ENGINEERING REPORT FOR NAN MAND WATER SUPPLY SYSTEM, KITTI MUNICIPALITY SECTION II FEDERATED STATES OF MICRONESIA

Ulla Mogensen
SOPAC Secretariat

September 1996 *SOPAC Technical Report 241*

This project was funded by the United Nations Development Programme

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

Appreciation is expressed for the excellent cooperation and invaluable support provided by the Luhkenmeonlap of Kitti, the Honorable Mitchuo Daniel, and his staff.

Special thanks must go to Mr. Dernel Panuel who provided essential information and guidance to facilitate the work and site investigations.

SUMMARY

The proposed Nan Mand water supply system is located in Section II in Kitti Municipality. The proposed system would service approximately 400 people. At present Nan Mand Village does not have a centralised water supply system.

There are two potential sources of supply for Nan Mand Village. One is surface water the other is utilising groundwater.

A desk hydrologic evaluation of the surface-water source shows that the safe yield is sufficient to cover the average daily water demand of the present population. A resistivity sounding investigation showed that the groundwater yield is not enough to supply the estimated daily water demand for the village.

A hydraulic analysis of the proposed system has indicated that 4" G.I. pipes for transmission line, and 4", 3", 2", 1½ and 1" for distribution lines, would be adequate to serve the community for the next twenty years. However, to keep the pressure in the pipes within required standards it is necessary to construct a break pressure tank.

The 2-phase project is proposed consisting of constructing an intake, constructing a storage tank, constructing a break pressure tank, constructing a slow sand filter, installing a chlorination unit and laying of 4" G.I, 4" PVC, 3" PVC, 2" PVC, 1½ " PVC and 1" PVC pipelines.

The phasing and the cost estimates of the project are given below.

Phase 1: Construction of an intake, a storage tank, a break pressure tank; and installation of 700 ft. (213 m) of 4" (100 mm) diameter G.I. pipeline, 2,080 ft. (634 m) of 4" (100 mm) diameter PVC pipeline, 2,790 ft. (851 m) of 3" (80 mm) diameter PVC pipeline, 704 ft. (215 m) of 2" (50 mm) diameter PVC pipeline, 3,322 ft. (1,013 m) of 1½" (40 mm) diameter PVC pipeline and 51 house connections: US$71100.

Phase 2: Construction of slow sand filter and installation of chlorination unit: US$52000.

INTRODUCTION

An engineering assessment of the Nan Mand water supply system on Pohnpei, Federated States of Micronesia was carried out in January 1996 as part of SOPAC's Work Program.

It was carried out in response to a request made by Senator Wagner M. Lawrence to the Office of Planning and Statistics, for technical assistance for the improvement of infrastructural facilities in the municipalities of Kitti and Madolenihmw.

The proposed Nan Mand water supply system is located in Section II of Kitti Municipality Pohnpei State (Figure 1). The proposed system would service approximately 400 people. At present the Nan Mand Village does not have a centralised water supply system. The villagers rely on wells, nearby streams and rainwater catchments to supply their water needs. The demand for water is mainly for domestic uses.

Water demand

The design daily water demand has been estimated as follows:

Table 1: Estimated water demand in gallons per day (gpd) and litres per day (lpd)

	gpd (lpd)
Domestic water consumption (per person)	110 (416)
Pigs (per pig)	30 (114)
Poultry (per 100 chickens)	10 (38)

According to the Federated States of Micronesia's Second National Development Plan the growth rate over the last forty years has exceeded 3% per annum. However, as people have a tendency to move from the rural areas to the urban areas, as well as leave the country, the annual growth rate for the next 10 years (1996-2006) has been estimated at 2%, while the growth rate for the years 2006-2016 has been set at 1%. For the Nan Mand project the population and domestic water demand for a twenty year period is estimated as follows.

