finishes on:	8-6-94
Well completed:	24-6-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

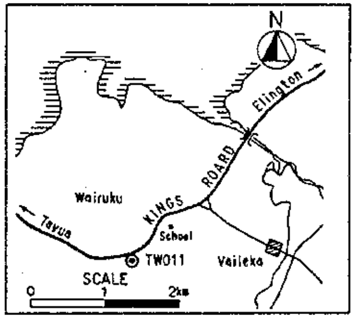
IN-SITU TEST

EC(MS/cm)	148	pH	7.09
Temperature	28.4	(°C)	

LABORATORY TEST Unit in mg/l

Na	7.0	K	0.2
Ca	28.0	Mg	17.0
Cl	10.0	SO4	108
HCO3	61.0	SiO2	68.6
NO2	0.02	NO3	1.50
Fe	0.14	Mn	<0.001
NH4	2.80	TDS	160

LOCATION MAP



Well No.	TW011
Location:	Wairuku
Coordinates:	1934620mE; 3957840mN
Elevation:	15m

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THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1.3 COMPOSITE WELL LOG (11)

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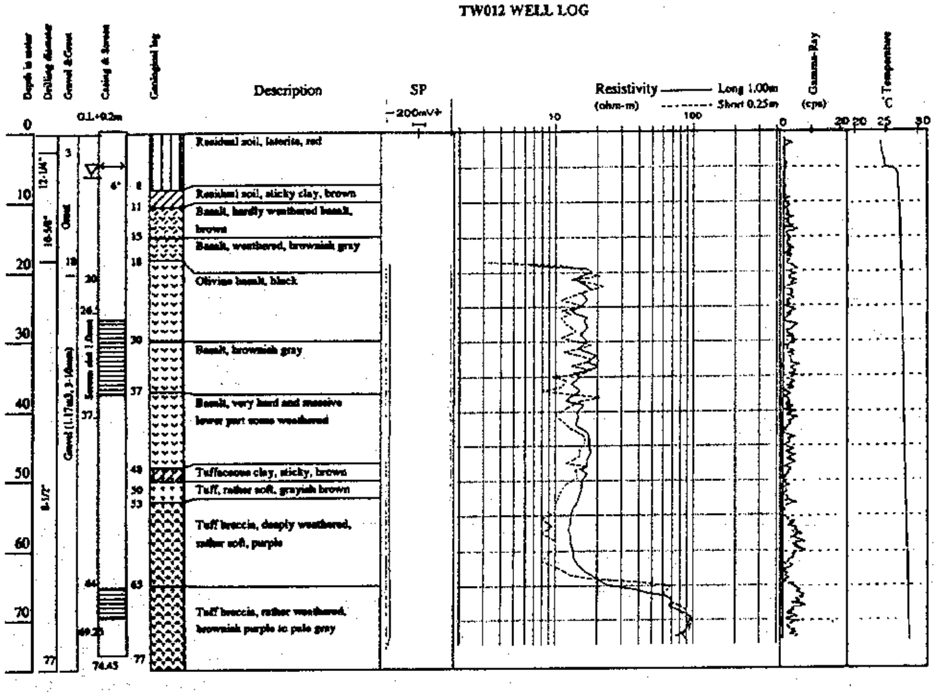


LEGEND

Topsoil	Volcanic ash
Basalt	Sandstone
Andesite	Mudstone
Volcanic breccia	Sand
Tuff breccia	Clay
Tuff	Weathered layer

Drilling starts on:	16-6-94
Drilling finishes on:	23-6-94
Well completed:	30-6-94
Drilling rig:	Tone Top-200
Drilling method:	Direct Rotary
Driller:	Kumano

WATER QUALITY

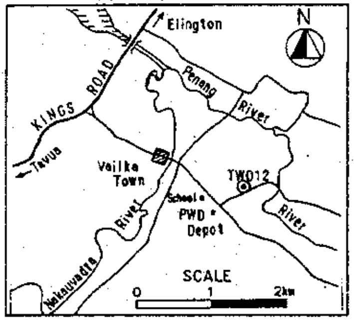
IN-SITU TEST

EC(MS/cm)	220	pH	8.03
Temperature	28.5	(°C)	

LABORATORY TEST Unit in mg/l

Na	8.5	K	0.3
Ca	21.6	Mg	5.6
Cl	11.0	SO4	30
HCO3	71.9	SiO2	21.6
NO2	<0.01	NO3	<0.01
Fe	0.03	Mn	<0.001
NH4	<0.01	TDS	160

LOCATION MAP



Well No.	TW012
Location:	Vaileka
Coordinates:	1937740mE; 3957480mN
Elevation:	20m

PUMPING TEST

STEP DRAWDOWN TEST

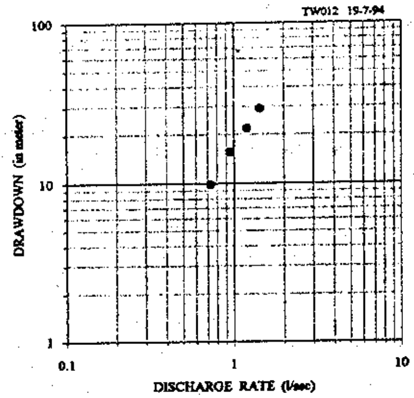
Date: 19/7/94

	Q (l/sec.)	Drawdown (m)
1	0.73	9.82
2	0.95	15.62
3	1.20	21.88
4	1.43	29.01

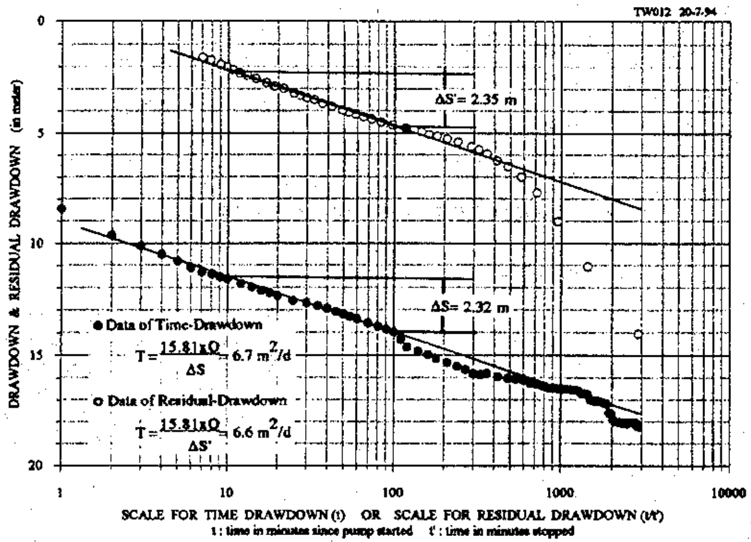
TIME DRAWDOWN TEST

Date:	20/7/94
Static water level:	5.68 m
Discharge rate (Q):	0.98 l/sec.
Drawdown:	18.23 m
Specific capacity:	0.05 l/s/m

STEP DRAWDOWN TEST



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



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THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-1.3 COMPOSITE WELL LOG (12)

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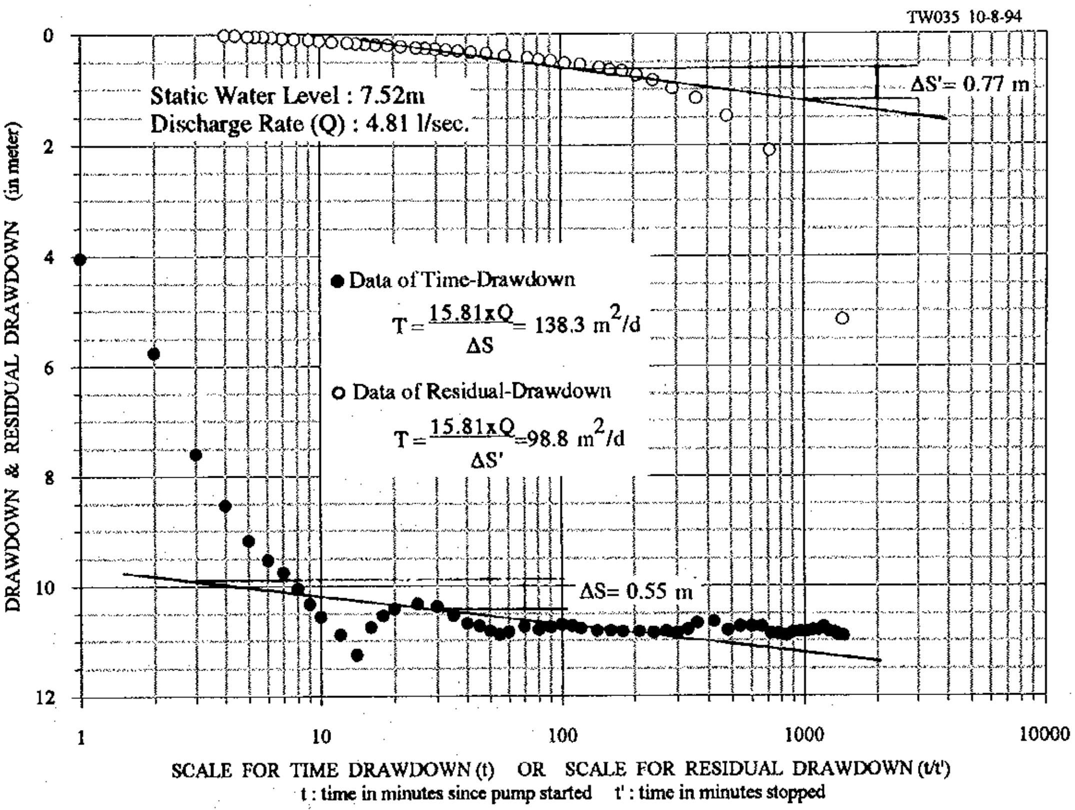
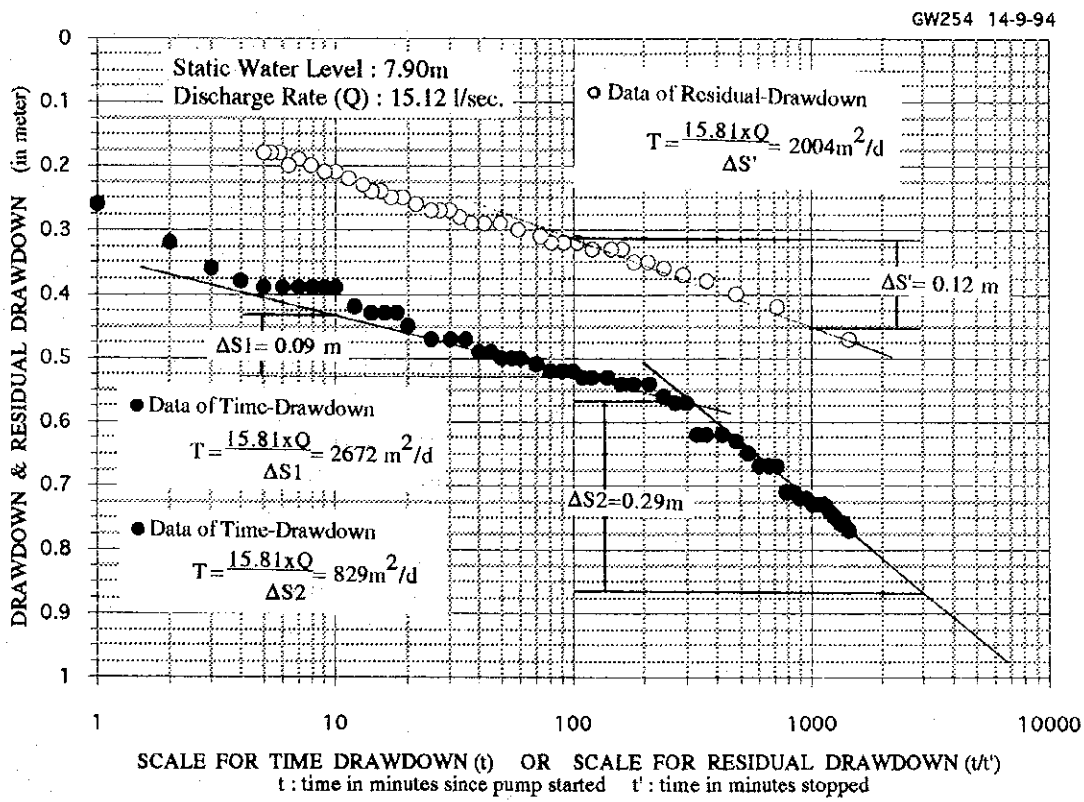
TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



