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A VILLAGE LEVEL OPERATION & MAINTENANCE (VLOM) SYSTEM FOR "WATSAN PROJECT" HANDPUMP EQUIPPED BOREHOLES IN NIGERIA

Prepared by: L. D. Donaldson (Water Supply Officer)
M. Karim (Equipment Maintenance Instructor)
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1. INTRODUCTION

1.1 PURPOSE AND STRUCTURE

This document is prepared to guide the UNICEF Assisted WATSAN Projects in Nigeria in implementing the VLOM concept as part of their Water Supply management strategy. Success is likely to be emulated by other water supply Organisations serving the Country. The timing is opportune since the Federal Government of Nigeria has identified Community Participation as a major plank for rural development. Through its Directorate for Food, Roads and Rural Infrastructure (DFRRI); in 1987 it implemented a Nationwide Rural Water and Sanitation (RUWATSAN) policy based on the UNICEF Assisted WATSAN development strategy. Additionally the Federal Ministry of Health, in its Primary Health Care strategy, may find the linkage of health and water supply valuable because of many similarities between the Bamako Initiative on Drugs and Community responsibility for sustaining their water supply.

The report is structured for Managers to use the main portion to advocate for increased attention and resources allocation for handpump maintenance while the self sufficient Appendix can be to be used to train maintainance personnel.

1.2. DEFINITION OF VLOM

VLOM is a concept that entrusts maintenance, and thereby sustainability, of a service facility to its users. For Handpump Equipped Boreholes 30 Sub-Saharan Countries, at a 1986 meeting in Abidjan, Cote d'Ivoire; recommended the system for planning and implementing low cost rural water supply programmes. The key part of what is now known as the Abidjan Statement is:-

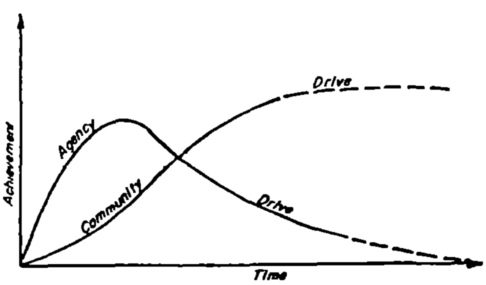
> **"Maintenance is the key to long term success. Community Maintenance, supported by a National Strategy of Standardisation and well organised distribution of spareparts, brings substantial increase in reliability and reductions in recurrent costs bringing per capita costs down substantially when compared with the alternatives of centralised Maintenance practices in many countries ...."**

The Statement arose against the experience that, while solutions can usually be found for installation and implementation problems, it is the operation phase that marks the difference between success or failure. This is particularly true for Nigeria where many rural water supply schemes have failed to provide the intended service because of poor maintenance.

1.3 NEED FOR IMPLEMENTATION OF VLOM

The need for VLOM in rural water supply sustenance is appropriately illustrated in Figure 1. It shows that whereas Government (Agency Driven) schemes can be implemented quickly, performance falls off as against a scheme with a slower initial implementation rate that considers the needs and potentials of the Community.

Fig. 1 : Comparison of Likely Project Sustainability (Agency vs Community Driven)



1.3.1 Increasing Handpump Population

There were in 1987 about 13,500 handpump equipped boreholes serving rural Communities in Nigeria. The numbers developed by different Agencies in 1987, and projected to 1990, are as follows:

	1987	1990
WATSAN Projects (Imo, Gongola, Kwara, Cross River, Niger and Anambra States plus FMOH Rural Clinics)	1,500	3,600
World Bank/UNDP Projects (in Northern States)	7,000	7,000
DFRRI RUWATSAN Project in 21 States	5,000	20,750
Total	13,500	31,350

At a designed service of 500 persons per borehole the estimated present, and projected (1990), benefitting populations are 6.75 M and 15.7 M respectively. The boreholes are scattered throughout the rural areas where poor access and great distances from central workshops and support service militate against success of conventional maintenance systems.

1.3.2 Protection of Investment in Handpump Technology

At an average cost of Naira 50,000 per handpump equipped borehole the 1987 investment is Naira 690 million which is projected to increase to Naira 1,583 million by 1990. WATSAN Projects therefore have a vested interest in evolving a replicable maintenance strategy since failure could call into question the suitability of the handpump technology and could lead to advocacy by policy makers and dissatisfied Users for change to more expensive, conventional systems which have already failed in the passed....!

2. PREREQUISITES FOR SUCCESSFULL VLOM

2.1 TECHNICAL

The old adage "prevention is better than cure" is an appropriate reminder that well designed and constructed civil works minimise maintenance. Successfull schemes must therefore provide adequately for maintenance at the design, costing, construction, and operation phases.

2.1.1 Adequately Designed and Constructed Boreholes

Handpumps are sensitive to sand which wears "down-the-hole" pump components. A borehole must therefore be appropriately designed and well constructed to produce sand free water. This includes appropriate screen and gravel pack (as necessary in most sedimentary formations); use of corrosion resistant material in ground water with low pH and low Total Dissolved Solids; secure level foundation for pump base; and suitable grouting to prevent contamination of the borehole water.

2.1.2 Knowledge of Specifications of Handpumps

The handpump plunger should be installed 3 m below the minimum (dry season) static water level, to accommodate seasonal water level fluctuations, and 2 m above the bottom of the borehole to prevent suction of sand. This requires an adequate Pump Test to determine the number of riser pipes and connecting rods, which must be carefully cut and threaded.

Additionally handpumps should be:

- Easily installed, withdrawn, and "taken apart" for inspection and servicing.

- Rugged to withstand the designed (service population) use. It is vital that the optimal yield/stroke ratio for smooth operation and conservation of User's energy be known.

2.2 COMMUNAL

There is high probability that a system will not be effectively used, or that it will fall quickly into disrepair, unless Community enthusiasm is present and ownership fostered, at the time the programme is being designed and implemented. For handpump equipped boreholes in rural areas the involvement of the Community is vital since conventional (centralised) maintenance services are usually difficult to deliver to extensive, remote rural areas of difficult accessibility.

2.2.1 Appropriately Trained Users

Improperly trained Users can cause abnormal wear and tear of the handpump (including premature breakage of connecting rods) by using short and fast strokes rather than steady, full strokes.

2.2.2 Rational Service Population per Borehole

Optimal benefit from the use of handpumped borehole water supply in Nigeria indicates an absolute maximum distribution of one borehole per 500 people. This is based on an average handpump capability of 0.25 l/s (i.e. 10,800 l/day for a 12 hour day). Assuming 30% usage for washing buckets, this leaves 7,560 l/day which for 500 people is 15 l/capita/day. Experiences have shown that application of such designed use will:

a) Maximize the health benefits from a reliable, safe, water supply;

b) Reduce the distance women and children trek to fetch water, ideally the maximum distance from household to handpump should be of 1000 m;

c) Ensure an optimal life for the pump and lessen breakdowns that would arise if a larger population used the facility.

2.3. Financial

Adequate funding by the Government or the User is necessary to procure the spareparts and pay maintenance workers. At present access by the Community to procure spareparts is limited since most handpumps, and their required spares, are imported. Local manufacture of handpumps is currently being supported in Nigeria to reduce dependence on importation. This should include manufacturing of spares and training facilities for pump Caretakers, both of which have been started by one local handpump Manufacturer.

3. ANALYSIS OF VLOM

3.1 ORGANISATION

Figure 1 shows a schematic representation of the operations of an ideal VLOM system. It indicates a cyclic flow of funds between Users and the Government Agencies (the State and the L.G.A.) that are to be intimately associated with VLOM. Figure 2 details the numbers of Staff to be provided by the State and the L.G.A.

Fig. 2: Flow Chart Showing Resposibilities of Govt. and Community in VLOM system

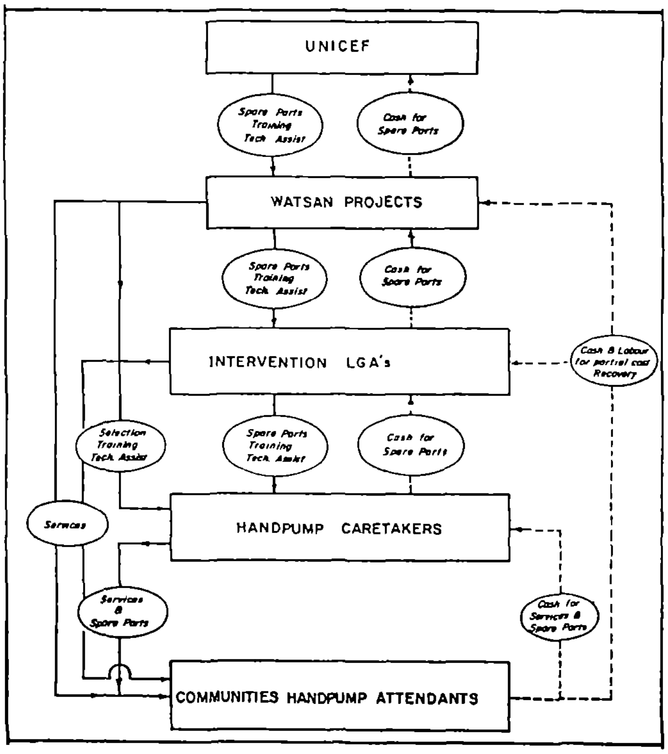
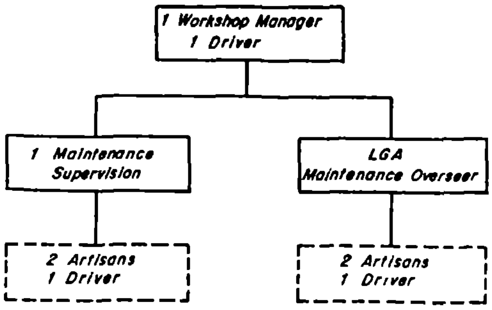