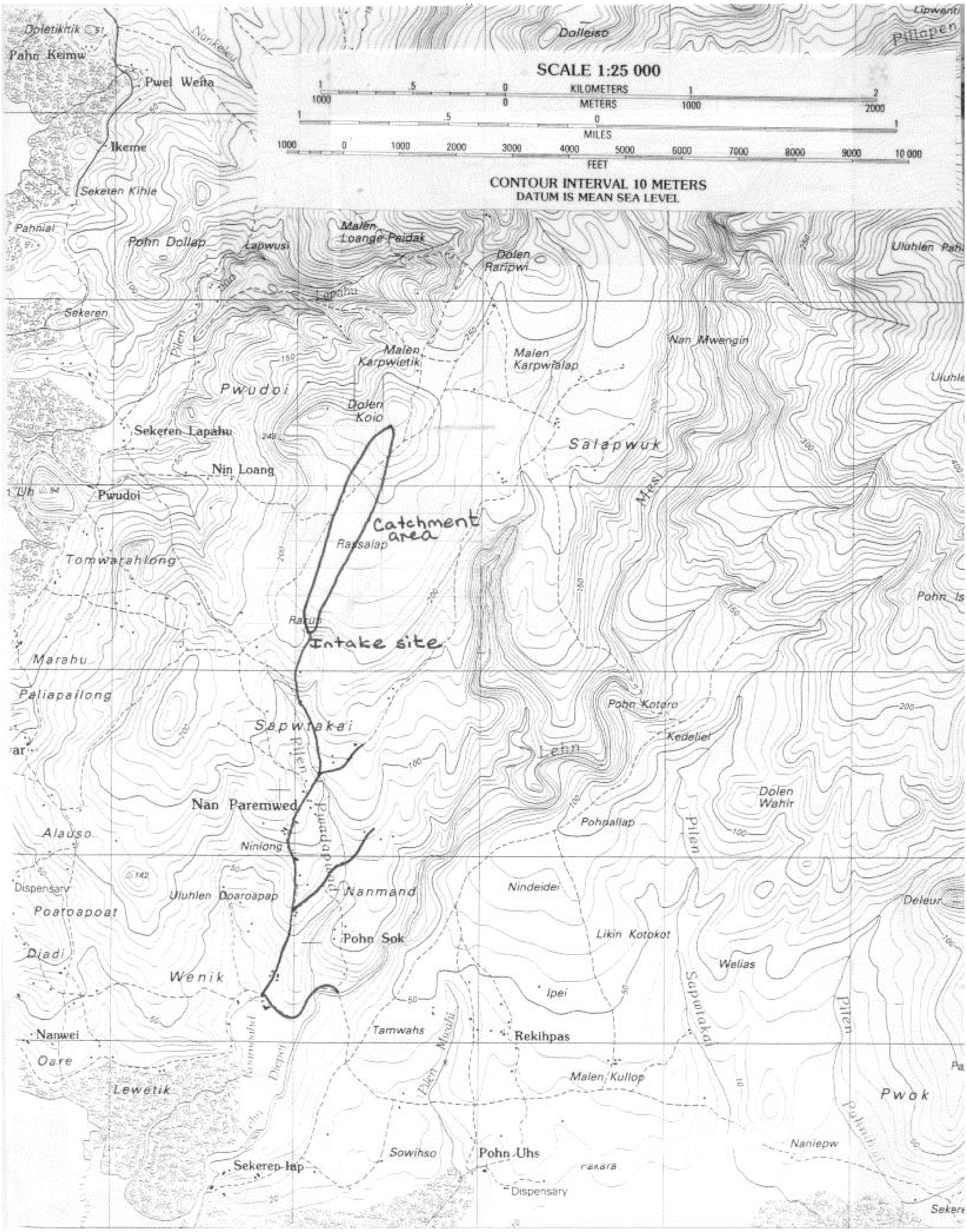


Figure 1. Location map of the Nan Mand water supply system.

Table 2: Estimated daily water demand for Nan Mand Village

Year	**1996**	**2006**	**2016**
Population	408	497	549
Domestic water demand	44 880 gpd (169 890 lpd)	54 670 gpd (206 950 lpd)	60 390 gpd (228 600 lpd)
Livestock (gpd)	7 650 gpd (28 960 lpd)	9 320 gpd (35 280 lpd)	10 300 gpd (38 990 lpd)
Total	**52 530 gpd (198 850 lpd)**	**63 990 gpd (242 230 lpd)**	**70 690 gpd (267 590 lpd)**

SOURCE OF SUPPLY

There are two potential sources of supply for Nan Mand Village. One is surface water the other is utilising groundwater.

Surface Water

The proposed dam site (Figures 1 and 2) is located at an elevation of 640 feet (195 m), and is filled by a catchment area covering approximately 0.06 sq. miles (0.16 sq. km).

Based on the USGS report "Water Resources of Pohnpei, Caroline Islands" a figure of 1.5 cubic feet per second per square mile has been used as a basis for estimating the 30-day low flow under a 5-year drought condition. This results in a safe yield of 58 164 gpd (220 175 lpd), which is sufficient for the average daily water demand of the present population of the Nan Mand system. However, with the projected demand for the year 2016 of 70 690 gpd (267 590 lpd) the source will not support the demand during a five-year drought. If this source is to be used to supply the water system, it will be necessary to enforce rationing measures during extended dry periods.