TIME DRAWDOWN GRAPH & RESIDUAL DRAWDOWN GRAPH



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-3.1	**RESULTS OF THE PUMPING TEST ON MRD WELLS**

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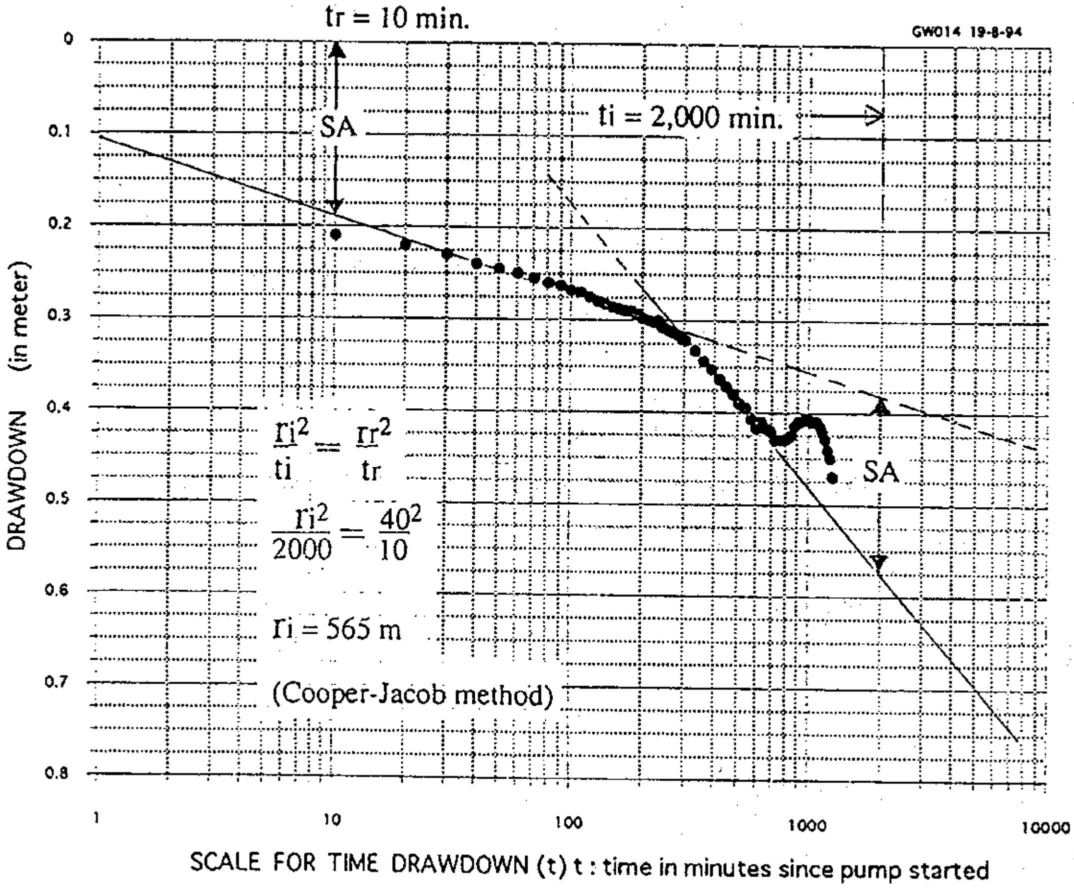
TIME DRAWDOWN GRAPH



Note: rr= Between the pumping well and the observation well
ri= Between the observation well and image pumping well
SA= Arbitrary drawdown
tr= Selected time to SA
ti= Same drawdown to produced by the image well

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE STUDY ON GROUNDWATER DEVELOPMENT IN NORTH VITI LEVU IN THE REPUBLIC OF FIJI

Fig. C-3. 2 DRAWDOWN CURVE OF THE OBSERVATION WELL (GW014) AT YAQARA

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APPENDIX - D

WATER SUPPLY SYSTEM AND WATER USE

APPENDIX - D

WATER SUPPLY SYSTEM AND WATER USE

TABLE OF CONTENTS

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1. INTRODUCTION

This Appendix presents the condition of the existing water supply and its use in the Study Area obtained through the field reconnaissance. The objectives of the survey are to grasp the existing water supply conditions in the Study Area and identify the areas facing water shortage.

The reconnaissance consists of mainly the interview survey in the respective offices concerned and the questionnaire survey. The existing water supply facilities were also visited to confirm the present operation modes. The results of the surveys constitute the basic data to formulate and evaluate the Study.

PWD is the agency responsible for water supply. Planning and design of the water supply facilities has been conducted in the Head Office of PWD in Suva. Construction and maintenance of the water supply facilities in the Study Area have been conducted by the Western Divisional Office of PWD in Lautoka.

With regard to the water supply plan in the Study Area, various efforts have been emphasized by PWD. Among them, the under-listed documents roughly present the latest water supply plan, including the future water demand forecast:

- Ba Regional Water Supply Distribution Study, James Flugan, Peace Corp volunteer, January 1985 (hereinafter referred to as the "Ba Report")
- Tavua-Vatukoula Regional Water Supply Study, Harrison Grierson Consultants Ltd., May 1985 (hereinafter referred to as the "Tavua/Vatukoula Report")
- Draft Rakiraki Water Supply Master Plan, Fred de Brujin, September 1985 (hereinafter referred to as the "Rakiraki Report")

These documents describe the condition of the water supply up to the present and the recommendations for the extension of the water supply systems. The extension has been conducted following the recommended plan. The Rakiraki Report is still at the draft level, and it does not seem likely that the report will be finalized.

Other than these three reports, the following pamphlet was prepared by PWD:

- Tavua / Vatukoula Regional Water Supply Scheme, PWD, November 1989 (hereinafter referred to as the "Tavua/Vatukoula Pamphlet")

The pamphlet sets forth the background, general description and engineering details, and system statistics of the scheme.

For the selection of communities for the questionnaire survey, the following report was referred to:

- Assessment of Drought Problems in Fiji, Final Report, Ministry of Fijian Affairs and Regional Development and United Nation Department of Humanitarian Affairs - South Pacific Office, April 1993 (hereinafter referred to as "Drought Assessment Report")

The report describes drought hazards and vulnerability, the emergency water supply in periods of drought, mitigation of future droughts, and recommendations for the whole of Fiji, based on the existing information in combination with the field visits and interviews carried out in November 1992. However the existing data are limited and scarce, and the statistical data referred to in the report are only data for 1992, although droughts were recently experienced in 1983, 1987, and 1992.

The regional water supply conditions and drought problems have also been grasped, in cooperation with the under-listed government personnel concerned.

- Mr. R.S. Shandil	Principal Engineer, Water (Planning and Design), PWD Suva
- Mr. John Tavo	Senior Engineer, Water PWD Suva
- Mr. Shandra Nand	Technical Officer High Grade, PWD Suva
- Mr. Ajay Prasad Gautam	Supervisor, Water Engineer, PWD Western Division Lautoka Office
- Mr. Kushal Naidu	Water Supervisor, PWD Tavua District Office

The questionnaire survey owed much, especially to the following personnel, as much as three interviewers.

- Mr. Chandra Pal	Supervisor High Grade, PWD Western Division Lautoka Office

2. EXISTING WATER SUPPLY SYSTEM

2.1 Water Supply Administration

The Study Area is broadly divided into three districts in view of the water supply system, consisting of Ba, Tavua, and Rakiraki. PWD, the agency responsible for water supply, has branch offices in each district. Ba district embraces three Tikinas (Ba, Vuda in part, and Magodro in part) including Ba town, and Tavua district includes two Tikinas (Tavua and Navosa in part) including Tavua and Vatukoula towns. Rakiraki district consists of Rakiraki and Saivou Tikinas including Rakiraki (Vaileka) town.

PWD has three piped water supply systems in the Study Area. The water supply covers a large area with the towns as the water demand centers. Since the systems have spread outside the outskirts of the town areas, they have effectively become regional water supply systems rather than urban water supply systems. The following three systems are under the jurisdiction of PWD as follows:

- Ba regional water supply system,
- Tavua / Vatukoula regional water supply system, and
- Rakiraki regional water supply system.

In consideration of the PWD water supply systems, the Study Area is classified into the following two areas:

Service Area : the area served at present and /or to be served in future with piped water by these three regional systems.

Non-service Area : The area without the piped water supply of the regional water supply systems at present and / or in future, except the Service Area.

In addition to the regional water supply systems, some communities have established their own piped water supply systems, so called communal water supply systems. Where water supply facilities, including boreholes, are privately constructed, the government subsidizes the construction cost by up to F$1,000 as an upper limit. There are a large number of boreholes constructed with the subsidy (Borehole Subsidy Scheme).

Other than the regional and communal water supply systems, there are two piped water systems. One is the system owned by FSC (FSC system) in Ba and Rakiraki and the another is owned by a private company, M. R. Dayal in Ba (Dayal system).

In the Non-service area, dug wells, tube wells, rainwater stored in roof tanks and river / creek water are the main sources of supply. In the dry season, many communities, even in the Service Area, face water shortage problems and emergency water is supplied.

The service areas of the existing and future extensions of the water supply systems are shown in Fig. D-2.1. Each water supply system and the supply modes described above are explained in the succeeding sections.

2.2 Regional Water Supply Systems

In this section, the outlines of the three existing regional water supply systems and their existing condition are briefly explained. The information mainly referred to was the existing study reports on each regional system as described in Chapter 1. Field reconnaissance was also conducted, to confirm the information, with the PWD staff in the Western Division, who are responsible for the operation and maintenance (O&M) of the water supply systems.

The Ba regional system has been augmented following the recommendation plan outlined in the Ba report. The new findings which were obtained through the field reconnaissance were also included in this section.

As regards the Tavua / Vatukoula regional water supply system, the scheme has been modified from the original plan set forth in the Tavua / Vatukoula report. The present condition of the system, therefore, was referred to in the Tavua / Vatukoula Pamphlet.

The Rakiraki report is at the draft level, but the augmentation plan has been undertaken in part according to the recommendations outlined in the report. PWD has the extension plans of the system, however, there are not documented yet.

2.2.1 Ba Regional Water Supply System

The potable water for this system is derived from three surface water sources and four groundwater sources. The surface water is conveyed to Waiwai water treatment plant through raw water mains, then it is treated. The water is stored in several service reservoirs and then distributed. The groundwater is pumped up to a service reservoir located in the vicinity of each borehole and delivered to house connections without being treated.

(1) Source of supply

(a) Surface water sources

The raw water system, surface water sources, consists of gravity and pumping systems. There are two gravity intakes on the upper Varaciva and Nawetavuni rivers and a pumping intake is located on the lower Varaciva river. The raw water abstracted at the three intakes is conveyed to the Waiwai water treatment plant. Their locations and salient features are shown in Fig. D-2.2 and Table D-2.1, respectively.