Fig. 3: Organogram showing Govt. Staffing Required to Support VLOM



3.1.1 Responsibilities of the Project

The role of the Project must be always supportive and not routinely operational. This is vital since the staff, transport and finances that would be required for responsive maintenance for so many pumps is beyond the affordability of most, if not all, Projects. The envisaged responsibilities of the Project are therefore to:

a) Train LGA Maintenance Teams so that they will understand the VLOM system, have capability to undertake specialized repairs, and be capable of monitoring the work of the Community Level Caretakers.

b) Assist the Communities to select, and the LGAs to train and certify, the selected Caretakers.

c) Prepare monthly maintenance report collated from those by the LGA Teams.

d) Maintain spareparts inventory system and replenish LGA stocks.

e) Integrate maintenance strategy into PHC concept.

f) Undertake repairs which cannot be done in the villages, e.g. welding.

g) Distribute (sell) spares to the LGAs.

3.1.2 Responsibilities of LGA

The LGA is the vital link between the Community and the Project Office. It must therefore be allocated sufficient resources to:

a) Support Project Team in selecting and training of Caretakers.

b) Register Caretakers, and renew their licences every 2 years.

c) Monitor performance of Caretakers including submitting monthly reports to Project Office.

d) Conduct repairs referred to it by Caretakers

e) Maintain spareparts inventory system including selling spareparts to Caretakers and purchasing spareparts from Project Office.

f) Integrate PHC messages into Community.

3.1.3 Responsibilities of the Communities

Communities should provide the resources to ensure sustainability of their handpumps. They may vest responsibilities for VLOM to a Village Committee which would;

a) coordinate the activities of the Handpump Caretakers, the VBW. and the User.

b) fix compensation for the Caretaker and the VBW.

c) arrange for Caretaker or LGA Office to be contacted as necessary.

Handpump Caretaker

The responsibilities of the Handpump Caretaker are detailed in Appendix A 7. It is envisaged that one Caretaker can maintain 10 - 15 handpumps (10 selected for costings). For effectiveness the Caretaker must reside in, or near to, a Community so that a bicycle or motor cycle (motor cycle used in costing) can be used for transportation.

Users

Success of VLOM requires awareness and cooperative Users who accept the service and are willing to contribute towards its maintenance. Significant improvement in user awareness of their responsibilities (detailed in Appendix A 9) can be gained by increased Community involvement and demonstration of proper pump use through appropriate communication and education techniques. Local handpump manufacturers should have a vested interest in including such training component as part of the marketing strategy for their products.

3.2 COMPARISON OF VLOM WITH NON-VLOM STRATEGIES

Table 1 indicates the respective roles of the Government and the Community for VLOM compared with the alternative systems.

Table 1: Comparison of VLOM and Non-VLOM Maintenance Systems

ADVANTAGES	DISADVANTAGES
A VLOM	
1. Easy integration with PHC programme; 2. Funds generated, and used, within the Community; 3. Short response time for action; 4. User ownership ensures safety and durability of systems; 5. Involves LGA in Administration.	1. Requires access by Community to well; 2. Trained and dedicated personnel; 3. Requires high level of Mobilization to promote acceptability by Users; 4. Community Leaders can abuse position by restricting use.
B Government Funded and Operated System	
1. Funds provided in Budget; 2. Recognition of the need for adequate maintenance by Govt.; 3. Easy to Integrate with other PHC interventions.	1. Top-Bottom beaurocratic structure causes high cost external to Users; 2. Long communication channel delays action at user end; 3. Possibility of diverting funds to other purposes; 4. Community do not perceive themselves as owners and may abuse facilities.
C Community Funded, Private Sector Operated, System	
1. No strain on the Govt Budget; 2. Quick response since Operators will want to maximise profit; 3. Quality workmanship guaranteed if payment tied to performance.	1. Services difficult to integrate with the other PHC Components; 2. Abdication of Government role to provide service to justify taxation; 3. Inability of some Communities to meet the costs.

3.3 REQUIREMENTS TO SET UP VLOM, COMPARED TO NON-VLOM SYSTEMS

Table 2 summarises the financial, human and transport inputs to set up VLOM as compared to a Government, and a Private Sector Non - VLOM operated system. The costs assume a borehole population of 400 boreholes in each Project and useful lives of 20 and 15 years respectively for a borehole and the handpump. Additionally it presumes that Private Operators will have the same cost factors as the Government operated system but earn a margin of 25% as return for the use of private capital.

Table 2: Comparative Logistics and Cost Required For VLOM.

Requirements		VLOM										NON-VLOM						
		Project			LGA			Community			Total	Project			Private			Remarks on Reqirements
No	Description	No	% Use	Cost N	No	% Use	Cost N (000)	No	% Use	Cost N (000)		No	% Use	Cost N (000)	No	%	Cost N (000)	
A	Facilities Workshop (1)	1	10	2000	1	20	600				2600	1	20	4000	?	25	5000	Useful life = 30 yrs
B	Staff/Franchaisee																	
1	W/shop Manager + Driver	1	20	5000							5000	1	40	10000	1	50	12500	
2	Maintenance Team																	
a	Supervisor	1	100	8000	1	100	5000				13000	4	100	32000	?	125	40000	
b	Artisan	2	100	10000	2	100	8000				18000	8	100	40000	?	125	50000	
c	Driver	1	100	5000	1	100	4000				9000	4	100	20000	?	125	25000	
3	Community Mobilizer (2)	1	20	3000	1	30	4500				7500	1	40	6000	1	100	15000	
4	Caretakers							40	100	50000	60000							1 per 10 HP
5	Village Based Workers							400	?	?		400	?	?	400	?	?	1 per HP
C	Vehicle/Equipment/Tool																	
1	W/shop Manager's Vehicle(3)	1	20	4800							4800	1	40	9600		50	10660	Useful life = 5 yrs
2	Pickup + Trailer (4)	1	100	30000	1	50	15000				45000	4	100	120000	?	125	145000	Useful life = 5 yrs
3	Motorcycle (5)				8	100	32000				32000							Useful life = 3 yrs
4	Set of Tools	1	100	200	4	100	800	40	100	8000	9000	40	100	8000	40	125	10000	Useful life = 3 yrs
D	Spare parts for vehicles																	
1	W/shop Managers veh	1	20	24000	1	50	12000				36000	1	30	36000	1	37 5	45000	% of Vehicle Cost
2	Caretakers Motorcycle				8	100	19200				19200							% of Vehicle Cost
3	Spare parts for HP (6)							400	6 25	112500	112500	400	5	90000	400	6 25	112500	% of Handpump Cost
	Annualised Total			92000			101100			180500	373600			375600			470660	
	COST PER BOREHOLE (7)			230			253			451	934			939			1177	
	COST PER CAPITA (8)			0 46			0 5			0 9	1 87			1 88			2 35	

(1) Workshop facilities for Project estimated at N600,000 and N100,000 respectively
(2) Ccommunity Mobilizer/Health Eucator for the Private System would be a cost to Government
(3) Cost of Hilux 4 wheel Drive Diesel Pickup = N120,000
(4) Cost of Hilux 4 wheel Diesel Pickup + Trailer = N150,000
(5) Cost of Motorcycle = N12,000
(6) Cost of Handpump = N4,500 (without Riser Pipes
(7) Cost per borehole = Annualised Total/400
(8) Cost per capita = Cost per borehole/500

The cost per borehole compares favourably with the findings of The Sokoto Agricultural and Rural Development Authority - SARDA which, in 1986 for a borehole population of 1,400; estimated a direct maintenance cost per handpump (excluding overheads and depreciation) of Naira 250 per year. When commuted to 1988 costs this would be about Naira 1500 per year.

3.4 IMPLICATIONS OF CONVERTING TO VLOM

UNICEF Assisted WATSAN Projects in Nigeria, as well as DFRRI - based on its "Policy and Implementation Guidelines", have taken the decision that handpump development in Nigeria must incorporate the VLOM concept.

3.4.1 Technical Implications

Conversion of Handpumps

VLOM will require that the 1 1/4" riser pipe and water tank of the "Standard" India Mark II handpump be replaced by its 2 1/2" "Open Top" version. The change will allow for withdrawal of the connecting rods and plunger without removal of the riser pipes. This will facilitate Community maintenance of down-the-hole pump components since it does not require costly accessory equipment like a hoist.

Appropriate Handpump Installation Materials.