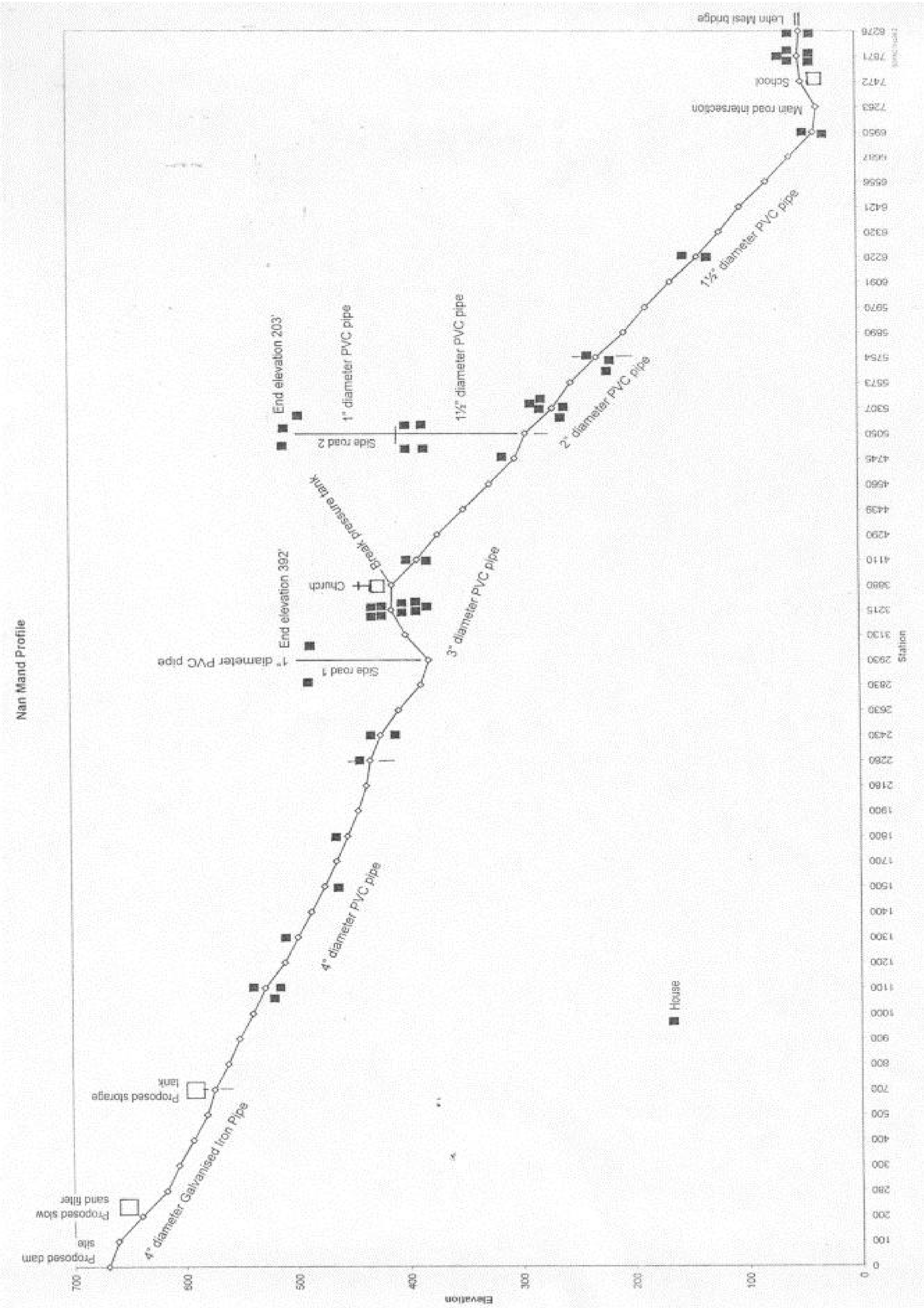


Figure 2. Schematic profile of the Nan Mand Water Supply System.

Groundwater

A resistivity sounding investigation was conducted in the vicinity of Nan Mand Village to determine whether an appropriate groundwater aquifer was present. The detailed results from the resistivity sounding can be found in Annex 1. A groundwater aquifer was located approximately 49 - 62 ft. (15 - 19 m) below the surface. The safe yield has been estimated at approximately 10 - 20 gpm (0.63 - 1.26 l/s) or 14 400 - 28 800 gpd (54 510 -109 020 lpd). This yield is not enough to cover the estimated daily water demand for the village.

Water quality

No water quality investigation was conducted at the proposed intake site. It is recommended that water quality tests be conducted as soon as possible. The water quality tests that should be conducted are fecal and total coliform bacteria, nitrate, pH, conductivity and turbidity.

PROPOSED SYSTEM

It is proposed that a centralised system be based on surface water from a stream near the Pwadapwad River. The water supply which is a gravity system will consist of a river intake, a slow sand filter, a storage tank, a break pressure tank and transmission and distribution pipelines.

The hydraulic analysis of the transmission pipeline from the proposed dam site to the slow sand filter and from the slow sand filter to the storage tank shows that for average flow a 4” galvanized iron (G.I.) pipe would be adequate to supply the system for the next twenty years (Tables 3-5 and Figures 3-5).

As the flow of source is not enough to cover the peak demand during dry periods, it is necessary to provide a storage tank. A storage tank with a total storage capacity of 21 000 gallons (80 m^3) would cover 7 hours (equivalent to a peak demand period) of the average (year 2016) water demand.

The analysis of the distribution line from the storage tank to the community indicates that the pressures in the pipes become too high. It is therefore necessary to install a break pressure tank. The calculations show that this tank should be placed at an approximate elevation of 382 ft. (116 m) above mean sea level. Table 4 shows the pressures in the distribution line (with and without the break pressure tank) during a worst case scenario where there is no consumption, creating a static pressure in the line. Assuming the use of Schedule 40 PVC pipes, which have a safe working pressure of 160 psi or 370 ft., Table 6 shows that even with the break pressure tank the pressures come very close to the safe working pressure. This means that it becomes extremely important to ensure that the pipes are laid according to standards. It is recommended that very close supervision be given during the laying of the distribution lines and that pressure tests should be conducted to ensure that there are no leaks on the pipeline.

The hydraulic analysis (Tables 3-5 and Figures 3-5) of the proposed distribution system indicates that the combination of 4" PVC, 3" PVC, 2" PVC, 1½ PVC and 1" PVC pipeline given in Figure 2 is adequate to supply the village for the next twenty years.