The total average flow into the treatment plant is 556 m^3/hr, (= 13,344 m^3/day), and the safe yield in periods of drought over a 15 year return period is estimated at 342 m^3/hr (= 8,200 m^3/day) in the Ba Report. However, the effective safe yield flowing into the treatment plant is 80 l/s (= 6,910 m^3/day = 288 m^3/hr) since the raw water mains of the gravity systems join on the way to the treatment plant, the intakes of the two gravity sources are built with a difference in elevation of 5 m, and only one gravity intake functions at any given time.

It is stated in the Ba Report that the yields from the catchments have been drastically reduced since the early 1970s when pine plantation was begun in the catchments. The reduction is assumed as 40% below the original yields, thus the original safe yield was estimated at 133 l/s (=80 / 1-0.4 = 11,500 m^3/day).

At the lower Varaciva pump station, the following pumps are operated for delivering the raw water to the treatment plant.

Type	Purpose	Capacity (l/s)
Flygt B2201-11	duty	60
Flygt B2201-11	standby	60
Flygt B2400-402	duty	100

The possibility of development of two surface sources has been suggested in the Ba Report. One is the Nadrou river, adjacent to the Varaciva catchment in the south and another is the Ba main river. The safe yields were estimated at 53 l/s (= 4,580

m^3/day) with a catchment area of 40 km^2 for the Nadrou river and 2.6 m^3/sec (= 22,400 m^3/day) for the Ba river. However, these plans are at the conceptual level and no detailed plan has been established.

(b) Groundwater sources

Four boreholes, Varavu, Navoli, Koronubu, and Veisaru, are at present in operation for the regional system. The borehole water is pumped up to the service reservoir located in the vicinity of each borehole. Their location and salient features are shown in Fig. D-2.2 and Table D-2.2 respectively.

The boreholes were initially developed as the water source for the communal water supply system in the areas surrounding the borehole. At present, the boreholes are used as one of the water sources of the regional system by being connected to the pipeline of the regional system.

Maintenance and repair of the Veisaru borehole was in process in November, 1994. Since the productivity of the borehole has been become low, PWD intends to abandon it.

(2) Waiwai Water treatment Plant

Waiwai water treatment plant was expanded in 1991. The Ba Report states that originally the treatment plant consisted of only pressure filtration using 12 vertical pressure filters with a capacity of 23 m^3/hour each. Although a total capacity of 6,550 m^3/day was possible, it was reduced to about 6,000 m^3/day during heavy rainfall on account of the continual backwashing of pressure filters due to the high turbidity of the raw water. However, the actual treatment capacity is assumed as 5,500 m^3/day based on the interview survey at the treatment plant.

To augment the production capacity, the primary sedimentation basin was constructed in 1991 and 8 pressure filters were added simultaneously. According to the interview survey, the total capacity was increased to 7,500 m^3/day by the augmentation. The salient features and present operation mode of the treatment plant are shown in Table D-2.3 and the general layout of the treatment plant is shown in Fig. D-2.3 Treated water is delivered to the service reservoirs / house connections directly via two storage reservoirs in the treatment plant.

The monthly production records of the treatment plant are shown in Table D-2.4. When the water demand in the service area exceeds the production capacity and excess water is available in the intakes, non-treated water seems to be distributed through bypass pipes without undergoing the sedimentation and filtration processes.

In general the water treatment plant is operated and maintained well, however, turbid water is occasionally delivered to the consumer during / after heavy rainfall.

(3) Distribution system

The present service area and future expansion area of the regional system are shown in Fig. D-2.2 There are 5 existing service reservoirs including the storage reservoirs in the Waiwai water treatment plant and 2 planned service reservoirs. The principal features of each reservoir are shown in Table D-2.5 and their locations are shown in Fig. D-2.2. In addition, the service reservoirs of the boreholes serve nearby areas.

The AC trunk main, 300 mm diameter x 5,394 m long, connects the Waiwai water treatment plant to Vaqia reservoir. The trunk main and the Vaqia reservoir were constructed simultaneously in 1989. The purpose of these structures was to augment the water supply on the east bank of the Ba river.

Vunisamaloa reservoir was constructed in 1990 in order to serve the Vunisamaloa, Vaqia, Korovuto, and Namada areas and high area of the Koronubu and Veisaru borehole zones. The water is pumped up from the Waiwai-Vaqia trunk main through the PVC pumping main, 150 mm diameter x 2,124 m long, at the booster pump station. The booster pump station was constructed in 1990. Two pumps, one for duty and the other for standby, were installed in the pump station. Each pump has a 42 m pumping head and 11.5 l/s pumping capacity.

Varadoli reservoir used to supply water to the town area, but at present it is used for emergency purposes only since the water level in the reservoir is lower than the Hydraulic Gradient Line (HGL) of the pipeline in the vicinity of the reservoir.

The water for the Tauvagavaga reservoir is pumped up at the Tauvagavaga booster pump station. Two pumps, one for duty and the other for standby, were installed in the pump station. Detailed information about the pumps is not available.

The detailed study for and design of the planned Vadravadra and Vadraulailai reservoirs have not been carried out and the plans are at a conceptual level.

2.2.2 Tavua / Vatukoula Regional Water Supply System

(1) Background

The Tavua waterworks were constructed in the 1950s and abstracted water from the Nasivi river 800 m upstream of the Kings Road bridge. They served the areas along the Vatukoula Road up to about 2.15 km to the south, including Tavua town, and along Kings Road to Tagitagi to the west and the Yaladro area to the east. The Vatukoula Gold Mine had its own water supply system which delivered untreated water for domestic and industrial uses to Vatukoula town.

The risk of pollution of the water supply system due to chemical deposits of effluent from the mining were of concern for many years, since abstraction was made downstream of the effluent point.

The government decided to develop a new water supply system to cope with the increasing water demand and the risk of pollution. In 1976, a new scheme was prepared with the assistance of the Government of New Zealand and included drawing water from the Nasivi river upstream of the mine intake. Due to the uncertainty of the mine future and water rights and land acquisition problems, the proposed scheme came to a standstill.

In 1985, a study (the Tavua / Vatukoula Report) was carried out to review the scheme and look for another source again with the assistance of Government of New Zealand. An intake on Basala creek was proposed in the study. However, this subsequently proved unacceptable for the same reasons.

After a review of the situation early in 1986, the final scheme was selected. This scheme includes an intake on the Nasivi river downstream of the mine intake, but upstream of the effluent point, a treatment plant, and service reservoir. All the previous problems were therefore overcome.

The construction commenced in late 1986 with completion in November 1989. The scheme consists of Stage I and II, of which the existing facilities are included in Stage I.

(2) General description

The principle features and location of the regional water supply system are shown in Table D-2.6 and Fig. D-2.4, respectively. A diagrammatic layout of the system is shown in Fig. D-2.5.

The new supply scheme supersedes the initial intake and water treatment plant. The service area at present extends from Tagitagi toward Ba and Nabuna toward Rakiraki including Tavua and Vatukoula towns and the area in/between these towns. The service area is planned to expand to cover Rabulu toward Rakiraki including Korovou, Balata and Malele and Qalela toward Ba . The service area at present / in the future is shown in Fig. D-2.1.

The water treatment plant has been designed to treat 5,500 m^3/day (Stage I) with the future extension treating 8,250 m^3/day (Stage II), by when it is envisaged that 25,000 people will be served (2005).

(3) Intake

The intake is located just downstream of the Emperor Mine Intake on the Nasivi river. Water is abstracted by the submersible pumps as described in Table D-2.6. The pumps are controlled either manually or by a signal generated by the water level in the main storage reservoir.

(4) Water treatment plant

The water treatment plant consists of the mixing chamber, clarifier, and filter. Their features are shown in Table D-2.6. The raw and treated water quality and treatment chemicals used in the treatment plant are shown in Tables D-2.7 and D-2.8, respectively. The monthly production records of the treatment plant are shown in Table D-2.9. The water production rate is largely below the capacity.

(5) Booster pump and main storage reservoir

After the treatment process, treated water enters the pump well, from where it is pumped to the main storage reservoir. The booster pumps are controlled automatically by the water passing from the water treatment plant.

(6) Interconnecting pipelines

The following pipes were installed to connect the facilities:

- Raw water rising main : 500 m of 300 mm diameter AC pipe links the intake to the water treatment plant.
- Clear water rising main : 1,050 m of 300 mm diameter AC pipe links the water treatment plant to the main storage reservoir.
- Distribution mains : about 750 m of 300 mm diameter AC pipe has been laid to link with the 300 mm AC pipe of the initial Tavua water system.

(7) Distribution system

A new distribution system, except for pipes to 2 km east of Tavua town along Kings Road, has not been constructed. Water is delivered to consumers mainly through the old distribution pipes which are connected to the main storage reservoir by the distribution mains.

The storage reservoirs of the old Tavua water treatment plant are used as the service reservoirs of the Tavua town area and its neighboring area. And the Tagitagi reservoir, which was used as the storage tank of the Tagitagi borehole, which is abandoned at present, serves western consumers. The distribution pipes on the Vatukoula Road branch near Tavua town to the Tavua reservoir.

A booster pump station is planned at Nabuta about 4 km east, along Kings Road, of Tavua town to supply the water for the eastern service area up to Rabulu. The plan, however, is still at a conceptual level.

As described above, the Tavua / Vatukoula regional system is presently functioning well. However, there are problems, such as low pressure at the edge of the service area, because of the inadequate size of the distribution pipes.

The Tavua / Vatukoula report reveals that the mine intake has 6 pumps housed in on intake tower located just upstream of the intake for the system. The pump capacity is 36 m^3/hr (= 227 l/s) each, with a pumping head of 120 m.

The source capacity at the existing intake was studied and estimated as 250 l/s in periods of drought over a 15 year return period by PWD. However, it is said that the Emperor Mining Company has water rights to abstract 250 l/s of water. In periods of drought, there is no water available for the regional system when water is abstracted at the mine intake.

2.2.3 Rakiraki Regional Water Supply System

With regard to the Rakiraki regional water supply system, a definite plan and detailed study are less documented. The existing condition and proposals for future extension of the system are set forth in the Rakiraki report, however, there are many parts which are not mentioned, the report is incomplete. This section describes the existing condition and future extension plan of the system based on the information obtained through the interview survey in the PWD head and branch offices and by referring to the report.

(1) Source of supply

The potable water is derived from three surface water sources consisting of two gravity sources and one pumping source. The principal features of the gravity sources are shown in Table D-2.10. The features of the pumping source are not documented. The locations of the sources are shown in Fig. D-2.6.

(a) Gravity source

Narara and Nakasia creeks, the gravity sources, have small catchment areas at the intake point of 3.56 km^2 in total. The available water of these two sources amounts to almost nil in the dry season. Land use in the catchment area is mainly cattle grazing. It has been reported that the water is usually of an acceptable physical quality for water supply, however, color and turbidity increase during the rainy season and bacteriological contamination is rather high due to the land use of the catchment area.

The Nakasia source consists of upper and lower intake dams. A storage tank was installed at the upper intake. During daytime in drought periods the upper source is closed to fill the storage tank and the lower source is opened to deliver water.

The pipes from the Narara and Nakasia sources join and deliver water to consumers in the upper part of the service area of the system. Then the joined pipes connect to the distribution pipes from the town reservoir, which stores the water from the pumping source. Since HGL of the gravity pipe is lower than that of the pipe from the reservoir at the connecting point, the gravity water cannot enter the distribution system in the lower service area when water is delivered from the reservoir.

When the yield of the Nakasia source is sufficient all the gravity water comes from the Nakasia and the Narara water is suppressed because the Nakasia source is more elevated than the Narara source. The monthly production records of the gravity sources are shown in Table D-2.11.