Groundwaters in Nigeria are very frequently corrosive, which implies that selection of corrosion resistant riser pipes and connecting rods are important for the success of VLOM. This is especially important since for VLOM the riser mains will not regularly be removed for inspection.

Failure of galvanized iron (GI) riser pipes installed in groundwaters with pH less than 6.5 forced UNICEF to change all pipes in the Imo State WATSAN Project to PVC in 1984. The latter also failed and was ultimately substituted by stainless steel (SS) in 1986.

The cost of SS riser pipes however is so prohibitive, especially the 2 1/2" size required for VLOM, that its large scale use could make handpump technology unattractive. Consequently, in collaboration with the local Private Sector, UNICEF is undertaking investigations to adopt a new design of riser pipes using PVC once again. The innovations consist of:

a) Male treading on both ends of the riser pipes (3 m long) joined couplings;

b) Couplings serve also as spacers to minimize horizontal movements during pumping;

c) Two steel cables will suspend the down-the-hole installation to minimize vertical movements;

d) Spacers will be installed inside each riser pipe to prevent contact with connecting rods.

The improved design of PVC riser mains seems feasible but will require field testing for confirmation. The field testing will start in January 1989.

Appropriate Types of Handpumps

Handpumps selected for proliferation must be amenable to the VLOM concept of Community involvement in maintenance. The Federal Government of Nigeria, through DFRRI and the Federal Department of Water Resources (FDWR), jointly with the World Bank, UNDP and UNICEF are participating in field testing of selected imported and locally manufactured pumps to determine those that are most appropriate for the VLOM concept so they can be recommended for large scale local manufacture.

3.4.2 Cost Implications

Conversion of Existing System

Table 3 analyses the financial implications for the estimated 1500 pumps that would require conversion from "Standard" to "Open Top" and incorporates the differential costs for several alternatives of riser pipes and connecting rods. The data shows that:

- Conversion will require a financial input of Naira 14.5 million if the change to VLOM is based entirely on SS riser mains.

- The cost of the conversion would be about 50% of that for the use of SS riser pipes if PVC were to be substituted for SS.

The differential cost for the different types of riser pipes highlights clearly the significance of the research being undertaken with local PVC manufacturers, since success would reduce the cost from about Naira 9,700 per installation to a minimum value of Naira 4,500 if PVC were to be used.

Although the average borehole installation depth (about 30 metres) indicates that total substitution is theoretically feasible, even a mix of 50/50 would reduce the investment to Naira 11.1 million, i.e. an average of Naira 7,500 per borehole.

Increased Cost of Handpumped Water Supply

After the conversion of the 1500 existing handpumps, implementation of VLOM will involve a differential cost for handpumped water supply. Table 4 indicates that, for the estimated borehole production rate of 600 per year and allowing for the potential salvage value of the present installed riser mains, there would be an approximate increase of Naira 3.18 million per year for total SS conversion and Naira 58,000 if total PVC substitution were to be effected, with Naira 0.66 million if a 50/50 mixed was feasible. The corresponding unit installation cost would be Naira 5,300 for 100% SS, Naira 100 for 100% PVC, and Naira 1100 for a 50/50 mix.

Table 4: Constant Cost Differential with Adoption of VLOM

COST ITEMS:		EXISTING SY STEM (1)												DIFFERENTIAL COST (2)-(1)	
NO	DESCRIPTION	No.		UNIT COST $		TOTAL COST			UNIT COST ($)			TOTAL COST $			
		G I.	S.S.	G I	S S	G I	S S	NO	G I	S.S.	P V C	100% S S	100% PVC	100% S.S	100% PVC
A	CAPITAL														
a	India Mark II HP·	600	-	1,200	-	120,000	-	600	1,800	-	-	1,080,000	1,080,000	960,000	960,000
b 1	Riser Mains (10 per B H)	2,000	4,000	90	480	180,000	+1,920,000	6,000	-	720	200	4,320,000	1,200,000	2,220,000	(900,000)
	TOTAL	-	-	-	-	2,220,000		-	-	-	-	5,400,000	2,280,000	3,180,000	60,000
B	RECURRENT														
a	Maintenance		-	-	-	375,600		-	373,600		-	373,600	373,600	(2,000)	(2,000)
	TOTAL	-	-	-	-	2,595,600		-	373,600	-	-	5,773,600	2,653,600	3,178,000	58,000
	COST PER B H PER YR. / 600 (1)	-	-	-	-			-	-	-	-			5,297	97
	COST PER CAPITA PER YR. (1)/500.	-	-	-	-			-	-	-	-			11	0

Table 3: Costs To Convert 1500 Handpumps for Consistency With VLOM

COST ITEMS.		QUANTITY			TIME	REQUIRED FOR VLOM				
NO	DESCRIPTION	2 1/2"	1 1/4"		(YRS.)	UNIT COST ($)			TOTAL COST $	
			G.I.	S.S.		G.I.	S.S.	P.V.C	100% S.S.	100% PVC
A	MATERIAL COSTS									
a	India Mark II HP.	1,500				180			270,000	270,000
b 1	Riser Mains (10 per B H)	15,000				-	720	200	10,800,000	3,000,000
2	Sale of Riser Pipes	15,000	4,500	10,500		9	72		(796,500)	(796,500)
c	Connecting Rods (10 per B H)	15,000	1,500			-	180		270,000	270,000
	SUB-TOTAL	-	-	-		-	-	-	10,543,500	2,743,500
B	LOGISTICS COST									
a	4 Man Team to convert 50 HP/MTH.	30			2.5	23,000/Team			1,725,000	1,725,000
b	Vehicles									
1	Depreciation				2.5	15000/YR/VEH.			1,125,000	1,125,000
2	Running Costs				2.5	15000/YR/VEH.			1,125,000	1,125,000
	SUB-TOTAL	-	-	-		-	-	-	3,975,000	3,975,000
	TOTAL	-	-	-		-	-	-	14,518,500	6,718,500
	COST PER B H / 1500 (1)	-	-	-		-	-	-	9,679	4,479
	COST PER CAPITA (1)/500.	-	-	-		-	-	-	19	9

Explanation of Assumptions:

Aa .Represents difference in cost of Open Top (2 1/2") Cylinder Water Tank, Spareparts and Tools as against those for Standard (1 1/4"). Costing based on UNICEF SCF NO. 0759.

Ab.2 ·Salvage value form sale of 1 1/4" G I. and S.S. Riser Mains estimated at 10% of procurement price. Costings based on UNICEF SCF NOS. 495 & 760.

Ac :Charging of 10% of G.I Connecting Rods which would require changing. Costing based on UNICEF SCF NOS. 0456 & 083.

General 1·All costings were adjusted to 1988 values and appropriately adjusted for freight charges and exchange rate charges.

General 2.Exchange Rate conversion from US$ to Naira = 6.

Total Annual Cost of Implementing VLOM

Table 5 shows the calculated cost per handpump up to, and after 15 years. The calculations are based on a successfull handpump equipped borehole production rate of 600 per year with each providing the designed service for 500 people. Additionally it is assumed that the 50/50 mix of SS and PVC riser mains will prove feasible and that the cost of conversion of the existing pumps may be capitalised over 15 years (i.e. the usefull life of the pump).

Table 5: Projected Annual Cost Variation for Implementing VLOM

COST ITEMS		COST/YEAR (Naira)					
No.	Description	100% SS	50% SS	100% PVC	100% SS	50% SS	100% PVC
1.	Conversion of 1500 HP's	968000	740000	448000			
2.	Cost of VLOM in perpetuity						
	a) Capital	3180000	540000	60000	3180000	540000	60000
	b) Recurrent	(2000)	(2000)	(2000)	(2000)	(2000)	(2000)
	TOTAL	4146000	1278000	506000	3178000	538000	58000
	Cost per BH	6910	2130	845	5300	890	100
	Cost per Capita	13.8	4.26	1.69	10.6	1.79	0.20

3.4.3. Affordability of VLOM by Community

Capacity of User to Pay

Water is necessary to sustain life and the provision of water requires energy, which in all cases includes a cost. For this Study cost estimates were based on the requirement to provide water for an average family of 8 which requires the women to trek 3 kilometres to provide a minimum requirement of 10 litres for each member (i.e. 80 litres per family). These estimates assume that the woman carries 20 litres (equivalent of 20 kilograms) 4 times per day. If the return trip takes one hour then 2 hours is spent carrying a load of 20 kilograms and 2 hours spent walking to the source.

Based on studies by White and Bradly (1972), a woman will use 190 calories for each empty trip and 210 calories for each loaded trip so that the daily caloric expenditure will be of 1,600 calories i.e. (4 x 190 + 4 x 210).

White and Bradly also estimated a conversion rate from a maize meal to calories of 1 gram maize meal = 3.5 calories. The woman in fetching water uses the equivalent of 430 grams = 0.043 kilograms of maize (i.e. 1,600 divided by 3.5). At a cost of Naira 2.00 per kilogram for maize the family will have an inescapable expenditure of Naira 0.086 per day (i.e. Naira 2.00 x 0.043) to provide sufficient calories for the woman to fetch water. If this work is done 200 days per year (165 taken as rain days in which water is collected at or near the household) then the annual cost is Naira 17.20 (i.e. Naira 0.086 x 200). This translates into:

Naira 2.15 per person/year (for each of the 8 family members), or;

Naira 0.0072 per metre per year (for the trek of 6,000 metres).