RECOMMENDATIONS

The first phase of establishing the system would consist of constructing an intake at elevation 640 ft. (195 m) above mean sea level, laying approximately 700 ft. (213 m) of 4" G.I pipeline, 2080 ft. (634 m) of 4" PVC pipeline, 2790 ft. (851 m) of 3" PVC pipeline, 704 ft. (215 m) of 2" PVC pipeline, 3322 ft. (1013 m) of 1½ " PVC pipeline and 2600 (793 m) 1" PVC pipeline as indicated on Figure 2. Furthermore, constructing a 21 000 (80 m^3) gallon capacity storage tank at elevation 543 ft. (166 m), and a 1000 gallon (4 m^3) capacity break pressure tank at elevation 382 ft. (116 m).

A phase two of this project would be to install a slow sand filter and chlorination unit at elevation 610 ft. (186 m) between the intake and the storage tank.

The phasing of the works and the cost estimates are given below.

Phase 1

Description of work	*Estimated cost*
• Construct a dam/intake	US$ 5,000
• Construct a storage tank, capacity 21,000 gallons (80 m^3)	US$ 15,000
• Construct 700 ft. (213 m) of 4” diameter G.I. pipeline	US$ 10,190
• Construct 2,080 ft. (634 m) of 4” diameter PVC pipeline	US$ 11,440
• Construct a break pressure tank, capacity 1,000 gallons (4 m^3)	US$ 4,000
• Construct 2,790 ft. (851 m) of 3” diameter PVC pipeline	US$ 10,460
• Construct 704 ft. (215 m) of 2” diameter PVC pipeline	US$ 2,080
• Construct 3,322 ft. (1,013 m) of 1½ “ diameter PVC pipeline	US$ 6,650
• (793 m) 1” diameter PVC pipeline	US$ 3,900
• House connections	US$ 2,380
Total	**US$ 71,100**

Phase 2

Description of work	*Estimated cost*
• Construct slow sand filter	US$ 50,000
• Install chlorination unit	US$ 2,000
Total	**US$ 52,000**

Table 3: Hydraulic Analysis of the Nan Mand System for the year 1996.

Table 3: Hydraulic Analysis of the Nan Mand System for the year 1996.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							640	
Dam - SSF	4" (100 mm)G.I.	200 (61 m)	36 (2.3 l/s)	0.28	1	639	610	29
Slow sand filter (SSF)							610	
SSF - Tank	4" (100 mm)G.I.	500 (152 m)	36 (2.3 l/s)	0.28	1	609	543	66
Tank							543	
Tank - A	4" (100 mm) PVC	1,580 (482 m)	108 (6.8 l/s)	0.90	14	529	403	126
A - Sideroad 1	3" (80 mm) PVC	650 (198 m)	97 (5.9 l/s)	3.35	22	507	350	157
Side road 1 - BPT	3" (80 mm) PVC	1,200 (366 m)	85 (5.4 l/s)	2.77	33	474	382	92
Break Pressure Tank (BPT)							382	
BPT - Side road 2	3" (80 mm) PVC	940 (287 m)	62 (3.9 l/s)	1.73	16	366	263	103
Side road 2 - C	2" (50 mm) PVC	257 (78 m)	44 (2.8 l/s)	5.20	13	353	239	114
C - D	2" (50 mm) PVC	447 (136 m)	33 (2.1 l/s)	3.26	15	338	200	138
D - Main road	1½" (40 mm) PVC	1,509 (460 m)	26 (1.6 l/s)	9.45	143	195	15	180
Main road - end	1½" (40 mm) PVC	1,013 (309 m)	16 (0.4 l/s)	4.46	45	150	19	131

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (See figure ..). Peak factor: 3 Points A, B, C, D are indicated on Figure 2.

Table 3 (cont.) Hydraulic analysis for side roads 1 and 2.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
						507		
Side road 1 - End	1" (25 mm) PVC	750 (209 m)	4 (0.3 l/s)	1.48	11	496	392	104
						366		
Side road 2 - End	1½" (40 mm) PVC	800 (244 m)	15 (0.9 l/s)	2.61	21	345	203	142
	1" (25 mm) PVC	1,850 (564 m)	7 (0.4 l/s)	4.16	77	268	172	96

Table 4: Hydraulic Analysis of the Nan Mand System for the year 2006.

Table 4: Hydraulic Analysis of the Nan Mand System for the year 2006.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							640	
Dam - SSF	4" (100 mm)G.I.	200 (61 m)	44 (2.8 l/s	0.42	1	639	610	29
Slow sand filter (SSF)							610	
SSF - Tank	4" (100 mm)G.I.	500 (152 m)	44 (2.8 l/s)	0.42	1	609	543	66
Tank							543	
Tank - A	4" (100 mm) PVC	1,580 (482 m)	132 (8.3 l/s)	1.41	22	521	403	118
A - Sideroad 1	3" (80 mm) PVC	650 (198 m)	114 (7.2 l/s)	4.71	31	490	350	140
Side road 1 - BPT	3" (80 mm) PVC	1,200 (366 m)	104 (6.6 l/s)	4.00	48	442	382	60
Break Pressure Tank							382	
BPT - Side road 2	3" (80 mm) PVC	940 (287 m)	76 (4.8 l/s)	2.22	21	361	263	98
Side road 2 - C	2" (50 mm) PVC	257 (78 m)	54 (3.4 l/s)	8.85	23	338	239	99
C - D	2" (50 mm) PVC	447 (136 m)	41 (2.6 l/s)	5.20	23	315	200	115
D - Main road	1½" (40 mm) PVC	1,509 (318 m)	33 (2.1 l/s)	12.61	190	125	15	110
Main road - end	1½" (40 mm) PVC	1,013 (309 m)	20 (1.3 l/s)	4.46	45	80	19	61

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (See figure ..). Peak factor: 3 Points A, B, C, D are indicated on Figure 3.

