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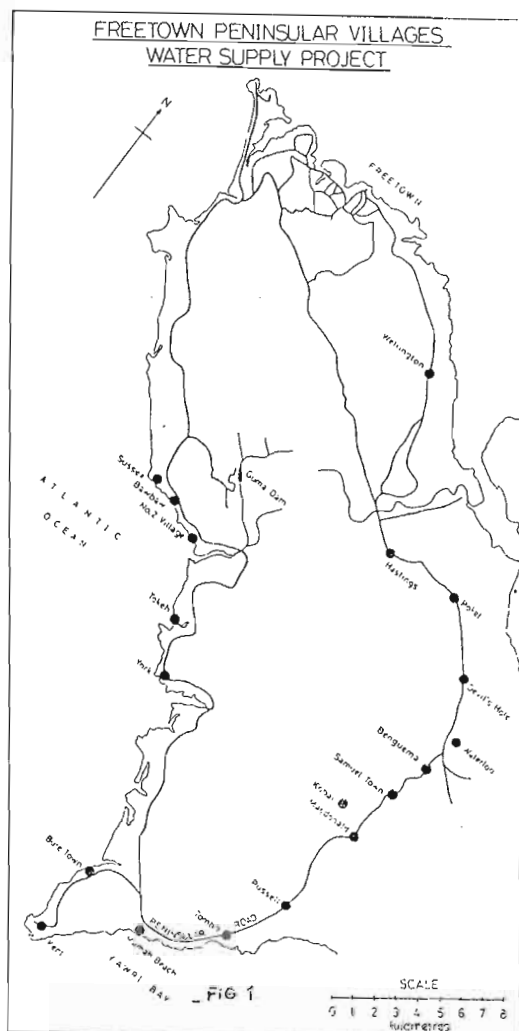
Simple village gravity water supply

Philip Boocock

1. INTRODUCTION

Providing potable water supplies for villages of a few hundred people is a requirement occurring numerous times throughout the world. This paper describes a scheme for meeting this requirement in the Freetown Peninsula of Sierra Leone, West Africa.

The scheme was one of many stimulated by the United Nations World Water Decade. With a mortality rate for under 5 year olds of 30%, it was considered a suitable area to try and improve health standards by decreasing the incidence of water borne diseases. The area consisted of a coastal strip, of some 50 kms in extent, with well wooded hills rising to some 800m. in height. Some dry season streams were known to exist.



2. CONDITIONS

The project was to provide potable piped water by gravity to some 17 village and small towns around the Freetown Peninsular. It originated from a three way discussion between

- (a) Ministry of Energy and Power, Water Division Sierra Leone (M.E.P).
- (b) Water Aid United Kingdom, and
- (c) C.A.R.E., Sierra Leone Branch.

Engineering, survey and design staff to be supplied by Water Aid. Transport, accommodation and support staff to be provided by M.E.P. Major finance by C.A.R.E.

3. METHOD

Surveying

Maps to scale 1:10,000 were mostly available from the Directorate of Overseas Surveys. From these and by consultation with local people rivers which offered potential sources were identified.

(a) Field investigations were carried out to identify the most suitable source for for a particular village.

(b) Temporary bench works were established at a selected spot on the source river and in the village to check that the head was adequate.

(c) A tentative pipeline route was identified on the maps.

(d) Starting at the source a pilot line was established, using a hand bearing compass and referring to the maps.

(e) Elevations were judged by eye and the route altered where necessary.

(f) Once the pilot line was established, the route was cleared sufficiently for the survey party to proceed with theodolite and levels.

(g) Distances along the ground were measured with a 50m tape and marked with red painted stakes.

(h) Levels were taken every 50m and a longitudinal section drawn.

4. DESIGN

A typical set of calculations follows:

Current population 500
 2.8% pa growth, 10 yr 700 say, for design purposes
 Allowing 40 litres/person/day
 = 40 x 700 = 28,000 litres/day
 Allowing 10% leakage, say 31,000 litres/day

Water source for gravity supply, small dam in stream

Quality pH = 6

Flow measured by calibrated bucket collecting all flow and timed, V-notch method not necessary. Dry season flow.