Assuming that a handpump is located 250 metres from the family's compound, the annual water collection cost to the family would be of Naira 0.18 i.e. (Naira 0.0072 x 500 metres). This converts to a net saving to the family of Naira 1.97 per person/year (i.e. Naira 2.15 - Naira 0.18).

Apportioning of VLOM Cost to User

Application of the results obtained in Table 5 to the above determined estimated per capita affordabilty level of Naira 1.97 per year indicates that the User would only be able to fund the VLOM system during the first 15 years, i.e. based on 100% utilisation of PVC riser mains. After that he could afford both the 50% and 100% PVC based systems. However if this was done the direct benefit of the improved water supply would be negligible since the savings in energy would be translated into labour to pay for water and not for self development.

3.4.4 Health and Development Impact Needed to Jusify VLOM

Studies by WHO have shown that the impact of safe water supply on health is considerable. The results, documented in Table 6, show that the benefits are maximised if improved personal and household hygiene practices are applied by the User.

Table 6 Impact of Safe Water and Sanitation on Diarrhoeal Morbidity

Improvement in:	Median % Reduction
Water Quality	18
Water Quantity	25
Water Quality and Quantity	37
Excreta Disposal	22

It is interesting to note here first how important excreta disposal by itself can be and secondly that quantity of water has a greater impact upon health than quality, but when both quantity and quality of water are increased benefits are maximised. This is important and borne out by "Pollution Path Studies" carried out by WATSAN Projects (Ologe - October, 1988 of Kwara State and London School of Hygiene and Tropical Medicine et al. 1983 - 1986) which show that there is a significant increase in Faecal Coliform Count (FCC) from the usually 0 mg/l at the handpump to as much as 50,000 FCC/100 ml of water in household containers. The significance of this is that VLOM must be integrated with a health component in its implementation if the desired maximum impact is to be derived. Failure to do this will mean continuation of under-development caused by the vicious cycle of ignorance, poverty and poor hygiene practices.

3.4.5 Funding for Handpumped Rural Water Supply Development

Figure 4, developed by WHO, shows the direct and indirect effects of water supply and sanitation, on health as well as on economic development. It follows therefore that if external assistance is not seen to be making beneficial impact on the lives of the target population then in all probability there will be increasing difficulty to attract such assistance. The domino effect could continue at the National level if the budgetary investment does not result in concrete developmental improvement. The conclusion therefore follows that the people involved in Handpump technology must have vested interest in making it work.

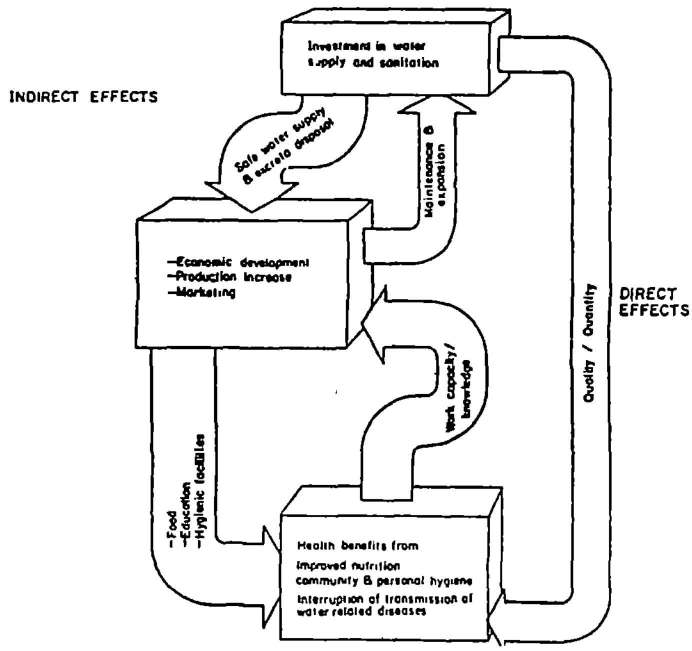


Fig. 4: Direct and Indirect Effect of Water Supply & Sanitation on Health; A Conceptual Framework

4. CONCLUSIONS and RECOMMENDATIONS

4.1 CONCLUSIONS

The foregoing analysis indicates that VLOM is feasible as well as necessary to improve the service provided by handpumps. Success requires the committment of the Project Managers and their Staff to apply their knowledge of appropriate technology to ensure the sustenance of the service provided to the Rural people. However change usually attracts resistance so Implementors of VLOM must be aware of probable sources of frustration such as:

a) Project Officials who may fear giving up direct control for Maintenance because of the anxiety over their jobs or the belief that "ordinary people" cannot do such a complex job.

b) Difficulty in instituting a system where Users probably see provision of water as a social service and would resist payment for it.

c) Insufficient vehicles and financial commitment at the L.G.A. level.

d) Finding suitable candidates for Caretakers and assurance of their continual support when located.

4.2 RECOMMENDATIONS

4.2.1 General

The main general recommendations arising from this analysis are:

a) The framework must be set for successful implementation of VLOM throughout the project planning, construction and operations. When this is done the Community will have accepted the service including its responsibility as a partner in its development, the borehole will have been appropriately constructed and equipped with suitable handpump installation materials, and the flow of spareparts against cash will have been established.

b) Caretakers must be appropriately selected, trained and registered so they have the know-how and the authority to perform their functions.

c) All boreholes must be installed with 2 1/2" riser pipes.

d) Appropriate staff and finances must be provided to ensure sufficient back-up to the Communities and LGA's during the Pilot Project stages.

e) The Communities and LGAs must be treated as full partners.

4.2.2 Apportioning of Costs between Government and Users

It is recommended that the funding of VLOM be guided by the data on Table 3 which show that the Community would pay 50% while the Project and LGA is responsible for 25% each. For the conversion of existing pumps and the increase in cost of the handpump installation materials this could depend on the affordability level of the particular Community. Possibly in some cases a similar percentage contribution could be investigated. However the decision should not be to the detriment of the individual User who needs to improve his economic status.

4.2.3 Strategy and Timeframe

It is desired that the Pilot Project be implemented in each Project urgently so that an interim report can be prepared on the performance by July, 1989.

WATSAN Projects should implement the system in 1 Community of 1 LGA as a pilot Project for monitoring so that data can be collected to facilitate full implentation throughout the Project.

4.2.4 Monitoring of VLOM Implementation

Success of any Maintenance system requires effective and efficient means of reporting so that variations from normal performance or breakdowns may be speedily addressed. For handpumps the need is great since by virtue of their limited service coverage a large number are required for extensive service , and unrepaired pumps may be a disbenefit to health because of reversion of Users to poor alternative water sources. Table 7 sets out the minimum data required for a well run maintenance system.

The single reporting format will:

Allow participation by Caretakers, LGA and Project. This will enable Project Management to continuously review and, if necessary, adjust the operations of VLOM.

Provide inbuilt mechanism for physical, financial and performance monitoring.

Provide checklists for inspection by the Caretakers and VBWS.

It is so structured that a literate (in English) Maintenance personnel will, with adequate training, be able to complete it using the instuctions incorperated in the form. They must therefore form an integral part of any Handpump Maintenance Training course so they can be routinely used.

4.2.5 Final Remarks

During the finalization of this report the UNICEF Nigeria WATSAN Section learned of the existance of a composite material probably carbon-based, with properties similar to that of stainless steel but much cheaper than it. Samples of both rising mains and connecting rods made of this material have been ordered for testing just in case the trials with the newly designed PVC do not proof successful.

Even if PVC proves successful, composite connecting rods could be experimented as their use would reduce the cost of handpump installations even further in the future.

Another interesting trial which will soon be undertaken includes the testing of AFRIDEV subsurface components with India Mark II Handpumps.