Table 4 (cont.) Hydraulic analysis for side roads 1 and 2.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
						490		
Side road 1 - End	1" (25 mm) PVC	750 (209 m)	5 (0.3 l/s)	2.24	17	473	392	81
						421		
Side road 2 - End	1½" (40 mm) PVC	800 (244 m)	18 (1.1 l/s)	4.46	36	325	203	122
	1" (25 mm) PVC	1,850 (564 m)	8 (0.53 l/s)	5.36	99	226	172	54

Table 5: Hydraulic Analysis of the Nan Mand System for the year 2016.

Table 5: Hydraulic Analysis of the Nan Mand System for the year 2016.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							640	
Dam - SSF	4" (100 mm)G.I.	200 (61 m)	49 (3.1 l/s)	0.42	1	639	610	29
Slow sand filter (SSF)							610	
SSF - Tank	4" (100 mm)G.I.	500 (152 m)	49(3.1 l/s)	0.42	1	609	543	66
Tank							543	
Tank - A	4" (100 mm) PVC	1,580 (482 m)	147 (8.3 l/s)	1.59	25	518	403	115
A - Sideroad 1	3" (80 mm) PVC	650 (198 m)	127 (8.0 l/s)	5.45	35	483	350	133
Side road 1 - BPT	3" (80 mm) PVC	1,200 (366 m)	116 (7.3 l/s)	4.71	57	426	382	44
Break Pressure Tank							382	
BPT - Side road 2	3" (80 mm) PVC	940 (287 m)	90 (5.7 l/s)	2.77	26	356	263	93
S2 - C	2" (50 mm) PVC	257 (78 m)	60 (3.8 l/s)	8.85	23	333	239	94
C - D	2" (50 mm) PVC	447 (136 m)	45 (2.8 l/s)	5.20	23	310	200	110
D - Main road	1½" (40 mm) PVC	1,509 (460 m)	35 (2.2 l/s)	12.61	189	120	15	106
Main road - end	1½" (40 mm) PVC	1,013 (309 m)	22 (1.4 l/s)	6.75	68	52	19	33

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (See figure ..). Peak factor: 3 Points A, B, C, D are indicated on Figure 4.

Table 5 (cont.) Hydraulic analysis for side roads 1 and 2.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
						483		
Side road 1 - End	1" (25 mm) PVC	750 (209 m)	6 (0.4 l/s)	3.14	24	459	392	67
						356		
Side road 2 - End	1½" (40 mm) PVC	800 (244 m)	20 (1.3 l/s)	4.46	36	320	203	117
	1" (25 mm) PVC	1,850 (564 m)	9 (0.6 l/s)	6.63	123	197	172	25

Table 6: Static water pressure in the Nan Mand Water Supply System.

Table 6: Static water pressure in the Nan Mand Water Supply System.

Pipeline	Without the Break Pressure Tank		With the Break Pressure Tank	
	Elevation of end of line (ft)	Pressure in pipe (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam	640		640	
Dam - SSF	610	30	610	30
Slow sand filter (SSF)	610		610	
SSF - Tank	543	67	543	67
Tank	543		543	
Tank - A	403	140	403	140
A - Sideroad 1	350	193	350	193
Side road 1 - BPT	382	161	382	161
Break Pressure Tank	-	-	382	
BPT - Side road 2	263	280	263	119
S2 - C	239	304	239	143
C - D	200	343	200	182
D - Main road	15	528*	15	367
Main road - end	19	524*	19	363
Side road 1 - End	392	151	392	151
Side road 2 - End	203	340	203	179
	172	371	172	210

* Static pressure exceeds the safe working pressure of the PVC pipe.