(b) Pumping source

The Nakauvadra pumping source is located 1 km south of Vaileka town center. The water is pumped up by three pumps through two pressure filters to the storage reservoir (Town reservoir) which has a storage volume of 568 m^3 and a water level (WL) of 116 m.

The general layout of the pump station is illustrated in Fig. D-2.7. Of the three pumps, two are electrically driven and one is diesel driven. The two electric pumps are operated 24 hours a day and the diesel pump is operated 16 hours a day.

The water from the pumping source is usually of a reasonable physical quality, but turbidity and color increase after heavy rainfall and bacteriological contamination is rather high. The pumping station has flooded several times. The monthly production records of the pumping source are shown in Table D-2.12.

(2) Treatment

There are no full treatment facilities in the system. Only chlorination has been carried out at both the gravity and pumping sources.

(a) Gravity sources

Both the gravity sources are separately chlorinated in a concrete tank located at the upper Nakasia and Narara intakes by mixing in an amount of hypo chlorite solution twice daily. This is a very inaccurate measure of disinfection and quite unreliable on a 24 hour basis.

The disinfection method is considered to cause significant bacteriological contamination of both the gravity sources. In addition, the Nakasia source is not disinfected during the closing period of the upper source.

(b) Pumping source

The Nakauvadra pumping water is chlorinated in the pump sump at the pumping station by a continuous drip feed of hypo chlorite solution. Then the water is pumped through the pressure filters. Since the water is chlorinated prior to filtration, a lot of chlorine is absorbed by suspended particles especially after heavy rainfall when the river water displays a high content of suspended solids and a dark color. This chlorination method is inadequate.

(3) Distribution

The system is divided into daytime (5:30~20:30) and nighttime (20:30~5:30).

In the daytime, water from the pumping source is pumped to the Town reservoir and reticulated to the lower part of the service area (downstream of the reservoir) and the upper part of the service area is served with water from the gravity sources.

In the nighttime, the pumped water is stored in the Town reservoir and is not reticulated. The water from the gravity sources is delivered to all the consumers in the service area.

When the water is discharged from the reservoir, the gravity water cannot be reticulated to the lower part of the service area as described in Clause 2.2.3 (1) (a).

(4) Problems faced and measures to solve them

In the existing water supply system, as described in the former clauses, there are a lot of problems in operating the water supply adequately. The problems faced at present are:

a) inadequate water treatment of both the gravity and pumping sources,
b) impossible abstraction from the two gravity sources simultaneously,
c) impossible distribution to the lower part of the service area from the gravity and pumping sources simultaneously, and
d) flooding of the pumping station.

To solve the above problems, the following measures have been considered and implemented in part:

a)-1 to construct water treatment plant including chlorination and filtration facilities for the gravity sources, a)-2 to improve the existing water treatment facilities in the pump station and/or to construct new water treatment plant for the pumping source,

b)-1 to improve the gravity intake facility by raising the Narara dam,

b)-2 to duplicate the pipe from the Narara intake,

c)-1 to construct a "Low Level Reservoir" for the gravity sources,

c)-2 to install a bypass pipe in the town area, the installation was done in 1993 not only for problem c) but also for the future extension of the service area described in clause 2.2.3 (5),

d)-1 to relocate the pump station and construct new water treatment plant, and

d)-2 to construct boreholes for replacement of the pumping source.

These measures are schematically illustrated in Fig. D-2.8.

(5) Future extension plan

As well as the measures to solve the problems faced at present, the future expansion plan of the service area has been considered at a conceptual level. The service area and water supply facilities in the expansion plan are shown in Fig. D-2.6.

PWD has a plan to create two service areas as follows:

Town Area : to be served with water from the pumping source via the existing Town reservoir

Other Areas : to be served with water from the gravity sources via the planned low level reservoir

To expand the service area toward the east, the installation of the bypass pipe in the town area was done in 1993. A booster pump station may be constructed depending on HGL required to supply water to the edge of the service area in the future expansion.

2.3 Communal Water Supply System

There are three departments, the Ministry of Fijian Affairs and Regional Development (MFARD), the Ministry of Health (MOH), and PWD, involved in government supported or implemented rural water supply programs. Implementation of and financial assistance for communal water supply systems are carried out through only one department, to which a requested is made by a community.

Projects conducted by MFARD are carried out under the responsibility of the District Officer of MFARD. The projects typically include a borehole with pump, storage tank, and gravitation fed piped water supply. In general, MFARD provides the storage tank and pipes, and the community pay for the other parts, and provide the unskilled labor.

MOH, through its district health officers, sometimes implements or finances communal projects as well. The involvement of the ministry, however, seems to depend to a large extent on the training and capacities of the health officer involved.

Not all the water supply facilities implemented by MFARD and the MOH are constructed based on engineering judgment, therefore, problems with the facilities have occasionally arisen.

PWD has constructed communal water supply systems under the "Self-help Rural Supply Scheme" which has been implemented by the Government during the past 20 years. "Rural Water Supply in Fiji" was prepared by PWD as the manual for the survey, design, and cost estimate of the systems.

The scheme makes available to villages and communities piped water supply systems. The survey, design, and cost estimate are carried out by PWD. The construction is carried out with construction materials supplied by the government, while the community provides all the unskilled labor for the excavation and backfill of pipe trenches, etc., free of charge. When the system is completed, PWD maintains the system for a period of 6 months following completion, then it is handed over to the community, which becomes entirely responsible for maintenance and repair.

The existing communal systems have creeks, springs and boreholes as their water sources.

The cost of the schemes is apportioned in the following way:

- The cost of the construction materials required to complete the system is estimated and the community is required to contribute one-third of the cost.
- The government contributes the remaining two-thirds of the cost for the construction materials, together with the costs of transportation to the nearest road access or landing point and the provision of skilled labor such as pipe fitters, etc.

Thus, when the scheme is proposed the community is required to provide the following:

- The required funds to be deposited with PWD to cover one-third of the cost of the construction materials.
- Transportation of the construction materials from the ship or nearest road access.
- When construction is being carried out, all the unskilled labor necessary and quarters for the PWD employees engaged on the scheme.

When the scheme has been surveyed and proposals drawn up, the community is notified of the estimated cost and pays the above contribution. The scheme is placed on the waiting list for construction while all of the community contribution is deposited with PWD. However, the government funds for the scheme are generally fully committed in advance of the commencement of any annual program, therefore, construction cannot normally be undertaken promptly following the deposition of the full contribution.

To cope with the sudden changes in the cost of construction materials which result in the final cost of schemes greatly increasing, the following additional measures are applied:

i) When the community has completed paying its required contribution as estimated from the original proposals and before construction is scheduled.
   - The estimates are inspected and any changes in the cost of construction materials is evaluated.
   - The community is notified of any changes and is required to deposit with PWD one-third of any increase in the cost of construction materials before the scheme is placed on the waiting list for construction.

ii) When the scheme has been completed and one-third of the estimated cost is not used.
   - The contributed money is refunded to the community.

Because of this measure, it is advised that communities, whose schemes were proposed and underwent cost estimation more than 2 years before the contribution was completed, should regard the estimate as out of date.

2.4 Borehole Subsidy Scheme

The objective of this scheme is to encourage private people or groups of people to develop boreholes for water supply by offering a government subsidy toward the cost of the works. The procedure for requesting the subsidy and construction of the boreholes with the subsidy is as follows:

- applications to PWD by a person / people requesting the subsidy
- checking of the applications by PWD and written approval of the subsidy by PWD
- arrangement with a contractor for construction of the borehole and land and site access arrangement by the applicant
- provision of written notice, at least one day before the commencement of the work by the contractor, to the Divisional Engineer of PWD
- site inspection by PWD within 14 days after the commencement of the work
- admission and payment of a contractor

When a contractor claims payment for the works and after a site inspection and approval by PWD, the subsidy is paid on the following basis:

- F$24/m of borehole depth measured from ground level to the bottom of the borehole (F$48/m of which F$24/m is paid by the subsidy and F$24/m by the applicant's contribution)
- F$1.25/km for transportation of the drilling rig and support to and from the borehole site

The transportation cost is intended to cover the contractor's cost for transporting his drilling equipment, plus any support vehicles, to the borehole site, and for setting up his rig for drilling. The cost of this is fully covered by the subsidy and is measured in both directions, either from the contractor's home base or the last drilling site, whichever is the shorter distance.

The borehole shall be 4" (100 mm) in diameter with class 'C' PVC solvent jointed pipes. As a general guide to the borehole depth, drilling shall continue for 6 m below the level at which water is struck. A pumping test shall be carried out for not less than 2 hours. The results of the test and other relevant details shall be sent to PWD with the contractor's claim for payment.

The contractor shall guarantee the completed borehole for a period of two years from the date of the PWD inspection. In general, applications are not approved in areas where the water supply of the PWD system is available, or where there already is an alternative and reliable water supply. The subsidy only covers the borehole and never exceeds F$1,000 for any one borehole. The pumping equipment, engines, pipework, tanks, and all other fittings, together with their O&M are entirely the applicant's responsibility.

When the above procedure is followed, the subsidy will be paid for a dry borehole, but it will not be paid for a borehole which has to be abandoned as a result of the contractor's negligence, that is, dropped or jammed drilling tools.

2.5 Water Supply System Owned by Private Companies

The FSC systems supply piped water for industrial uses in the FSC factories and domestic uses in the employees quarters. The source of the systems is surface water from rivers / creeks. The systems are independent water supply systems of the PWD regional system.

The FSC system in Ba abstracts water from Samau creek, one of the tributaries of the Ba river which flows in from the left bank. The water is chlorinated at the intake and then delivered to the FSC quarter, located near Ba town, via a 6"(150 mm) pipe for domestic uses and an 8" (200 mm) pipe for industrial uses. Three boreholes were dug within the quarter for the domestic water supply in case of emergencies.

On the other hand, the FSC system in Rakiraki, which normally abstracts water from the Tuvavatu river and Penang river in drought periods, is used for running the factory only, while the Rakiraki regional system is used to serve the staff quarters. FSC has indicated that it will continue to provide its own independent water supply to run the mill. Although in emergency situations a request may be made to PWD to use PWD regional water, no extra allowance needs to be made to provide the sugar mill with water.

The Dayal system was constructed in 1957 prior to the PWD Ba regional system. Water is abstracted at the intake dam on Waise creek and delivered directly to the households without treatment or being stored in a reservoir. The service area of the Dayal system is adjacent to that of the Ba regional system along the northern border, and has been reduced in accordance with the extension of the regional system.

Presently, the Dayal system serves about 300 households with a charge of F$80 per household annually. However, the collection of the charges is not going well and the Dayal company would like to sell the system to PWD. The people who use the Dayal System have complained of its poor water quality and insufficient water quantity.

2-6 Emergency Water Supply

The emergency water supply is an arrangement by which the government supplies water for household purposes to those facing serious problems with their normal water supply. The arrangement is not necessarily limited to drought situations, but also includes people suffering from failures of the piped water schemes, areas in which wells dry up, or areas where other problems, not directly attributable to the people, exist. However, the emergency water supply is only utilized where larger areas are affected by the continued lack of rainfall, causing normal water sources to be disrupted.

Since 1984, MFARD became responsible for the supply of emergency water to drought stricken areas through the Divisional Offices and Head Office of MFARD. Although relieved of the task, PWD still handles the transportation / carting to the affected areas. The District Officers of MFARD are responsible for the evaluation of requests and their compilation and the Divisional Commissioner is responsible for the budget.

The government has consistently allocated F$100,000 for this purpose, which at times was insufficient. The highest yearly expenditure on emergency water was in 1987, when F$1,182,701 was spent.