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TRAINING GUIDELINES FOR HANDPUMP MAINTENANCE

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LIST OF FIGURES

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TRAINING GUIDELINES FOR HANDPUMP MAINTENANCE

A.1 HYDROLOGIC CYCLE

Figure A.1 graphically illustrates the Hydrologic cycle and shows the interdependence between clouds, oceans, topography, rainfall and ground as well as surface waters. The sources of water can be broadly divided as follows:

- Rain water: collected from roof or rock catchments.
- Surface water: obtained from rivers, springs, lakes or ponds.
- Ground water: abstracted from wells or boreholes.
- Sea water: requires desalinisation for domestic use

Figure A.1 Schematic of the Hydrologic Cycle

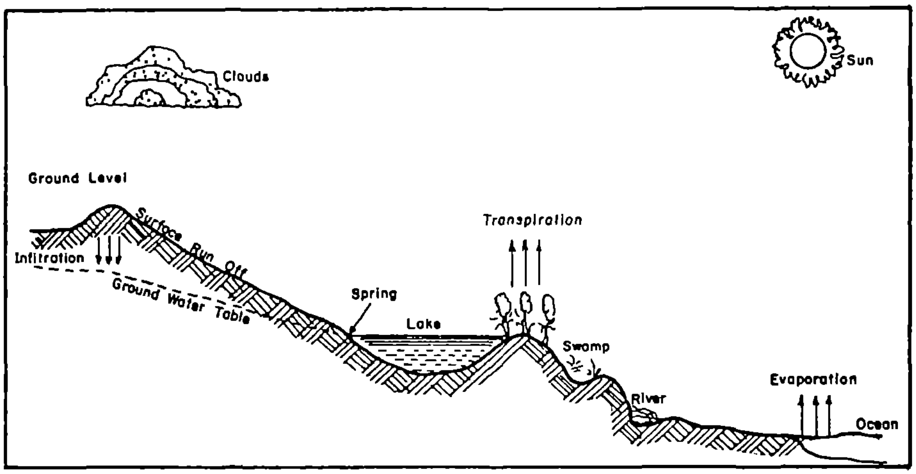
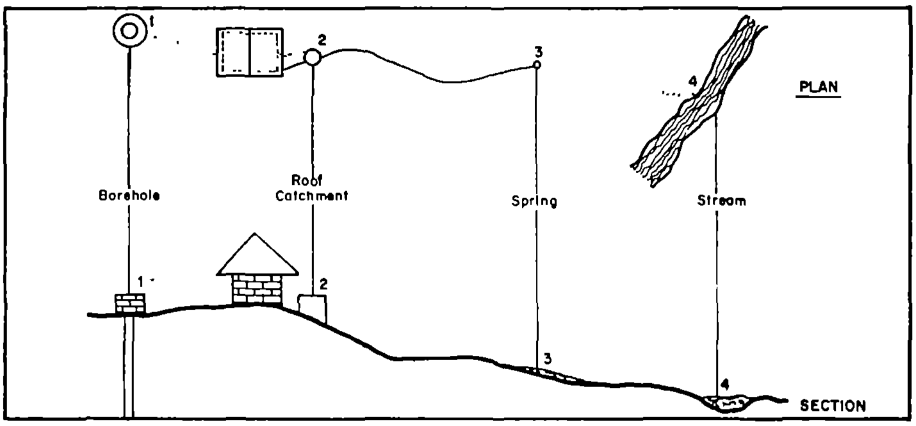


Figure A.2 Sources of Water



A.2 PREFERRED SOURCES OF WATER

Water may become impure during its movement through the hydrologic cycle and this can impair its use. The method of pollution may be:

a) Rain water picking up dust and industrial emissions from the atmosphere during its passage from clouds to the earth.

b) Surface water (rivers, ponds and lakes) acquiring impurities because of human activities - including methods of disposing of waste and agricultural practices.

c) Ground water, which generally is of good quality since it is filtered during its passage through the soil, may become polluted by latrines that are too near to a well or by poor construction of boreholes and wells which allows poor quality surface water to reach the water table.

In choosing a water source preference is usually as follows:

1. Ground water requiring no treatment, e.g., deep or shallow wells.

2. Spring water requiring no treatment.

3. Ground water requiring simple treatment.

4. Rain water as roof catchment, before it reaches the ground.

5. Spring water requiring simple treatment.

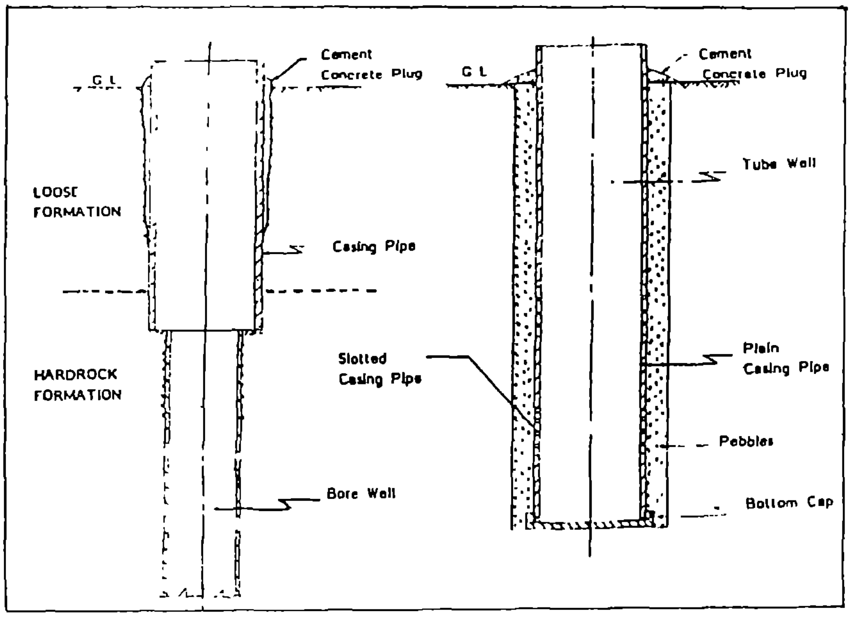
6. Lake, pond, stream water requiring simple treatment.

7. River water requiring extensive, treatment.

Ground water, i.e. springs and boreholes (including wells), will normally yield safe drinking water. Figure A.3 illustrates the factors that must go into a good well.

Figure A.3

Features of a Correctly Constructed Well



A.3 WATER BORNE DISEASES

About 80% of all diseases are estimated as being associated with bacteriologically unsafe, or insufficient, water. These diseases can be grouped as:

a) Water borne diseases transmitted by poor water quality e.g. cholera, typhoid, bacillary disentry, giardiasis and gastro enterities;

a) **Water washed diseases** caused by **lack of water** e.g. scabies skin sepsis and ulcers, leprosy, bacillary dysentry, amoebic dysentry, paratyphoid fever and ascariasis;

c) **Water based diseases** **caused by infecting agents spreaded by contact with water** e.g. schistosomiasis, dracunculiasis and bilharziosis;

d) **Water related Vector Transmitted Diseases** caused by insects (e.g. mosquitoes) which live close to water, such as yellow fever, dengue, hemorrhagic fever, malaria, diarrhoea, sleeping sickness.

A.4 WATER QUALITY STANDARDS

The World Health Organisation (WHO) recommends drinking water quality standards for human consumption needs as shown in Table A.1.

Table A.1 Selected (WHO) Standards for Potable Water Supply

Parameters	Undesirable Effect	Highest Desirable Level	Minimum Permissible Level
A. PHYSICAL			
Colour (Units)	Discolouration	5	50
Odour	Odours	Unobjectionable	Unobjectionable
Taste	Tastes	Unobjectionable	Unobjectionable
Total Solids(mg/l)	Taste Gastroenteritis	500	1500
Suspended Matter (units)	Turbidity Gastroenteritis	5	25
B. CHEMICALS			
pH (units)	Corrosion when <6.5	7.0 to 8.5	6.5 to 9.2
Calcium (mg/l)	Scaling	75	200
Chloride (mg/l)	Taste	200	600
Fluoride (mg/l)	Mottling of teeth	1.0	1.5
Iron (mg/l)	Taste Discolouration	0.01	
C. BACTERIA			
(Coliform Count/100ml)	Gastroenteritis	0	2

A.5 COMMUNITY PARTICIPATION

The success of VLOM depends on the successful use and maintenance by the users. This however must be communicated to the Users since an enthusiastic Community will be more likely to use the system effectively and will maintain and report the operational/maintenance problems to allow prompt repairs.

Communities which do not use or maintain their systems effectively must be stimulated or educated to their needs and duties. This involves educating them as to the significance of water quality and the ill effects or diseases caused by polluted waters from ponds, lakes or rivers. With sufficient effort and time they will see the need to protect their water supply.

A.6 ANALYSIS OF DEEP WELL HANDPUMPS

This section deals mainly with the India Mark II handpumps which dominate (over 99%) in the WATSAN Projects. Depending on the outcome of the Bauchi Pilot Handpump Testing Project other pumps may achieve greater importance.

A.6.1 Handpump Specifications

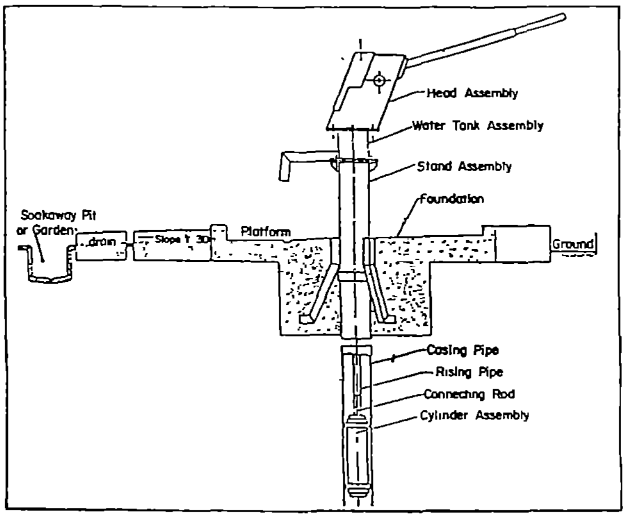
Figure A.3 shows the macro components of the India Mark II Handpump while Table A.2 lists the performance indices of various types of the pumps. For the "Standard" pump the cylinder should be installed at a minimum depth of 24 metres for maximum efficiency. If installed less than 25 metres deep, the corresponding loss in weight of the Connecting Rods can be made up by use of heavier Connecting Rods (16mm dia.) or a suitable Handle Bar Assembly.