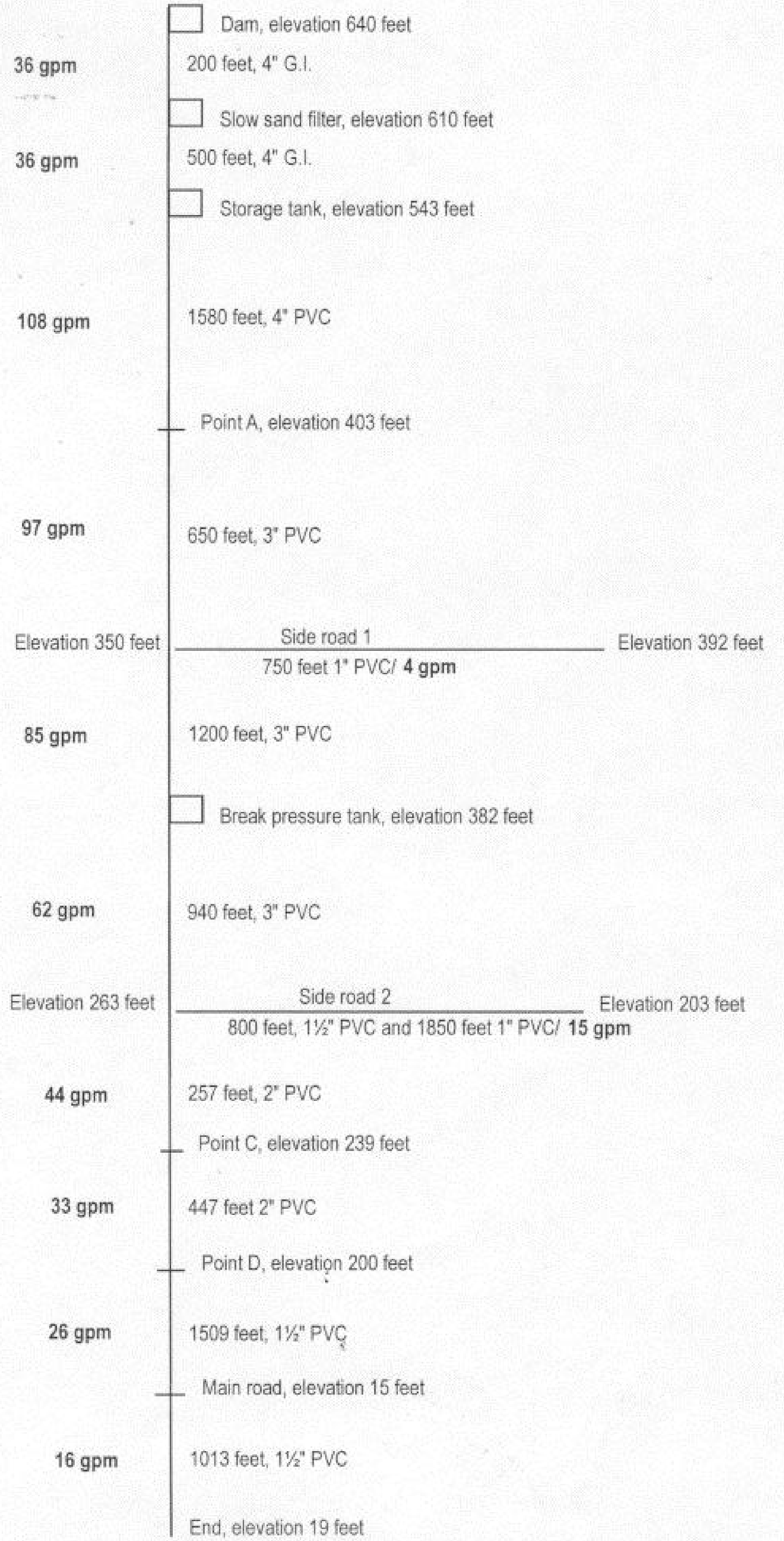


Figure 3. Schematic layout of the Nan Mand Water Supply System - 1996 flows.