The procedure for requesting and distributing emergency water is as follows:

- complaint / request to the District Officer of MFARD by the Chairman of the Advisory Council or village representative (including a list of people in need of water),
- checking of the request by the District Officer / Health Inspector of MFARD,
- request by the District Officer to the Divisional Commissioner of MFARD for emergency supply to his district (with a list of names and settlements),
- approval of the Divisional Commissioner / Planning Officer of MFARD and request to the Chief Water Engineer of PWD to supply emergency water, and
- instruction from the Chief Water Engineer to the District Water Engineer of PWD to cart water to the specified areas and people,

This institutional arrangement is mainly sectoral, with some integration at the divisional level. Requests come in via MFARD and at the divisional level are handed over to PWD which arranges for the implementation. The reason that PWD provides emergency water is partly historical, as traditionally it was the department that owned trucks. Currently, however, only hired trucks are used.

The emergency water supply delivered by trucks with 1,000 gals.(4,550 l) water storage tanks supply each family with two drums of water on a weekly or twice weekly basis. People have to have their own storage drums.

There is no clear policy or agreement on the question of people being charged for the emergency water supply. There is agreement on the transportation cost of emergency water, it is charged to MFARD, but the cost for the water itself is less clear. In some districts, during part of the emergency supply period in 1992, people were charged 5 cents per drum. In other areas there was no charge. The Divisional Water Engineer Western of PWD was instructed by his Headquarters to start charging people 5 cents per drum from November 1992, however, there were objections to this by MFARD.

The selection of families in need of emergency water supply seems to function adequately. There are sufficient controls on the selection process through the District Officer and Health Department of MFARD. During the operation, there does not seem to be a lack of knowledge on who to actually supply the water to and in what locations.

However, records and overviews are not systematically kept. Information on the emergency water supply in the years previous to 1992 is not available at district and divisional levels. Such information would have been very helpful in identifying key problem areas.

3. PRESENT CONDITIONS OF WATER USE IN THE COMMUNITIES

3.1 General

This chapter presents the present condition of each community in the Study Area based on the existing information obtained through the interview surveys at the governmental offices concerned and site reconnaissance. The condition consists of location, population, and which kind of water is used at present.

This survey was carried out to mainly grasp the actual water supply condition of each community in the Study Area. The results of this survey were also basic data for visiting the communities, the questionnaire survey set forth in Chapter 4. To broadly grasp the drought problems in the Study Area, the Drought Assessment Report was also referred to.

3-2 Identification of the Communities

There are no statistical data / information on the communities other than the population census, and information on the type of water supply system in each community is less well documented. Detailed inventories of water supply systems by community are not available.

Identification of the communities in the Study Area was, therefore, conducted based on the 1986 population census, the latest census. The lists of communities provided with the emergency water supply in 1992, shown in the Drought Assessment Report, were also referred to. Some communities on the report are not included in the lists of communities for the census. This is caused by names of communities not always being in accordance with the names used in the census.

The locations of the communities were identified in cooperation with the PWD staff in the Head Office/ Western Divisional Office, as well as in the District Office. The communities in the Study Area are listed in Table D-3.1 and their locations are shown in Fig. D-3.1. The Study Area includes the whole area of the Ba, Tavua, and Rakiraki Tikinas and parts of the Vuda, Magodro, Navosa, and Saivou Tikinas. Four towns, Ba, Tavua, Vatukoula, and Rakiraki, and 174 communities were identified as listed in Table D-3.1.

3.3 Present Water Use

The present water use of each community is classified in accordance with the kind / mode of the existing water supply described in Chapter 2, and listed in Table D-3.1.

In general, the older villages are traditionally located near adequate water sources, whereas newer settlements are often located in drier areas. These areas are adequate for the crops grown by the settlements, mainly sugarcane, but their water supply is more vulnerable. Moreover, these settlements are often more dispersed, which makes it more difficult to provide them with an adequate water supply. This is the reason that these settlements tend to rely more on private dug wells.

In the Ba Tikina, there are 68 communities, of which 41 are served with the piped water of the Ba regional water supply system at present and 3 communities will be served in the future. Piped water supply systems have been well developed for the communities. 59 communities in the Ba Tikina, around 85 % of the communities, are served with piped water at present.

The Magodro and Navosa Tikinas are located in hilly and/or mountainous areas. Most of the communities are Fijian villages. On account of their locations, it is expected that the creek is adequately used as their water source although the kind of water used is not documented / identified in some communities.

46 communities were identified in the Tavua Tikina. The Tavua/Vatukoula regional water supply serves only 11 communities at present, but will serve 8 more communities after the expansion of the system. Although, new water treatment plant for the system was constructed, the distribution system has not been well developed. In 1992, 29 communities, around 60 % of the communities, were supplied with emergency water.

In the Rakiraki Tikina, 33 communities were identified. The existing Rakiraki regional water supply system has served a limited service area in and around Rakiraki town. Almost all of the communities are located outside the present service area. Nevertheless, 21 communities have the piped water supply system, since the communal water supply system has been developed in 19 communities.

Three communities in the Vuda Tikina are located on a narrow plain lying between a mountain and the sea. Tube and dug wells and small creeks are the dominant water sources in the communities due to their topographic conditions. The communities in the Saivou Tikina are served with creek water from the Rakiraki regional water supply and/or communal water supply systems.

4. QUESTIONNAIRE SURVEY ON THE PRESENT STATUS OF WATER USE IN DROUGHT AREAS

4.1 Objectives

Socio-economic aspects concerning water use can be clarified, to some extent, with a questionnaire survey on the beneficiaries. By the nature of the survey, its results may be subjective, but reflect the beneficiaries' behavior and perceptions with regard to water supply. In the Study, a questionnaire survey was carried out with the following main objectives:

- to grasp the present status of water use in water shortage areas, and
- to identify the extent of water supply problems and needs for the Project

Besides, the survey aimed at getting information on women's roles concerning water use, so called "Women in Development"

4.2 Selection of the Communities for the Survey

To select the communities for the survey, the data on the present water supply and especially drought problems are a prerequisite . However, historical data and statistics on drought problems in Fiji are scarce, which makes it difficult to identify the specific areas which experienced drought over the years.

In the Drought Assessment Report described in Chapter 1, it is stated that the provision of emergency water was used as an indicator for drought proneness, since the emergency water supply is not restricted to specific areas. All drought prone areas seem to have been covered by emergency water.

Therefore in the selection of communities for the questionnaire survey, firstly, the communities where emergency water was supplied to in 1992, listed in the report, were identified as the areas facing water shortage. 74 communities were identified as shown in Table D-4.1. Among them, little affected communities were excluded from the questionnaire survey based on the affected ratio (No of Households / No. of Families affected) and results of the interview survey conducted in the PWD District Office.

In due consideration of the geological and hydrogeological aspects, the communities located in the areas in which groundwater potential is not expected were also excluded. Finally, 59 communities were selected for the survey as listed in Table D-4.1 and their locations are shown in Fig. D-4.1.

4.3 Methods of the Survey

The questionnaire survey was conducted by three interview teams for three weeks in August 1993. Two kinds of questionnaire forms, one for representative of the community and the other for the household, were prepared . The forms for the questionnaires are shown in Tables D-4.2 and D-4.3.

At first, the representative of the community was visited to get information about the whole area of the community. In addition to this information, three households in each community were interviewed to get more detailed information and to confirm the information about the community.

In order to avoid collecting partial information, household interviewees were selected in consideration of different types of water use, as much as possible. Women were selected as one of the interviewees to get women's opinions on women in development, thus household interviewees consisted of "two men and one woman" or "one man and two women".

4.4 Results of the Survey

The survey covered 59 communities, of which 6 were Fijian Villages and 53 were Indian settlements. The households in the Fijian villages are densely located, but those in the Indian settlements are scattered. 59 samples from the representatives of the communities and 177 (3x59) samples from households were collected.

In 10 communities a regional water supply system covers the whole or part of the community, however, water shortages and problems such as an insufficient quantity of water and low pressure are encountered, especially in the dry season.

Communal water supply systems have been developed in 33 communities. Out of these, 7 communities face problems with their system, such as the water supply facilities being out of order and the hopelessness of repairing the facilities due to financial problems. Systems are under construction or to be developed in three communities.

Individual house connection is normally applied as the method of delivery of water to households served with piped water. Public standpipes / share connections are utilized in villages where households are densely located.

In the communities without a regional or communal system and/or communities where the systems can not cover all the water demands, tube and dug wells and rainwater are mainly used in the rainy season and tube wells and river/creek water are the dominant water sources in the dry season.

The water is usually fetched in pulling drums (44 gal.= 200 l) by trucks/vans or bulls in the morning and / or evening. Men carry out this work. Women and children also bring water from the dug wells and creeks located in the vicinity of a household by buckets (9~20 l), but this is not the women's specific job, rather it is the men's job. In Fiji, people carrying water on top of their heads has not been seen for 20~ 30 years. In general, women perform housework, and some women work on farms.

Emergency water has been supplied every year to almost all of the communities between August and December in the form of two drums of water, on a weekly or twice weekly basis, per household. The water is generally carried to each household, but in a community the water is brought to the reservoir of the communal system to fill it up.

Water-borne diseases, such as infectious diarrhea, dysentery, typhoid fever, skin disease, and eye infection are generally encountered in almost all of the communities. However, there are no cases of death caused by the water-borne diseases. Based on the results of the survey, the percentage of water used was estimated by the water sources in both the rainy and dry seasons, as shown in Table D-4.4.

From the point of view of an adequate water supply, such as its reliability, quality, and convenience, the regional and communal water supply systems and privately owned tube wells are considered under this classification. Therefore, the total percentages of the regional, communal, and tube well water used were regarded as indicating an adequate water supply and estimated by each community as shown in Table D-4.4.

The present condition of the adequate water supplied is classified into the following three degrees:

Degree	Conditions	Percentage of Adequate Water Supply
A	Moderate	more than 70
B	Poor	between 20 and 70
C	Extremely Poor	less than 20

The present condition of water use by each community is briefly described hereunder.

(1) Ba/Vuda

B-2 : Benai

A communal water supply system, consisting of a borehole, two service reservoirs, and distribution pipes to individual house connections, covers 80% of the population in the community. The water is pumped to the reservoirs by a solar electric system. In some households, dug and tube wells and rainwater are also used in the rainy season and tube well and river/creek water is used in the dry season. No emergency water has been supplied to the community.

Water-borne diseases such as infectious diarrhea, dysentery, typhoid fever, influenza, and skin disease are encountered in some households using rainwater.

No serious water shortage is expected, but the inhabitants have complained of an insufficient quality of water in the communal system. It is proposed by PWD that the Ba regional water supply system be extended to the community.

B-3 : Bilolo

The water supply consists of a communal system and privately owned sources.

The communal system has three intakes on the creeks and water is collected into two service reservoirs and reticulated to each individual house connection. The system covers only 30% of the population. In the dry season, the quantity of water used decreases by one-third.

Rainwater stored in roof tanks and dug and tube wells, which are mainly privately owned sources, is used in the rainy season, and tube wells, river/creek water and emergency water are used in the dry season. Some dug wells dry up in the dry season, thus bathing and laundering are carried out in a river/creek.

Almost all the inhabitants who use rainwater suffer from water-borne diseases such as infectious diarrhea, dysentery, influenza, and eye infection every year.

B-9 : Karavi

The communal system covers around 40% of the population. Its water source is a creek and the water is supplied to households by individual house connection. The system can work properly throughout the year.

Other than the communal system, the tube and dug wells and rainwater stored in the roof tanks are used in the rainy season, and the dug and tube wells and emergency water are used in the dry season. The emergency water is always supplied in the dry season.

In a few households, water-borne diseases, such as infectious diarrhea, dysentery, typhoid fever, skin disease, and eye infection are encountered.