Table A.2 Performance Indices of Types of India Mark II HandPumps

ITEM	PARTICULARS	Unit	Amount		
			Standard	Extr Deep	OpenTop
01	Installation Depth - Maximum	Metre	60	90	
02	Installation Depth - Optimum	Metre	28 - 33	40 - 75	
03	Cylinder - Internal Diameter(I.D)	mm	63.5	63.5	63.5
04	Stroke Length	mm	100	100	100
05	Strokes Per Minute (Average)	No.	40 - 50	40 - 50	40 -50
06	Discharge Per Stroke	Litre	0.32	0.32	0.32
07	Discharge Per 15 Strokes	Litre	4.8-5.5	4.8-5.5	5.0-5.5
08	Discharge Per Minute	Litre	12 - 15	12 - 15	12 - 15
09	Discharge Per Hour	Litre	800-1000	same	same

Figure A.4

Features of an Installed India Mark II Pump



A.6.2 Components of The India Mark II Pump

Figures A.5 and A.6 respectively show the main components of the India Mark II pump while Tables A.3 and A.4 detail the parts and quantities used in the fabrication of the pump.

Fig. A.5: Sectional Details of Above Ground Components of India Mark II Pump

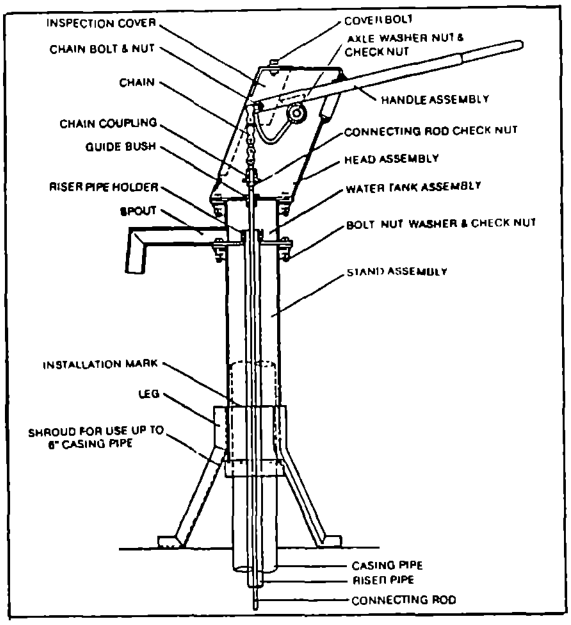


Table A.3 Above Ground Components of India Mark II Handpump

SI	Qty.	Description
01	8	Box Bolt M12x1.75x40 W/Nut
02	1	Hox Bolt M12x1.75x20
03	1	Hox Bolt H/Tons M10x1.5x40
04	1	Nut M10x1.5 Nylock
05	9	Washer M12 x 2mm
06	1	Washer M12 x 4mm for Axle
07	2	Ball Bearing (6204ZZ)
08	1	Handle Axle
09	1	Spacer Handle Assy.
10	1	Chain with Coupling
11	1	Handle Assy.
12	1	Head Assy.
13	1	Inspection Cover, Head Assy
14	1	Water Tank
15	1	Pump Stand/Pedestal Assy.

Figure A.6: Cylinder Assembly of India Mark II Handpump

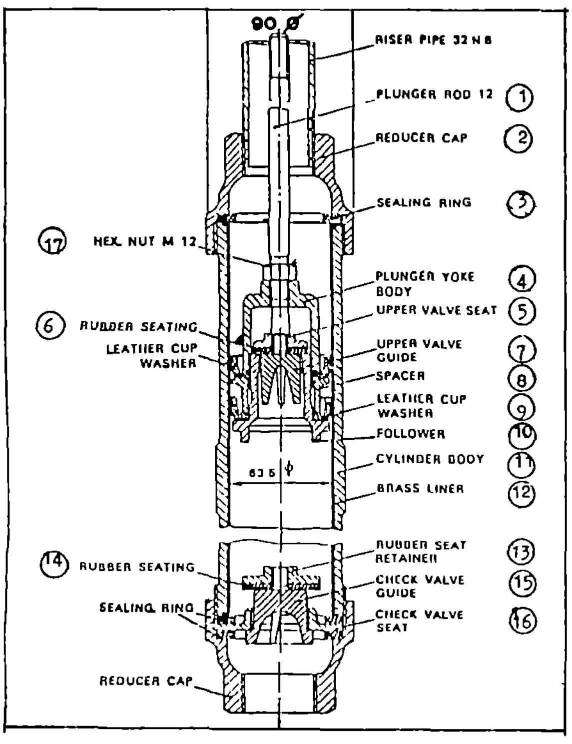


Table A.4 Component Parts of Cylinder of India Mark II Handpump

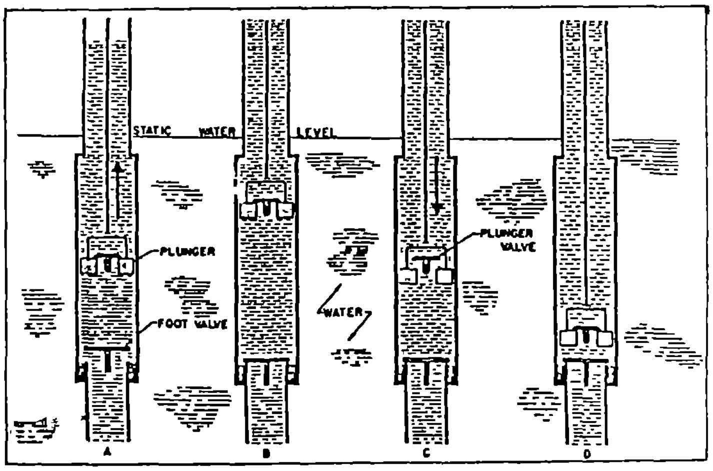
SI	Qty.	Description
01	1	Plunger Rod
02	2	Reducer Cap 1 1/4"
03	3	Sealing Ring - Lthr/Rbr
04	1	Plunger Yoke Body
05	1	Rbr Seat Retainer Pl Vlv
06	1	Rbr Seating Pl Vlv (small)
07	1	Plunger Valve Guide
08	1	Spacer Pl Valve
09	2	Cup Washer - Lthr/Rbr
10	1	Follower Pl Valve
11	1	Cylinder Body
12	1	Brass Liner
13	1	Rbr Seat Rot, Chk Valve
14	1	Rbr Seating Chk Vlv (lng)
15	1	Check Valve Guide
16	1	Check Valve Seat
17	1	Hox Nut M12 x 1.75

A.6.3 Operation of Deep Well Handpumps

Figure A.7 shows the action of the components of the pump cylinder in lifting water to the surface. The cylinders of deep well pumps are usually located below the water level to prevent loss of priming.

Figure A.7

Schematic of Operations of Deep Well Pump Cylinder



The water is lifted to the surface by the reciprocating action of the plunger assembly. The sequence of events are :

a) **First upstroke**: The water in the cylinder is raised and more water enters the cylinder through the foot valve. Upon completion of the upstroke, the foot valve closes by gravity, trapping the water in the cylinder;

b) **Downstroke**: The plunger valve opens, allowing water to pass into the cylinder. When the plunger assembly reaches the bottom of the cylinder and stops, the plunger valve closes, trapping the water above the plunger assembly;

c) **Next upstroke**: More water is lifted up the drop pipe and more is introduced into the cylinder. On each stroke the process is repeated until water comes out of the pump spout;

d) **Closing of Foot Valve**: If the foot valve is holding water well, the riser pipe should usually remain full of water. Water should then be delivered at the (above surface) pump spout within a few strokes if not on the first.

A.6.4 Steps for Installing an India Mark II Deep Well Pump

The depth at which to set the cylinder, and the appropriate types and quantity of riser mains and connecting rods, must have been predecided based on interpretation of pumping tests and water quality analyses. Table A.6 (A-O) shows graphically the steps involved while Table A.6 (P) gives a checklist to ensure that the installation is properly completed.

Checking of Pump Cylinder;

a) Tighten connections: Open cylinder and tighten all foot valve and piston connections. Reassemble cylinder and tighten both end caps.

b) Wet-test cylinder: Place cylinder in bucket of water and pump by hand. If water is not delivered or foot valve leaks, replace the cylinder or correct the problem.

Cut and thread riser pipe;

a) Measure and cut the riser pipe to length. Allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

b) Thread the drop pipe as follows: Wipe loose cuttings and dirt from the end of the pipe;

Thread the die on the pipe until the teeth begin to bite into the metal;

Apply cutting oil or animal lard liberally to the end of the pipe;

Cut the threads by turning the die clockwise 1/2 turn and then counter;

Clockwise 1/4 turn to allow cuttings to fall away. Continue in this manner until approximately 3 to 5 cm of threads have been cut;

Carefully remove the die without damaging the threads and wipe any loose cuttings off the pipe with a rag.