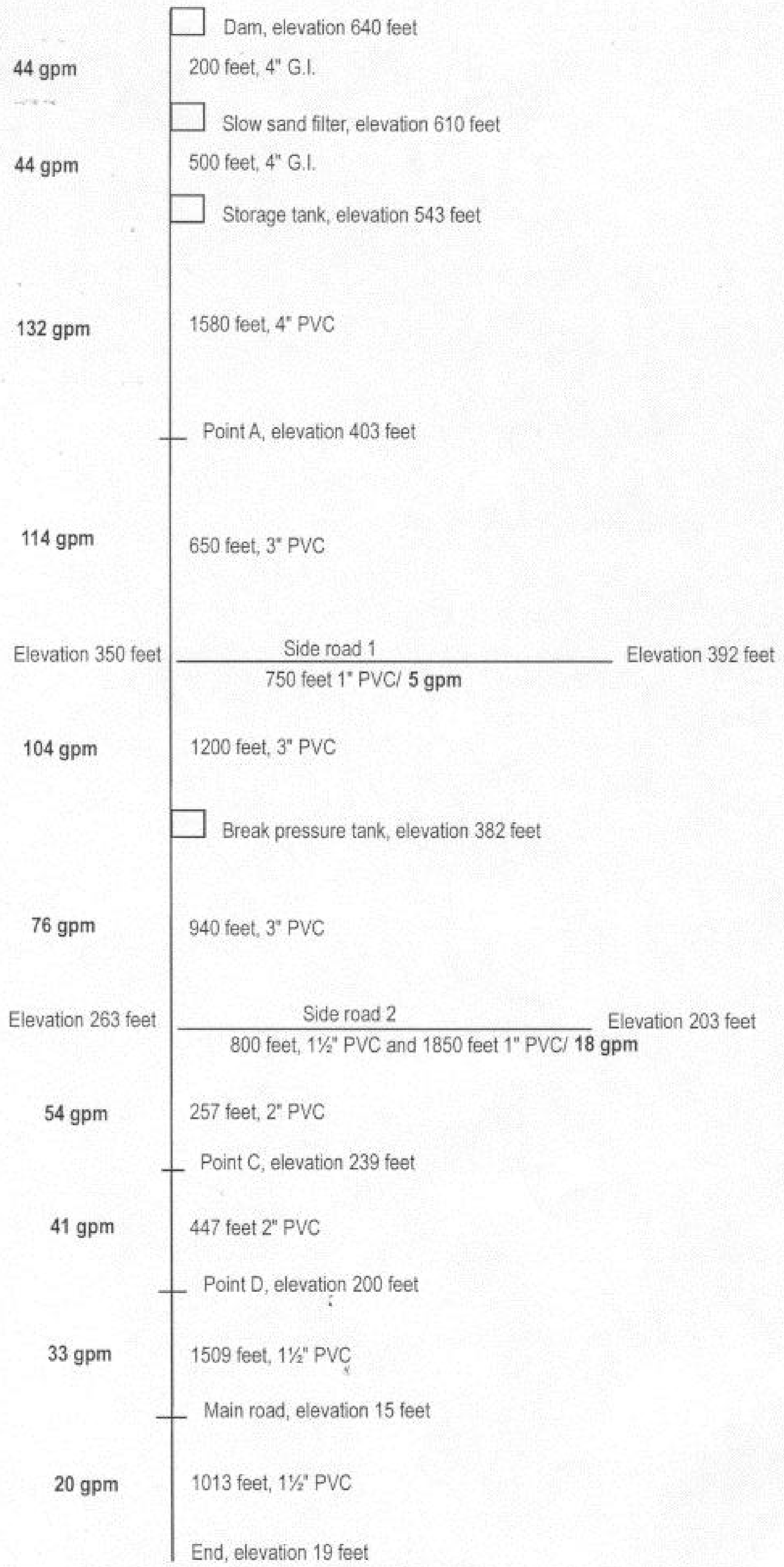


Figure 4. Schematic layout of the Nan Mand Water Supply System - 2006 flows.