B-10 : Koronubu

The Ba regional water supply system covers 80% of the population and supplies potable water by individual house connection. Its water source is the Koronubu borehole. The population have complained of an insufficient quantity of water and low pressure at the house connection.

The other 20% of the population uses water from dug and tube wells and rainwater in the rainy season, and water from the river/creek, tube wells and emergency supply in the dry season. The dug wells normally dry up in the dry season.

Water-borne diseases such as infectious diarrhea, dysentery, typhoid fever, influenza, skin disease, and eye infection are evident in households using the dug well and river/creek water.

B-13 : Kumkum

About 10 % of the population are served with potable water by the Ba regional water supply system and 60 % of the population are served by the M.R. Dayal water supply system. These systems supply water to each house by individual house connection.

The water supplied by the Dayal system is turbid and very dirty in the rainy season. And in the dry season, the system has not enough capacity to meet the demands and water pressure decreases. The main privately owned sources are the dug well and rainwater stored in the roof tanks in the rainy season, and the dug well, emergency water, and river/creek in the dry season. It takes about 1 hour per day to fetch water from the dug well and about 2~ 3 hours to fetch it from the river/creek by a truck / bulls.

No water-borne diseases are evident in the community.

B-18 : Moto

The Ba regional and Dayal systems cover almost all of the community. The water is supplied by individual house connection.

The regional system has properly supplied water in both the rainy and dry seasons. However, the Dayal system has many problems such as poor water quality, low pressure, and an insufficient quantity of water, especially in the dry season. In the dry season, the river/creek water and emergency water are used to supplement the Dayal system. It takes 1.5 ~ 2 hours per day to fetch water from the river using a truck/bulls. The river water is used for bathing, laundering, cleaning, gardening, and livestock, but not for drinking and cooking.
A few cases of water-borne disease such as infectious diarrhea, dysentery, skin disease, and eye infection have been encountered.

B-19 : Nabatolu

No regional water supply exists in the community. A communal system was constructed, but has not been working since 1981 due to facility trouble. Its water source is creek water.

Presently, the rainwater stored in a roof tank, dug well, and river water are used in the rainy season. In the dry season, the river water, emergency water, and dug well are used. It takes about 2~4 hours per day to bring water from the river. The emergency water is supplied every year, normally starting in August and ending in December.

Almost all the inhabitants suffer from water-borne diseases such as infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

B-24 : Nakavika

Almost all of the inhabitants purchase water from a tube well holder living in the community. The water is charged at F$ 1.0 per 1 drum (=200 l). Each household purchases 1 drum per day in both the rainy and dry seasons.

Other water sources are the rainwater and creek in the rainy season and the emergency water in the dry season. In the creek about 1 km from the community, bathing and laundering are carried out. Emergency water has been supplied in particular years.

B-32 : Natunuku Village

No regional and communal water supply systems exist. The community used to receive water from Vatutavui communal system, next to the village, but the supply has been stopped since 1991 because no excess water is available in Vatutavui.

At present, dug and tube wells and rainwater stored in a roof tank are used in the rainy season and dug and tube wells and emergency water are used in the dry season. Laundering and bathing are carried out in a creek in both the rainy and dry seasons. No water -borne diseases are evident.

The community has saved F$ 4,000 for construction of a communal water supply system.

B-35 : Navau

The Ba regional water supply system covers part of the community, about 30% of the households.

Other sources, rainwater and dug and tube wells, are generally used in the rainy season and the dug and tube wells and emergency water are used in the dry season. The emergency water is also supplied to the households with the regional system, and it is normally supplied between August and October. Some households go to Ba town / Sarava, located about 6 km from the community, to get water, this is taking 3 hours by truck.

In households without the regional system, almost all of the people suffer from infectious diarrhea, dysentery, typhoid fever, influenza, skin disease, and eye infection every year.

B-37 : Navoli

The Ba regional water supply system covers about 50% of the population in the community. The water source is the Navoli bore hole. The water is supplied to individual house connections from the Navoli service reservoir. The households served by the system have complained of low pressure at the taps, especially in the daytime. 20% of the population are served with piped water by a communal system consisting of an intake on the creek, a service reservoir with a capacity of 50 m^3, and distribution pipes to individual house connections.

In the dry season, the quantity of water from both the systems is not enough to meet all the demands, therefore, the households use river/creek water and emergency water as alternative water sources.

Other sources for households without the systems are rainwater stored in the roof tanks and dug and tube wells in the rainy season, and dug and tube wells, river/creek water, and emergency water in the dry season. In the dry season, bathing and laundering are carried out in a river /creek.

The per capita water consumption is estimated at 40~100 lpcd in households without the system and 100 ~ 150 lpcd in those with the system.

Water-borne diseases, such as infectious diarrhea, dysentery, skin disease, and eye infection are encountered in only those households using rainwater.

B-41 : Qerelevu

The communal system was constructed in 1984 to cover about 80% of the population. The water source is the creek and the water is supplied to individual house connections or public stand pipes. In the dry season, however, the system capacity decreases and bathing and laundering are carried out in a river /creek by some households.

For other households, water is brought from the dug well in the rainy /dry seasons and the river /creek in the dry season. It takes 2 hours to fetch the water on average. Emergency water is supplied every dry season, starting in August with one drum of water per household on a weekly basis.

In some households that use dug well water, water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection are encountered every year.

B-50 : Tauvegavega

The booster pump station and service reservoir of the Ba regional system are located in community. These facilities function to serve the area and/or the vicinity of the community with piped water. The system covers about 65% of the population in the community, the other 35% of the population lives mainly in illegal squatters located in the hilly area, surrounding the reservoir.

The system has not enough capacity to meet the water demands in the service area in the dry season, therefore, bathing and laundering are carried out in the creek and emergency water is also used as an alternative water source. In other households without the system, the main water sources are the rainwater and the dug well in the rainy season and creek water and emergency water in the dry season. Some households purchase water from neighbors who have the regional system.

Rainwater /creek water users suffer from water-borne diseases such as infectious diarrhea, typhoid fever, and skin disease.

The per capita water consumption in households with and without the regional system is estimated at 90~140 lpcd and 70~90 lpcd, respectively.

B-57 : Vatuyaka

The Ba regional system covers 40% of the population in the community. The water source is the Varavu borehole. The water is pumped to the service reservoir and then supplied to the individual house connection in each household. The water pressure at the taps is very low throughout the year and water quantity supplied decreases in the dry season. Therefore, other water sources such as the dug well in the rainy season and dug well and emergency water in the dry season are used.

For households without the system, the dug and tube wells and creek water are used in the rainy season and the dug and tube wells and emergency water are used in the dry season.

No water-borne diseases are encountered.

B-58 : Vatusui

There is no regional water supply system, but the Dayal system covers the whole area of the community by individual house connections. The water quality is relatively poor in the rainy season, and the water pressure is very low and quantity of water is insufficient in the dry season. Some households cannot get water from the system. Even in the rainy season, the households served with water from the system use rainwater and river water as alternative water sources.

The seasonal water sources are rainwater, the dug well and river water in the rainy season and the dug well, river water, and emergency water in the dry season.

In some households, water-borne diseases, such as infectious diarrhea, dysentery, and skin disease are encountered every year.

B-63 : Vutuni Creek

The Ba regional water supply system covers 10% of the population in the community. Other sources, dug well and creek water, are generally used in the rainy season and creek water and emergency water are used in the dry season. Spring water is used in a few households through pipes privately installed. Laundering and bathing are normally carried out in a creek.

Two communal systems, consisting of spring water and creek water sources, the service reservoir and the distribution pipes, were constructed. However, they are not working at present due to lack of maintenance and repair. The distribution pipes were broken and only a few households, vicinity of the water sources, are served with the water from the system.

In a few households using the creek water, water-borne disease, such as infectious diarrhea, dysentery, typhoid fever, influenza, skin disease, and eye infection are encountered.

Inhabitants without the Ba regional water supply system are not satisfied with the present water supply.

V-1 : Raviravi

There is no regional or communal system in the community, however, there are many privately owned dug and tube wells. The dug and tube wells are generally located within house compounds and water is pumped up and conveyed to a drum/tank.

Other sources are rainwater in the rainy season and creek water in the dry season. Emergency water is always provided during the dry season between August and December.

Some cases of water-borne diseases, such as infectious diarrhea, dysentery, typhoid fever, and skin disease are experienced every year.

V-2 : Tavarau

The whole area of the community is covered by a communal and FSC owned water supply systems. The communal system consists of an intake dam on the creek, a service reservoir with a capacity of 90 m^3, and distribution pipes to individual house connections. The FSC system serves 50 households (350 persons) with piped water. The inhabitants are FSC workmen. The FSC water source is also the creek and water is conveyed to share connections. In the rainy season, all of the water demand can be covered by both of the systems.

In the dry season, the tube well water is used and laundering is carried out in a creek by a few households.

No water -borne diseases are encountered.

V-3 : Tuvu

The community is located on the western edge of the Study Area. There is no regional or communal system.

Dug and tube wells are the main sources throughout the year. The creek water is used in some households and the fetching of this takes about 2 hours per day. Rainwater stored in a tank is also used in a few households. The dug and tube wells are dug within a house compound and water is pumped up to the tank. In the dry season between July and December, emergency water is supplied at a rate of two or three drums per household on a weekly or twice weekly basis.

Four households share a privately owned supply system. The system consists of a spring intake, service reservoirs, and distribution pipes to individual house connections.

No water -borne diseases are encountered.

(2) Tavua

T-2 : Balata

The community consists of Balata No 1 and No 2. Both of them have no regional or communal water supply system at present.

In the rainy season, rainwater stored in the roof tank, the dug and tube wells, and creek water are the main sources. It takes 0.5~ 1 hour to fetch water from the dug wells and about 3 hours to fetch it from the creek. The water from the river is carried by truck / bulls. The tube wells are located within a house compound and water is pumped up to the tank and stored.

In the dry season, the dug and tube wells, river water, and emergency water are normally used. Emergency water is supplied every year. It takes 0.5~2 hours to fetch water from the dug wells and 1 hour to fetch it from the tube well on average. The river water is fetched by a truck / bulls which takes 1~3 hours per day and is used for laundering and bathing. Water is fetched from the Nasivi river since the nearby creek is normally dried up.

The community has saved F$489,000 in funds for construction of a water supply system. PWD proposed that the community is included in the Tavua / Vatukoula regional system extension plan. Construction of two boreholes and distribution system covering 20 households in Balata No.2 was planned to be started in September 1993.

No water -borne diseases are evident in the community.

T-5 : Davota

A communal system covers 80% of the population in the community. The system consists of an intake on the creek, a service reservoir, and distribution pipes to individual house connections. The system is also used by the Rakavidi community.

The per capita water consumption is estimated at 30~50 lpcd, since the source capacity is small. Normally, the capacity decreases to nil in the dry season. To supplement the existing system, the construction of a new borehole is planned in cooperation with the Rakavidi community.

Other than the communal system, rainwater stored in a tank is used in the rainy season and the dug well, emergency water, and river water are used in the dry season. The river water is fetched by a truck / bulls, which takes 0.5~ 1 hour per day and is used for bathing and laundering. The dug well water is used in only a few households. Emergency water is supplied at a rate of two drums per household on a weekly basis during the dry season from June to December.

About one-third of the inhabitants suffer from infectious diarrhea, typhoid fever, influenza, and eye infection every year.

T-6 : Drumasi

There is no regional or communal system in the community. The community requested that PWD extend the Tavua /Vatukoula regional system, but there has been no progress with this.