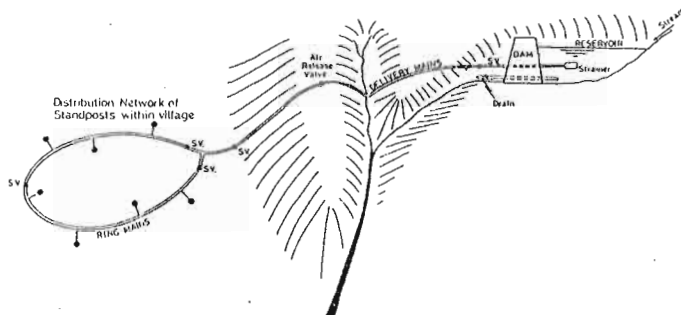
D.S.F. = 1.5 litres/second = 115,200 litres/day

Heads and Losses

Water level at source = 26.638m (88ft)
 Highest level in village = 2m (6.56ft)
 Head losses for flows of 0.5 l/sec (= 38,400 l/day)

Losses, extra lengths to be added

FIG. 2] SCHEMATIC DIAGRAM OF A TYPICAL GRAVITY SYSTEM



Strainers at inlet, large = 2m
 small = 2m
 Gate valves, 2 no. = 1m
 Pipeline length = 1600m + 5 = 1605m
 Friction head in main = 5 x 1605/1000 = 8m
 For 37mm, 1½ in. pipe Ref.1 page 18
 Available head below end of main =
 (26.6 - 2) - 8 = 16.6m
 (sufficient for good flow from taps)

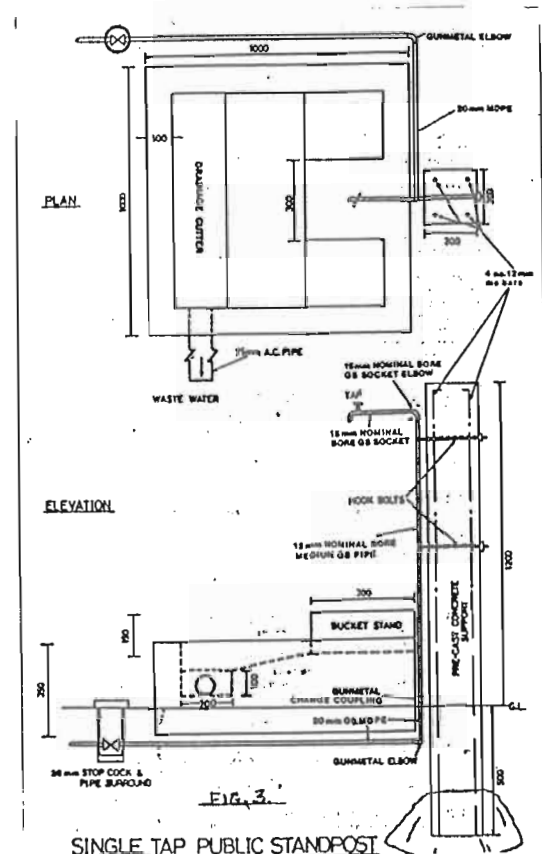
Adequacy of Sources

These have been selected following observations of lowest flows during the dry season, February to May.

The flow was considered adequate if it was able to supply 50 litres/head/day to the projected population in ten years time, based on a 2.8% annual growth rate. The following table shows the population that can be supported by a range of flows.

Flow (litres/sec)	Quantity (litres per day)	10% leakage wastage (litres per day)	Population factor
0.5	43200	38880	778
1.0	86400	77760	1555
1.5	129600	116640	2333
2.0	172800	155520	3110
2.5	216000	194400	3888

When a suitable stream had been located, it was necessary to select a site for the intake, based on topographical features and on storage potential. To determine the latter, we considered a peak flow requirement to be 3½ times the average, and allowed for one hour flow at this rate. The following table shows the storage volume required to supply the peak demand.



Flow (litres/sec)	Peak Flow (Litres/sec)	Quantity Required in 1 hour (Litres)	Volume (M) 3 (includes + 10% Waste Factor)
0.5	1.75	6300	6.93
1.0	3.50	12600	13.86
1.5	5.25	18900	20.79
2.0	7.00	25200	27.72
2.5	8.75	31500	34.65

Streams selected have not always been the nearest, due to such factors as (a) adequacy of flow, (b) pollution and (c) requirements for other purposes, such as horticulture. There is a major stream, Big Water, 2.5km east of York with an estimated dry weather flow of 100 litres/second which has not been used so far. This could be a source for a possible Peninsular Ring Main in the future.