Install cylinder, drop pipe and plunger rod to desired depth;

a) Thoroughly brush the pipe and rods threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag and apply grease to the rod thread to make future disassembly easier;

b) Attach a length of plunger rod to the rod section in the cylinder. Tighten the connection and lock nut;

c) Attach an equal length section of riser pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly;

d) If used, attach a strainer to the bottom of the cylinder;

e) Lower the portion of riser pipe assembly into the well. Secure it with a pipe clam or tripod;

f) Put a section of plunger rod inside an equal length section of riser pipe. Raise these sections over an already lowered portion of riser pipe assembly, connect the plunger rod first (be sure it is very tight). Apply Teflon tape or pipe joint compound to the drop pipe threads and then connect and tighten the drop pipe. Again, always wipe the threads clean before applying Teflon tape or a pipe joint compound and joining sections of pipe together;

g) Continue adding sections of plunger rod and riser pipe until the desired cylinder depth is reached.

Attach drop pipe to water tank;

Screw the drop pipe firmly to the water tank. Using the lifter pipe and lifting spanners lower the water tank onto the pedestal. Bolt tank to pedestal.

Cut plunger rod to desired depth and thread;

a) Push the plunger rod down to the lowest position (until it cannot be pushed down any further);

b) Mark the rod lever with the top of the water tank with a hacksaw or scribing tool;

c) Raise the rod up as far as possible. Place a rag into the water tank to keep rod cuttings from falling into the well;

d) Clamp the rod with a rise or clamp;

e) Cut and thread the plunger rod following the same procedure as for the drop pipe. This step ensures that the piston assembly will be centered in the cylinder. The stock and die (M12) must have a guide as well in order to attain a straight thread;

Attach plunger rod to head assembly;

a) Remove the inspection cover from the head and lower the head onto the water tank;

b) Screw the chain section onto the rod. Tighten the connection and the lock nut firmly;

c) Using a bar, lift the head off to the tank and remove the rod clamp. Then bolt the head to the tank;

d) Insert the handle through the head and bolt the chain firmly to the handle. Insert the axle through the handle and tighten retaining nuts on axle.

Test the pump;

Perform the following tests to check for leaks in the assembly. Allow the pump to stand idle for 15 minutes before pumping again. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky foot valve or leaky joints. This situation is inconvenient to the users since they may have to operate the pump a long time before it delivers water (especially when the water table is deep). The pump should be removed and the cause of the leak determined and corrected before reinstallation.

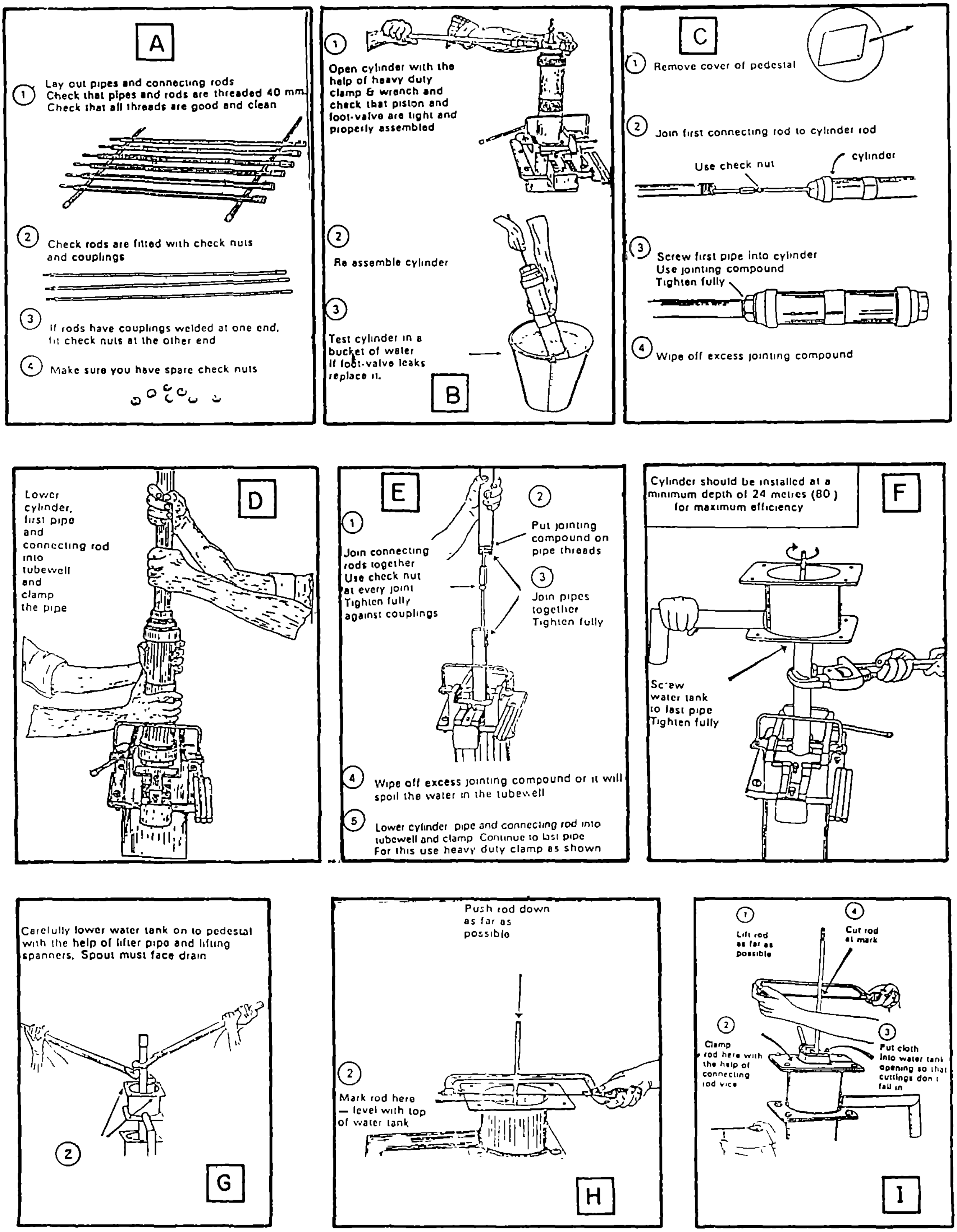
Lubricate the pump;

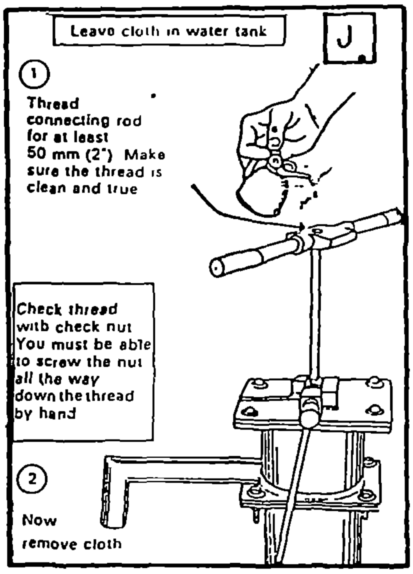
Apply grease to the chain. The handle bearings are sealed and do not need lubrication.

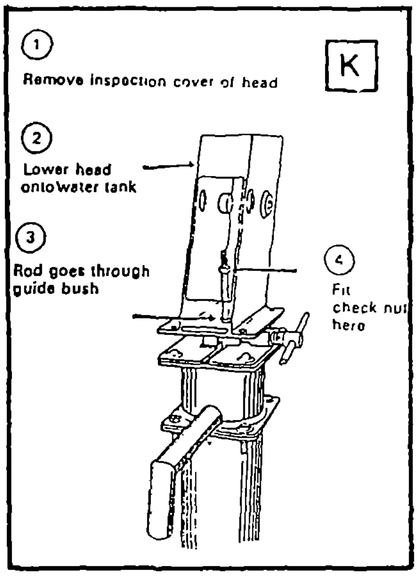
Disinfect the well;

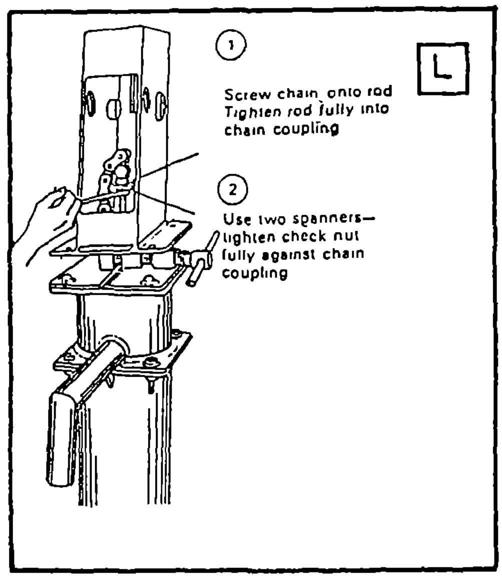
After installation of the handpump, desinfection is carried out with bleaching powder (calcium hypochloride). The amount used in each borewell should be a function of the volume of water and the level of contamination. In practice it has been found however that 12 grams of calcium hypochloride mixed in 3 litres of water (from the borewell), and re-introduced with a plastic tube and funnel is sufficient. The handpump should be left unoperational during a period of 72 hours after which 10 to 20 minutes of pumping suffices to extract the residual chlorine so that it reaches the WHO maximum recommended level of 0.05 mg/l.