In the rainy season, rainwater stored in a roof tank and a dug well are the main sources. A few households have a tube well located within their house compound. In the dry season, river water is the main source. Emergency water is also used. Water is fetched by truck from the Nasivi river located 4~10 km from the community, which takes 1~2 hours per day. Emergency water is supplied every year, normally from August to December at a rate of two drums per household on a weekly basis. Only one tube well is located in the community at the school and the tube well water is sometimes delivered to the households.

About half of the inhabitants suffer from infectious diarrhea and typhoid fever every year.

T-11 : Korovou Settlement

There is no regional or communal system at present. It has been proposed by PWD that the Tavua / Vatukoula regional system will be extended to cover the whole area of the community, and the construction is in progress.

Presently, in the rainy season, rainwater stored in roof tanks is the main source. Each household has a tank. Dug well water is also used, and the fetching of it takes 1~1.5 hours per day. A tube well is located in the school yard. In the dry season, the dug wells are normally dried up and river water is the main source. Water is fetched by truck from the Nasivi river located 2~4 km from the community, which takes 1~2 hours per day. Emergency water is supplied at rate of two drums per household on a weekly basis.

About half of the inhabitants suffer from water-borne diseases, such as infectious diarrhea and typhoid fever every year.

T-12 : Korovou Village

A communal system covers the whole area of the community. The system consists of one borehole, one service reservoir, and distribution pipes connecting to 8 public stand pipes. The borehole was dug at the end of the 1960s, the service reservoir was constructed in 1989, and the standpipes were installed in 1989. The standpipes are located within 10 ~ 20 m of each household. A few households use rainwater.

The system can supply water to cover all of the water demand in the rainy season, however, the system capacity decreases to cover 40% of the demand in the dry season. River water and emergency water are, therefore, used as the alternative sources. People go to the Nasivi river, located about 3 km from the community, by bus / truck for bathing and laundering. Emergency water is supplied every year at a rate of one or two drums per household, twice or three times a week.

Water-borne diseases, such as infectious diarrhea, skin disease and eye infection are encountered. Almost all of the inhabitants suffer from the diseases every year.

It has been proposed by PWD that the community be included in the Tavua / Vatukoula regional water supply system.

T-13 : Kukunirewa

There is no regional or communal system in the community.

In the rainy season, rainwater and dug wells are the main sources of water. Creek water is used in a few households. The creek water is fetched by bulls, which takes 1~2 hours per day. In the dry season, the dug wells, creek water, and emergency water are the main sources. The dug well and emergency water are used for drinking and cooking and bathing and laundering are carried out in the creek. Emergency water is supplied at a rate of 1~2 drums per household on a weekly basis every dry season.

About one-third of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, influenza, skin disease, and eye infection every year.

T-14 : Lousa

There is no regional or communal system. Dug and tube wells are the main sources of water supply in the community. Twelve tube wells were dug within a house compound. In the 1983 drought, the most severe drought ever experienced, all the wells in the community dried up. Rainwater is also used in some households in the rainy season and emergency water is supplied in the dry season. The dug well water is fetched by a truck / bulls, which takes 1~2 hours per day.

Almost all of the inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-15 : Lubulubu

The pipeline of the Tavua / Vatukoula regional system extends to half of the area of the community. The water is supplied only during the night (22:00 ~ 5:00), even in the rainy season. Water is stored in a tank during the night and used in the daytime.

In households without the regional system, the main sources of water are a dug well, spring, and creek in the rainy season and the creek and spring in the dry season. It takes 1~2 hours per day to fetch water. In the dry season, creek water is used for bathing and laundering. Some people go to the creek at Tagitagi by bus for bathing and laundering. A few households have a tube well within their house compound.

Water consumption is estimated at 20~30 lpcd in the households without the regional system. These values constitute the minimum level for sustaining life.

Almost all of the inhabitants without the regional system suffer from infectious diarrhea, typhoid fever, influenza, skin disease, and eye infection every year.

T-16 : Malele

There is no regional or communal system and tube wells are the main source of water supply in the community. Thirty-six tube wells are utilized in the rainy season, however, the capacity of some wells decreases in the dry season.

Other than the tube wells, the main water sources are dug wells and rainwater in the rainy season and dug wells and the river water in the dry season. The emergency water supply is also one of the water sources in the dry season. River water is fetched from the Nasivi river, located about 3 km from the community, which takes about 2 hours by truck. Emergency water is supplied every year between August and December on a weekly or biweekly basis.

No water-borne diseases are experienced in the households that use only tube well water. One-third of the inhabitants that use the dug well and river water suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-17 : Maqere

There is a communal system consisting of one borehole, two service reservoirs, and distribution pipes to individual house connections. The system covers about half of the population living in the northern part of Kings road. In the southern part, dug and tube wells are mainly used for the water supply. Some dug wells normally dry up and the capacity of the tube wells decreases in dry the season. Rainwater is also one of the water sources in the rainy season.

To supplement the water deficit in the dry season, emergency water is supplied every year. The supply is delivered to the households at a rate of one or two drums per week.

About two-thirds of the inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-18 : Matalevu

There is no regional or communal water supply system. The community has requested that PWD construct a communal system consisting of a borehole and spring sources, but no action has been taken to date.

Presently, the main water sources are dug and tube wells. The rainwater is also utilized in the rainy season. Laundering is carried out in the creek, located within the area of the community. In the dry season, some dug wells dry up, and emergency water is supplied at a rate of two or three drums per household once or twice a week. Some people go to a creek located 1~2 km from the community since the nearby creek is normally dried up in the dry season.

About half of the inhabitants recurrently suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, and eye infection. A few cases of skin disease are encountered.

T-19 : Matanigata

There is no regional or communal water supply system at present. The community has requested that PWD construct a communal system consisting of one borehole, one service reservoir, and distribution pipes to individual house connections. The community paid F$2,000 as part of the construction cost in

July 1993. The system will provide 20 households with piped water. Three other communal systems are planned. Their sources will also be boreholes. Investigation of these three systems was carried out.

Presently, the main water sources are rainwater and the dug wells in the rainy season, and the dug wells and the river in the dry season. There are 8 privately owned tube wells. The tube wells have enough capacity to supply the water used by each household throughout the year. The water from one tube well is delivered to neighbors at a charge of F$2.5 /$m^3$. In the dry season, the dug well capacity decreases. To supplement the deficit, some people go to the Nasivi river for laundering. Emergency water is supplied every year between July and December once or twice weekly.

About one-third of the people suffer from typhoid fever, skin disease, and eye infection every year. Some cases of infectious diarrhea are encountered.

T-25 : Natawa

The Tavua / Vatukoula regional water supply system covers 95% of the population in the community. There are no problems in the water supply area with the system. The other 5 % populate the hilly area, where water is fetched from dug wells. Emergency water is delivered to the households at a rate of two drums per week.

The community has requested that PWD extend the regional water supply system to provide all of the population in the community with piped water.

No water-borne diseases are encountered.

T-26 : Natolevu

The community has no regional or communal water supply system. The main source of water is the Nasivi river. The water is fetched by bulls which takes about 1 hour per day. The laundering is done in the river. Some households own a tube well and one tube well is shared with several households. However, all of the tube wells are normally dried up in the dry season. Emergency water is requested every year, but no water has been delivered, due to the difficult accessibility to the community.

About one-third of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-29 : Qalela

This community is divided into Qalela No.1 and No.2. No.1 covers a hilly area and No.2 occupies a lower lying area. Four communal systems are in operation and another system is at the planning stage at present. All the systems consist of a spring intake, service reservoir, and distribution pipes. The water is conveyed to the individual house connections by a gravity system.

Three spring water systems supply the Qalela No.1 area. The springs' capacities decrease or the springs normally dry up in the dry season. For Qalela No.2, one system is in operation and another spring water system is planned to supplement the existing system. The planned spring source has been observed to insure that the water will not dry up in the dry season.

Other than the water supply systems above, rainwater and creek water are used. Emergency water is supplied every year at a rate of one or two drums per household on a weekly basis. Extension of the distribution pipe of the Tavua/Vatukoula regional system to the community from Tagitagi, next to the community, has been proposed.

Almost all inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection.

T-30 : Rakavidi

There exists a communal system which is also used by the Davota community. The system consists of an intake on a creek, two service reservoirs, and distribution pipes to the individual house connections. The system was constructed in 1984 and covers 75 % of the population in Rakavidi. However, in the dry season, the source capacity decreases to nil.

In addition to the system, rainwater and dug wells are used in the rainy season, but dug wells normally dry up in the dry season. The water supply in the dry season, therefore, depends entirely on the river and emergency water. The river water is fetched from the Nasivi river, located 3 km from the community, which takes 1~2 hours per day by truck. Emergency water is supplied once a week at a rate of two drums per household.

Almost all of the inhabitants suffer from infectious diarrhea, typhoid fever, and eye infection every year.

T-34 : Vatia

There is no regional or communal system. The borehole utilized for the Maqere communal system was planned to be used for the Vatia communal system, but the plan was postponed due to financial problems.

Presently, a dug well is the main source of the water supply. Some households use rainwater stored in a roof tank and a tube well in a private house compound. In a few households, laundering is done in a creek. In the dry season, some dug wells dry up. To supplement the deficit, emergency water is supplied every year between August and December, once or twice a week.

Two-thirds of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection.

T-36 : Vuqele

A communal system, consisting of a pump intake on the Nasivi river, service reservoir, and distribution pipes to public standpipes, was constructed in 1989, but the pump was broken in 1991. Since the community could not raise the funds for the repair of the pump, the system is not in operation at present.

Presently, river water from the Nasivi river, fetched by bulls or a truck, is the main source of the water supply in both the rainy and dry seasons. It takes 1~2 hours per day to fetch the water. Dug wells and rainwater stored in roof tanks are used in the rainy season, but the wells are normally dried up in the dry season. Emergency water has been requested every year, but only in 1991 was water delivered. Only two privately owned tube wells exist, which are used in the rainy and dry seasons.

Two-thirds of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-40 : Wainivocea

A communal system, covering 80 % of the population in the community, was constructed in 1987. The system consists of an intake on a creek, three service reservoirs, and distribution pipes to individual house connections. Each household served by the system paid F$ 1,500 of the construction cost. Also, the households pay F$ 20 per annum for O&M of the facilities.

Other than the communal system, rainwater stored in the roof tank and creek and dug well water are used in the rainy season. In the dry season, the source capacity of the system decreases to about half of all demand. The deficit is covered by fetching creek water by truck or bulls, which takes 1 ~ 2 hours per day. No emergency water has been supplied.

Water-borne diseases, such as infectious diarrhea, typhoid fever, and eye infection are encountered.

T-42 : Nasomo Village

The existing communal system covers all of the population in the community. The system consists of two intake weirs on creeks, two service reservoirs, and distribution pipes to share connections. The supplemental communal system was studied in 1992. The proposed plan in the Study consists of one intake weir on another creek, a service reservoir, and pipeline to connect the existing distribution pipe network.

The existing system can meet all of the water demand in the rainy season, however, the stream flow decreases to meet half of the demand in the dry season. To help ease the deficit problem in the dry season, laundering and bathing are carried out in the creek located 800 m ~ 1.5 km from the community. In a few households, rainwater is used. Emergency water has been supplied only a few times to the community.

Three-quarters of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection.

T-43 : Tokoloa

The regional water supply system serves only 6 households with piped water by individual house connections. The system was extended to the households in 1986. The water is supplied continuously in the rainy season, but sometimes ceases in the dry season. The communal system in Vuqele, which is not in operation at present, was planned not only for Vuqule, but also for Tokoloa. Each household in Tokoloa paid F$ 150 for the construction of the communal system.

The main water sources of the community are rainwater and river water in the rainy season. Dug and tube wells are also used. In the dry season, the river water and tube wells are the main sources. Emergency water is supplied every year, but in limited amounts: 2 ~ 4 drums per household once or twice per month.