5. CONSTRUCTION

A suitable stream is located which is adequate to supply the requirements of each village for the next ten years and tapped at a level to provide sufficient head. An intake structure or small concrete dam is constructed, as necessary and is provided with a drain valve for cleaning purposes and a double strainer on the inlet to the main pipe. Reference Figure 2. The main pipe has stop valves at each end and air release valves at any high points or where considered necessary. The lower end of the main is connected to a distribution system, preferably a ring main, to equalise the pressures available at standposts. Standpipes, which drained concrete trays are tapped off the ring service main and provided with stopvalves and taps. Reference Figure 3. It is not within the provision of these schemes to arrange for private connections, but M.E.P. already has a scheme in existence to cater for these consumers.

Upstream, polyethylene medium density pipe would be used. Anchor blocks would be provided at suitable intervals. Galvanised medium steel pipe would be

used in populated areas, also for inlet works in the stream bed. Anchorage straps on the pipe would be used where necessary. Skilled labour - M.E.P. to provide. Unskilled labour - each village to provide Supervisor - Water Aid and M.E.P. to provide.

Workshop

A central plumbers workshop be established before work on the sites begins.

6. MAINTENANCE

It is obvious from inspection of existing schemes that failures have been mostly caused by lack of funds for maintenance. This has also been substantiated by scrutiny of the Water Supply Division's annual budget and funds granted. Therefore, any new schemes, however straightforward, must have a provision for maintenance otherwise in due course they will fail. It is considered of paramount importance to make detailed provision for the maintenance input at the time schemes are constructed, so that faults can receive immediate attention. Considerable provision for this input has been inserted in the early part of these proposals and working details, since it is considered to be crucial to the success of the schemes as a whole. These proposals are in fact, very similar to those prevailing in U.K. Water Companies and Guma Valley Water Company which are successful enterprises. It should be noted that the recurring annual input (marked * for this purpose), which must be provided, totals £12-15,000.

Organisation

The Peninsula, as administered by the Water Supply Division, Ministry of Energy and Power, consists of an area of approximately 500 sq.km. The nearest village to the Freetown offices and depot is Bawhaw, 16km away; the farthest is Kent, some 55 km and 1½ hours journey by road from Freetown. M.E.P. to retain overall responsibility for maintaining the scheme.

A stock of spare parts be provided by the funding agency; M.E.P. should then take over the responsibility of maintaining this stock at the initial level. Village technicians should be trained to carry out basic maintenance of the standposts. They should be capable of replacing taps, stopcocks and washers; tools must therefore be provided. They would also be responsible for keeping the standpost area clean.

PENINSULAR VILLAGES WATER SUPPLY - 3 YEAR BUDGET CONSTRUCTION COSTS
Costs in £ Sterling

NO.	VILLAGE	POPULATION	1983/4	1984/5	1985/6	DURATION		NOTES
						DESIGN	CONSTRUCTION	
1	BAMBAM	650		7,600		2 weeks	3 weeks	Drawings commenced
2	KO. 2 VILLAGE	300		5,800		3 "	12 "	" "
3	YOKER	500	6,760			1 "	8 "	Design mostly completed
4	YORK	2,150	22,385			0 "	12 "	Design completed
5	BURE TOWN	370		5,000		4 "	8 "	
6	KENT	200				1 "	5 "	Design part completed
7	NANAN BEACH/ MOXCA MIAM	800	8,300			1 "	1 "	Design part completed
8	TOND	8,000 EST.				1 "	1 "	Probably not required as C22 have built. Check in 1983/4.
9	RUSSELL	220		3,300		5 "	7 "	
10	MACDONALD/KORAI	480			7,600	8 "	8 "	Drawings partly completed
11	SANDEL TOWN	280			5,300	5 "	5 "	
12	JENCULINA	350			5,700	5 "	5 "	
13	WATERLOO	20,000			91,000	12 "	12 "	Amount very approximate, as no investigation so far.
14	HASTINGS	4,300		7,600		2 "	6 "	
15	BEVIL HOLE	300		3,300		2 "	4 "	
16	MAINTENANCE	-	17,100	16,750	15,600	7 "	2 "	Time required for setting up depot.
17	PLANT & TOOLS	-	11,000	1,000	1,000	3 "	3 "	Time required for starting work.
TOTAL POPULATION		39,000						
TOTAL INVESTMENT			(£,000)	59,750	176,900	60 wks	130 wks	TOTAL COST - £252,650
FOR YEAR			1983/4	1984/5	1985/6			