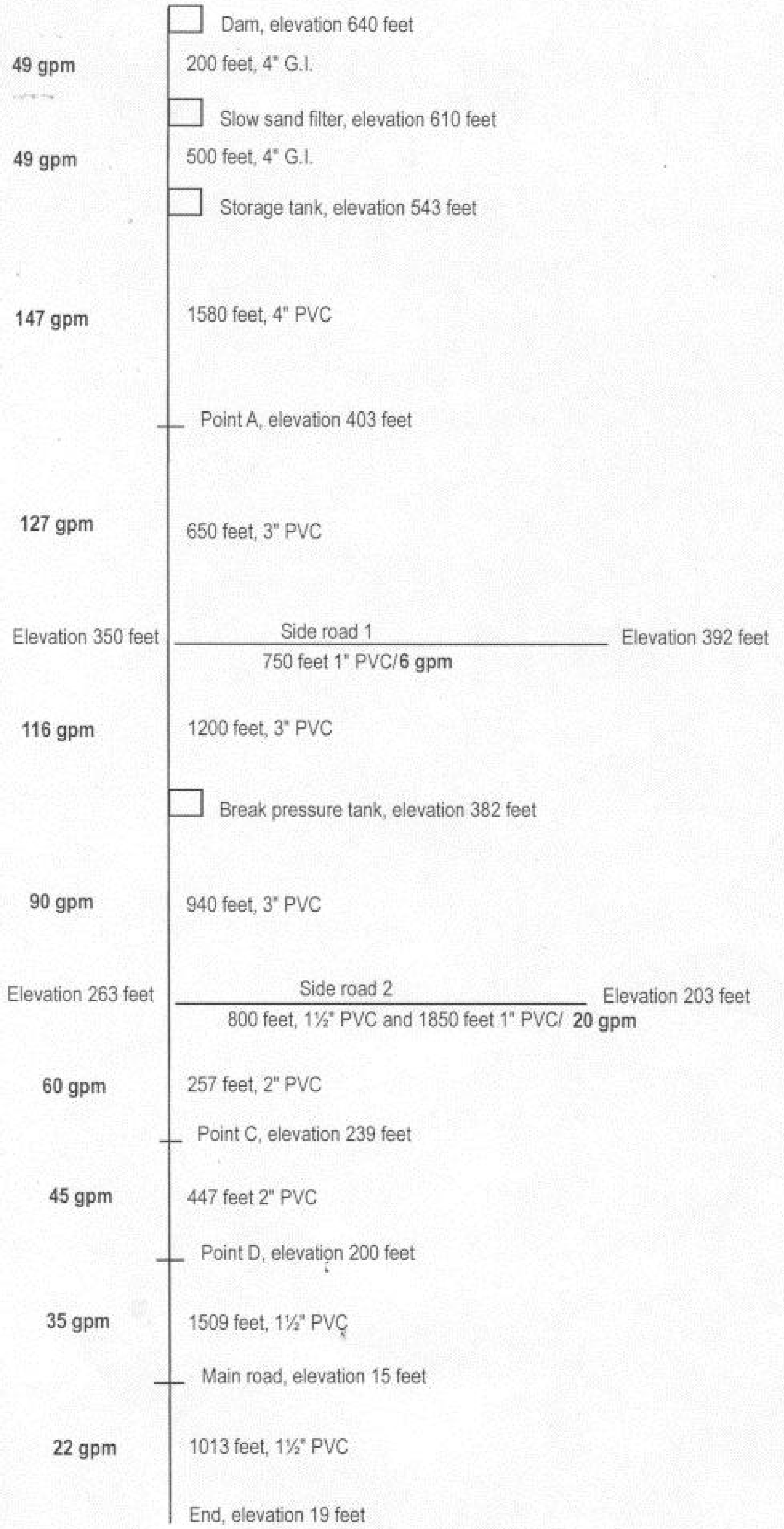
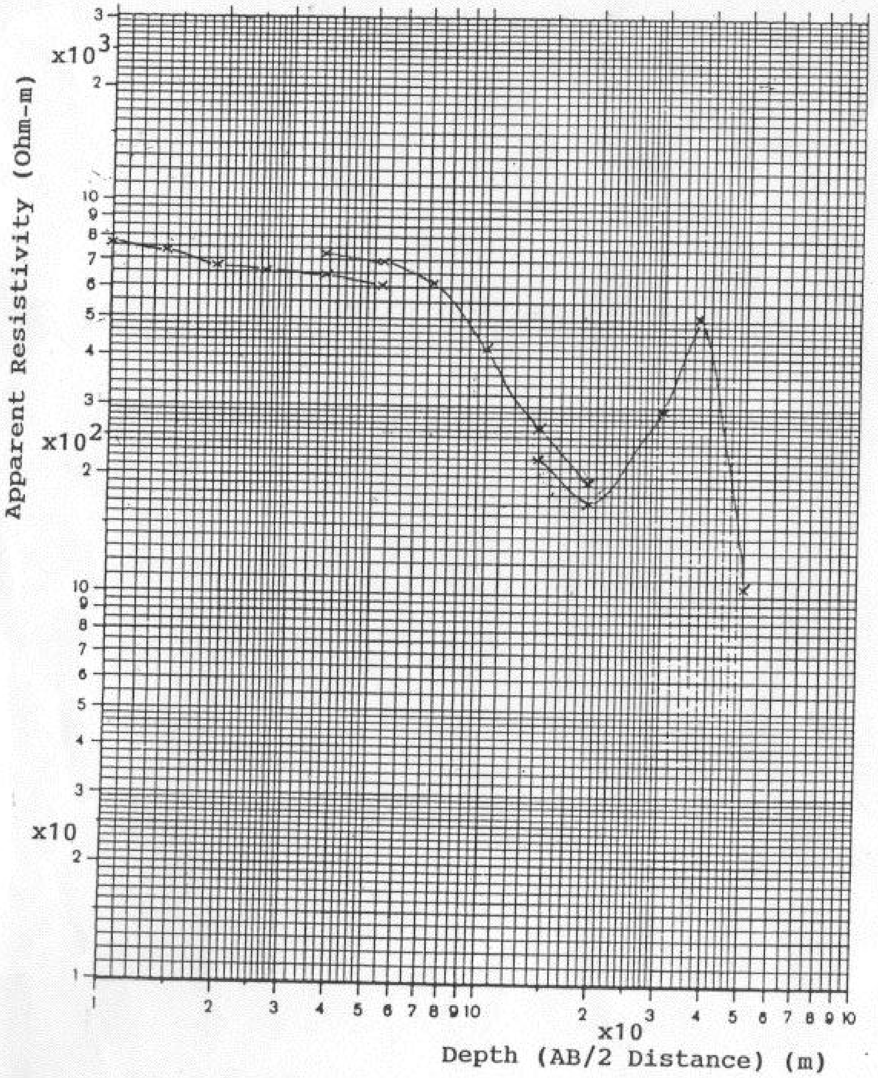


Figure 5. Schematic layout of the Nan Mand Water Supply System - 2016 flows.

ANNEX 1: RESISTIVITY SOUNDING DETECTION



RESISTIVITY SOUNDING DETECTION

Sounding No. NMD - 1

Location: Volleyball ground, Nanmand, Kiti

Test Date: Jan. 25, 1996 Direction: NW335°

Interpretation of Subgeology

Depth (m)	Depth (ft)	Resistivity ρ_2/ρ_1	Resistivity ρ (Ohm-m)	Lithology
0–1.0	0–3.3	1/1.5	770	Sandy soil
–4.0	–13	1/6	513	Talus
–15	–49'	25	86	Saprolite
–50	–164		2150	Basalt with fractures at 50m depth

Remarks:

1. Saprolite bottom looks like at the depth between 15–19 m (49–62 ft).
2. It is expected to produce 10–20 gpm groundwater. It will be sufficient for the demand of 300 people.
3. Water well should be drilled to 70 feet in depth with at least 4" in diameter for casing & screen.

MIC/91/007 PROJECT
Water Resources Assessment and Development

4. At most use 3/4 HP pump. It spend 724 KWh per month.

Figure 4. Schematic layout of the Nan Mand Water Supply System - 1996 flows.

Figure 4. Schematic layout of the Nan Mand Water Supply System - 2006 flows.

Figure 5. Schematic layout of the Nan Mand Water Supply System - 2016 flows.

ANNEX 1: RESISTIVITY SOUNDING DETECTION