About a quarter of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, and eye infection every year.

T-44 : Malotu

There is no regional or communal system. Rainwater is the main source of the water supply in the rainy season. Dug and tube wells are also used. It takes about 30 minutes per day to fetch dug well water, and about one hour to fetch creek water by bulls. The tube well water is pumped up through hoses which connect to the households. In the dry season, the creek water is the main water source. Emergency water is supplied every year between June/July and December at a rate of two drums per household on a twice weekly basis.

Two-thirds of the inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

T-45 : Garampani

There is no existing regional or communal system. The community has requested that PWD extend the Tavua/Vatukoula regional system and/or construct a communal system with a borehole, but no reply has been received.

At present, the main source of the water supply is river water in both the rainy and dry seasons. It takes 1~2 hours per day to fetch the river water by a truck/bulls. Rainwater and dug well water are also used. Six privately owned tube wells have been dug within house compounds. Emergency water is supplied to a few households in the dry season.

One-third of the inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

The community will be included in the Tavua/Vatukoula regional water supply system in the future.

T-46 : Lololevu

A communal system was constructed in 1985/86 to cover almost all of the population in the community. The system consists of a pump intake on a creek, service reservoir, and distribution network. However, the system has not been in operation because the O/M cost for pumping could not be paid. The community has requested that a survey be carried out to find new gravity sources.

At present, the main water sources are dug wells and creek water. Laundering and bathing are carried out in the creek. In the dry season, the amount of dug well water decreases, therefore the creek water is fetched by truck, which takes about 2 hours per day. Emergency water is supplied every year at a rate of one drum per household on a twice weekly basis.

Two-thirds of the inhabitants suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

(3) Rakiraki

R-2 : Draunivi

There is no regional and communal water supply system. The main water sources are dug wells and creek water throughout the year. It takes 1~3 hours per day to fetch water from the dug wells by buckets. Laundering and bathing are carried out in the creek. In the dry season, the creek in the community is normally dried up and some people go to the river located about 800 m from the community. Emergency water is rarely supplied, but recently the supply was delivered in 1990 and '91.

About half of the people suffer from infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

R-4 : Ellington

There is no regional or communal system at present. It has been proposed by the PWD that the Rakiraki regional water supply system be extended to the community, but the plan is at the conceptual level.

Only one household located near Ellington wharf, has a piped system constructed by FSC. The system used to supply water to the FSC wharf which is abandoned, at present. The main water sources are dug wells. Six privately owned tube wells have been dug in house compounds and are used as the households own supply. Creek water is only used in the rainy season. Some dug wells normally dry up in the dry season. On average, it takes 1~3 hours to fetch water from the dug wells. Only one creek flows through the community and some people go to the creek for laundering and bathing in the rainy season. However the creek is normally dried up in the dry season.

About half or three-quarters of the inhabitants suffer from infectious diarrhea, typhoid fever, and eye infection.

R-6 : Kavuli

There are two communal systems covering about 30% of the population in the community. Each system consists of one borehole, one service reservoir, and distribution pipes to share connections. However, the systems are unreliable due to the unstable water quantity.

Other water sources are privately owned the dug and tube wells. Creek water is also used in the rainy season. The dug well water takes 1 hour per day to fetch, on average. The tube wells are located within house compounds and the water is delivered to the houses through hoses. Emergency water is supplied every dry season between August and December at a rate of two or three drums per household on a weekly basis.

Water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection are encountered in the households using dug well water.

R-13 : Nanuku

The existing communal system covers 38 households in the community. The water source is a borehole. The water is supplied to individual house connections. The source has an insufficient capacity to meet the water demand in the dry season, therefore, dug well water is used as the alternative source.

To supplement the existing system, construction of another borehole and service reservoir was started, but stopped due to financial constraints. Also two other boreholes are planned. Presently, in the households without the communal system, water is fetched from the dug wells, which takes about 1~3 hours. Tube wells have been dug within several house compounds. Emergency water was only supplied in 1992, at a rate of one or two drums per household on a weekly basis.

In the households using the dug well water, infectious diarrhea, typhoid fever, skin disease, and eye infection are encountered.

R-15 : Narewa Village

A communal system covers the whole area of the community. The water source of the system is a creek. The water is supplied to share connections. All of the water demand can be met by the system in the rainy season, however, a water deficit of about 70% of the demand occurs in the dry season due to the limited source capacity.

To supplement the deficit, emergency water is supplied every year at a rate of two drums per household on a twice weekly basis. The people depend on the emergency water supply only. The per capita water consumption in the dry season is estimated at 30~40 lpcd.

Around one-third of the inhabitants suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, skin disease, and eye infection every year.

It has been proposed by the PWD that the Rakiraki regional system be extended to the community, but it is at the conceptual stage.

R-16 : Naria

There is no regional or communal water supply system in the community at present. The existing pipeline of the Rakiraki regional system extends to the western boundary of the community. It has been proposed by the PWD that the pipeline be extended to the community.

A dug well is presently the main water source. Only one tube well exists within a house compound and it is used for supplying pumped water to the house. The water quantity from the dug well decreases in the dry season, and emergency water is used as an the alternative source. Emergency water is supplied every year at a rate of two drums per household once or twice a week. Both the dug and tube well water are affected by saline intrusion due to their location, a low lying area near the sea.

About half of the people suffer from water-borne diseases, such as infectious diarrhea, typhoid fever, and eye infection every year.

R-19 : Rabulu

The existing communal water supply system consists of one borehole, one service reservoir, and distribution pipes. However, the system is not in operation at present since the pump is out of order. The community could not raise the funds for the repair. The system could not cover all of the water demands in the community.

Presently, a dug well is the main water source. Tube wells are used in some households. However, the well capacities decrease in the dry season, therefore the river water and emergency water are used as alternative sources. In a few households rainwater stored in roof tanks is used in the rainy season. The river water is fetched from the Yaqara river, which takes about three hours per day. Emergency water is supplied every year from August to December at a rate of two drums per household on a weekly basis.

About three-quarters of the people suffer from water-borne diseases, such as infectious diarrhea, typhoid fever and eye infection every year.

It has been proposed by the PWD that the Tavua / Vatukoula regional system be extended to the community.

R-20 : Raravatu

A communal system is planned, but is not in progress due to financial problems. The system is planned to cover only 24 households, 45% of the population in the community. The water source is a spring.

In the rainy season, dug well water is used to supply water for all the consumption, except for one household which has its own tube well. In the dry season, emergency water is used as an alternative source to the dug well since the capacity of the dug well normally decreases. Emergency water is supplied every year normally from August to December on a twice weekly basis.

Every year, about half of the people suffer from infectious diarrhea, typhoid fever, and eye infection.

The community is included in the Rakiraki regional system extension plan which is at a conceptual level.

R-23 : Vitawa

The existing communal system was constructed in 1986. The system consists of an intake dam on a creek and distribution system including individual house connections.

Other water sources are a dug well and creek in the rainy season, and the dug well and emergency water in the dry season. Some households get water from their relatives who live in other communities located 1 km ~ 15 km from the community. The water is carried by drums on trucks. It takes about 1~2 hours per day on average to fetch water from the dug well, and some people go to a creek for laundering and bathing in the rainy season. Emergency water is supplied during every dry season from August to December at a rate of one or two drums per household once or twice a week.

About half of the inhabitants suffer from infectious diarrhea, typhoid fever, and eye infections every year.

The community is included in the Rakiraki regional system extension plan .

R-24 : Vitawa Village

A communal water supply system covers the whole area of the community. The system consists of an intake on a creek, one service reservoir, and distribution system including share connections.

In the rainy season, all of the people are served with piped water by the system, however, a water deficit occurs in the dry season due to the limited capacity of the water source. To supplement the deficit, emergency water is supplied. The service reservoir of the communal system is filled with 60 m^3 of emergency water per week on a twice weekly basis on average.

This village is also included in the proposed extension plan of the Rakiraki regional system.

R-25 : Vitivanua

There is a communal system which was constructed in 1993. The water source of the system is a creek. Before the construction of the system, the dug wells and a creek were the sources of the supply in both the rainy and dry seasons. It took 1 ~ 2 hours to bring water from the dug wells and laundering and bathing were carried out in the creek. There are no records of emergency water being supplied according to the interview survey.

About a quarter of the people had suffered from infectious diarrhea, typhoid fever, skin disease, and eye infection every year up to the year 1993, before the construction of the communal system.

R-26 : Volivoli

Two communal water supply systems are being constructed, but are incomplete due to financial problems. These water systems will rely on boreholes. One system will cover only 7 households. The borehole and service reservoir have been completed, but the distribution system is incomplete. The other system will cover only 5 households and only the borehole is completed. After completion of the two communal systems, only 12 households will be served with piped water.

Presently, dug wells are the main water sources throughout the year. There are some privately owned tube wells within the house compounds. The water in the wells is saline because of their location beside the sea. During every dry season between August and December, emergency water is supplied at a rate of two or three drums per household on a twice weekly basis.

Infectious diarrhea, typhoid fever, skin disease, and eye infection are encountered every year.

The community is also included in the proposed extension plan of the Rakiraki regional system.

R-27 : Vunitogoloa Village

A communal water supply system, consisting of a spring intake and distribution pipes to share connections, covers the whole area of the community. Throughout the year, almost all of the water demand can be met by the system. A few households use dug well water. However, emergency water is supplied every year between August and December at a rate of one drum per household on a weekly basis. Inhabitants have complained of an insufficient quantity of water being supplied by the communal system.

About a quarter of the people suffer from water-borne diseases such as typhoid fever and skin disease. A few cases of infectious diarrhea are encountered.

R-31 : Dociu

There is no regional or communal water supply system. The main water source is a dug well in both the rainy and dry seasons. Rainwater is used in a few households in the rainy season. Only one tube well has been dug within a house compound. In the dry season, some households get water from relatives who live in other communities located 1.5 ~ 3 km from the community. The water is carried by drums on trucks. Emergency water is requested every year, but it was only supplied in 1990.

It has been proposed by PWD that the Rakiraki regional system be extended to the community. The survey for the extension was conducted in 1990, but nothing has been done up to now.

About half of the inhabitants suffer from infectious diarrhea, typhoid fever, and eye infection every year.

R-32 : Nuculaca

A communal system, consisting of a spring intake, service reservoir, and distribution pipes to share connections, covers about half of the population in the community. However, the spring source capacity decreases in the dry season, therefore, emergency water is used as an alternative source.

Other than the system, the main water source is a dug well. It takes about 1~2 hours per day on average to fetch water from the dug well using buckets and drums. Emergency water is supplied at a rate of two drums per week.

About one-third of the inhabitants suffer from water-borne diseases, such as infection diarrhea, typhoid fever, skin disease, and eye infection every year.

R-33 : Natunu

There is no regional system and a communal system is at the planning stage at present. The planned communal system will cover only 15 households, 60% of the total households since the capacity of the water source, creek water, is not enough to cover all of the households. The plan is not in progress due to financial problems.

Presently, water is supplied by a dug well and creek in the rainy season, and the dug well and emergency water in the dry season. It takes about 1 ~ 2 hours in the rainy season and 1~3 hours in the dry season to fetch the dug well water on average. Laundering and bathing are carried out in a creek in the rainy season. Emergency water is supplied every year between August and December at a rate of two or three drums per household on a twice weekly basis.

One household has a private piped system. The system consists of a spring intake and pipeline to a house connection. However, the system is normally only operated in the rainy season, because of the limited capacity of the spring source. It has been proposed by PWD that the Rakiraki regional system be extended to the community.

About half of the inhabitants suffer from infectious diarrhea, typhoid fever, and eye infection every year. A few people suffer from skin disease.