The M.E.P. area foreman would be readily available to advise them at no cost.

A village water committee should be set up to include the headman, his deputy, the M.E.P. area foreman and elected representatives of the water consumers (especially women who are generally the water bearers).

The role of the village water committee would be:-

To nominate the village technicians and ensure that they carry out their jobs adequately.

To ensure that any faults in the mains system are reported to M.E.P. area/or head office.

To report any faulty private connections and ensure that appropriate action is taken to remedy them.

To collect a suitable levy from the users of public standposts.

To promote the concept of the relationship between clean drinking water, sanitation and health within the village. Only when this is understood will it be possible to raise the levies to a more viable level without the risk of people reverting to present "less safe" water sources. It is also to be expected that this role of the committee will ensure that the sources and inlet works remain unpolluted.

These roles of the committee could be enlarged to cover other development projects when funds are available, e.g. pit latrines and wash houses.

The levy would contain two elements:-

An amount to pay water rates to M.E.P. head office, if and when the relevant legislation becomes effective.

A contribution to a capital fund to pay the technicians and repair the standposts.

Probably the best method is to collect a weekly/monthly tariff from each household based on the number of people residing there.

Finally, since people are not used to paying for water, the two levies should be low at first.

It will be advisable to divide the Peninsular into areas, as has already been partly done, and the following are suggested namely, (a) York, (b) Tombo, (c) Macdonald, (d) Waterloo, and (e) Hastings.

The composition of the areas would be as follows:-

- (a) York Area - Bawbaw, Tokeh, No. 2 Village and York
- (b) Tombo Area - Kent, Bure Town, Mamah Beach, Tombo & Russell
- (c) Macdonald - Macdonald, Kobai, Samuel Town, Benguema

(d) Waterloo - Urban Area

(e) Hastings - Urban Area

A foreman would be stationed at each village area above (such an arrangement already partly operates at York and Tombo areas), and be provided with a store, spares, labour and a motor cycle with adequate tools/spares box.

He would carry out weekly inspections of all dams and plant, other than taps, which would be dealt with by the local village technicians.

The Foreman would report defects and requirements to the Senior Supervisor or his Deputy by (i) a special journey to Freetown offices, (ii) by a monthly visit of the Senior Supervisor/Deputy or, (iii) contact with one of the travelling service vehicles (see below).

Travelling Service Vehicles - These would consist of 2 No. 5-seater cabs, open truck type with pipe rack (2 litre diesel). Any smaller vehicle has not proved robust enough for the road conditions.

T.S.V. Staff - A junior supervisor would accompany one or more gangs and these would consist of a plumber/fitter, assistant and a labourer.

Central Plumbers Workshop and Store - This would be set up at the Water Supply Division depot at Tower Hill, Freetown.

Monitoring of Maintenance Scheme - A Senior Engineer would accompany the Supervisor every three months on the latter's monthly visit. The Senior Engineer would then present a written report to the Chief Engineer. The Sponsors in turn would make biennial visits to judge the efficiency of the arrangements suggested.

7. CONCLUSION

Gravity schemes can be designed and built in suitable terrain to be extremely cost effective. Very basic maintenance only is required, but this is essential. They can be built for less than £10 per head of population, even at 1989 prices.

8. ACKNOWLEDGEMENTS.

To M.E.P., Water Aid, especially Steve Darvill (who worked as a partner colleague) C.A.R.E., V.S.O., S.W.A., and all colleagues and friends who helped.

9. REFERENCES

MANN and WILLIAMSON
Water Treatment and Sanitation
Intermediate Technology
Southampton Row
LONDON
England