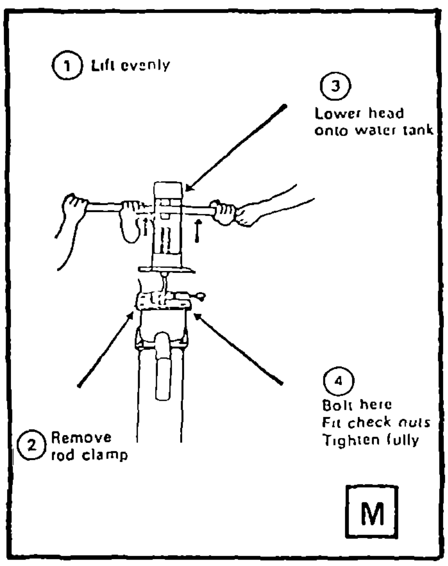
Figure A.8: Graphical Illustration of Steps Undertaken in Handpump Installation

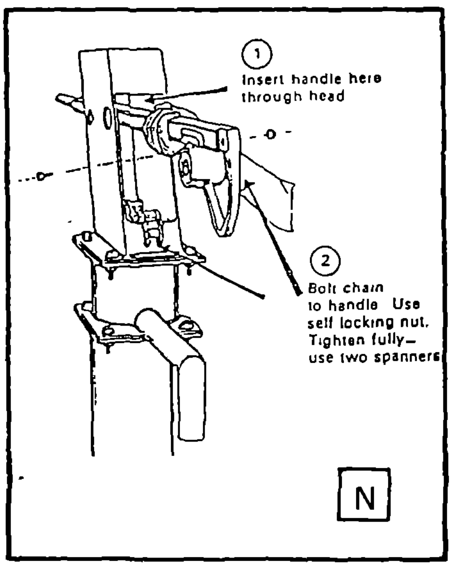


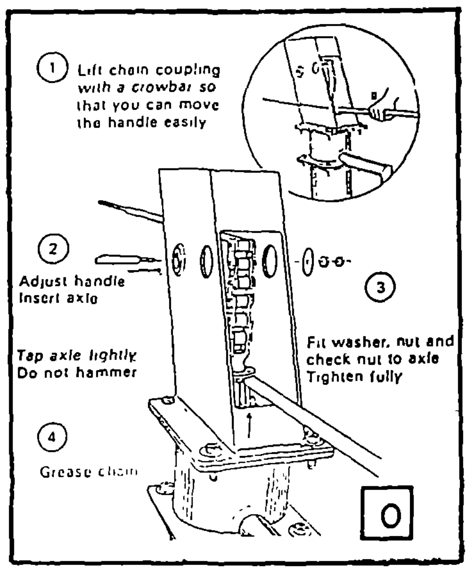












P

Now make sure that .

- When you pump, the handle touches the top and bottom stops If it does not then remove head and check the setting of the top connecting rod Refer to Step 16
- Connecting rod moves up and down freely in guide bush If it does not then the rod has been bent while threading
- *You have threaded* chain coupling fully on to connecting rod, and you have tightened the lock nut fully
- You have tightened axle nut and lock nut fully and the axle is firmly retained
- You have tightened chain anchor bolt and nut fully
- You have greased the chain
- All 8 flange bolts are tight and you have tightened the lock nuts fully
- You have left nothing inside the head

Now fit inspection cover
Tighten cover bolt fully

- Make sure that all tools and unused parts are clean and loaded on the vehicle

A.6.5 Price List for Components, Spareparts and Installation Materials for INDIA MARK II Handpump

Tables A.3, A.4, A.5 (A & B) and A.6 (A & B) lists the requirements. (with 1986 prices in US$*) of Handpump Assembly Components, installation materials, tools and spareparts needed routinely for handpump maintenance.

Table A.5 List and Prices of Above Ground Components for India Mark II Handpump

ITEM No.	PART/TRACER	DESCRIPTION	QNTY Set	UNIT PRICE (US$)
1.	M011-001	Conversion Head/Handle Assy-STD	1	40.00
2.	M011-002	Conv. Head/Handle Assy-Extra Deep	1	50.00
3.	M011-003	Conv. Head/Handle Assy-Shallow	1	50.00
4.	M011-004	Water Tank-Std 1 1/4"	1	25.00
5.	M011-005	Water Tank - 1 1/2"	1	25.00
6.	M011-006	Water Tank Open Top - 2 1/2"STD	1	25.00
7.	M011-007	Pump Stand/Pedestal STD	1	25.00
8.	M011-011	Cylinder Complete STD 1 1/4"STD	1	25.00
9.	M011-012	Cylinder Complete STD 1 1/2"	1	30.00
10.	M011-013	Cylinder Complete Ex Deep 1 1/4"	1	35.00
11.	M011-014	Cylinder Complete Ex Deep 1 1/2"	1	35.00
12.	M011-015	Cylinder Complete Open Top 2 1/2"	1	35.00

Table A.6 List and Prices of Subsurface Components for India Mark II Handpump

ITEM No.	PART/TRACER	DESCRIPTION	QNTY Set	UNIT PRICE
1.	M020-001	Connecting Rod M12x3m GI		6.50
2.	M020-002	Connecting Rod M12x3m SS		16.50
3.	M020-003	Connecting Rod W/Free Nut M12x3mSS		18.00
4.	M020-006	Riser Pipe 1 1/2" x 3m PVC		6.00
5.	M020-007	Riser Pipe 1 1/4" x 3m GI		8.00
6.	M020-009	Riser Pipe RT 1 1/4" x 3m SS		35.00
7.	M020-011	Riser Pipe 2 1/2" x 3m GI		
8.	M020-012	Riser Pipe RT 2 1/2" x 3m SS		
9	M020-013	Socket 2.5 inches		0.20
10.	M020-015	Guide RT SS Riser Pipe 1 1/4"TD		
11.	M020-016	Guide RT SS Riser Pipe 2 1/2"		
12.	M020-017	O-Ring RT SS Riser Pipe 1 1/4"		
13.	M020-018	O-Ring RT SS Riser Pipe 2 1/2"		
14.	M020-020	Adapt SS RT Fem x BSP Male 1 1/4"		
15.	M020-021	Adapt SS RT Male x BSP Fem 2 1/22		
16.	M020-022	Adapt SS RT Fem x BSP Male 2 1/2"		
17.	M020-023	Adapt SS RT Male x BSP Fem 2 1/2"		
18.	M020-024	Thread Tape Roll		1.00
19.	M020-025	Lub Grease Food Grade 1 kg		58.00
20	M020-026	Lub. Grease (All purpose)- 1 Kg		1.50

* For conversion to Naira multiply all values by current Naira/US$ "Autonomous Market Rate".

Table A.7 List and Prices of Tools and Installation Materials for India Mark II Handpump

ITEM No.	PART/TRACER	DESCRIPTION	QNTY Set
A	STANDARD TOOLS - SET (Cost per Set US$ 150.00)		
1.	M030-001	Button Die M12x1.75	1
2.	M030-002	Handle for Button Die	1
3.	M030-003	Die/stock Set 1 1/4x1 1/2"BSP	1
4.	M030-004	Pipe Wrench 600mm (24")	1
5.	M030-005	Pipe Wrench 450 mm (18")	1
6.	M030-006	Spanner-Double Ended M17xM19	2
7.	M030-007	Screw Driver 300m	1
8.	M030-008	Ball Pein Hammer 1 1/2 kg	1
9.	M030-009	Hacksaw Frame W/Blade	1
10.	M030-010	Oil Can - Press Type	1
11.	M030-011	Wire Brush	1
12.	M030-012	Half Round File 250mm	1
13.	M030-013	Flat File 250mm	1
14.	M030-014	Adjustable Spanner 300mm	1
15.	M030-015	Chisel 6"	1
16.	M030-016	Centre Punch	1
17.	M030-017	Spirit Level	1
18.	M030-018	Measuring Tape	1
19.	M030-019	Pipe Cutter 2"	1
20.	M030-020	Tool Box STD Tools	1
21.	M030-021	Nylon Rope 3mm x 75m	1
22.	M030-022	Screw Driver 100 mm	1
B	SPECIAL TOOLS SET - IND MK II (Cost per set US$ 300.00)		
1.	M041-001	Self Locking Clamp 1.25 "	1
2.	M041-002	Tank Pipe Lifter 1.25 "	1
3.	M041-003	Coupling Spanner	1
4.	M041-004	Handle Axle Punch	1
5.	M041-005	Connecting Rod Lifter	1
6.	M041-006	Crank Spanner (M17xM19)	2
7.	M041-007	Lifting Spanner 1.25 "	3
8.	M041-008	Connecting Rod Vice	1
9.	M041-009	Chain Couple Support Tool	1
10.	M041-010	Bearing Press Tool	1
11.	M041-011	Tool Box	1
12	M041-015	Heavy Duty Clamp 2.5"	1
13	M041 016	Tank Pipe Lifter 2.5"	1
14	M041-017	Lifting Spanner 2.5"	3
15	M041-018	FV Extra Tool (I.M.O)	1

Figure A.9 Special Tools Set - India Mark II

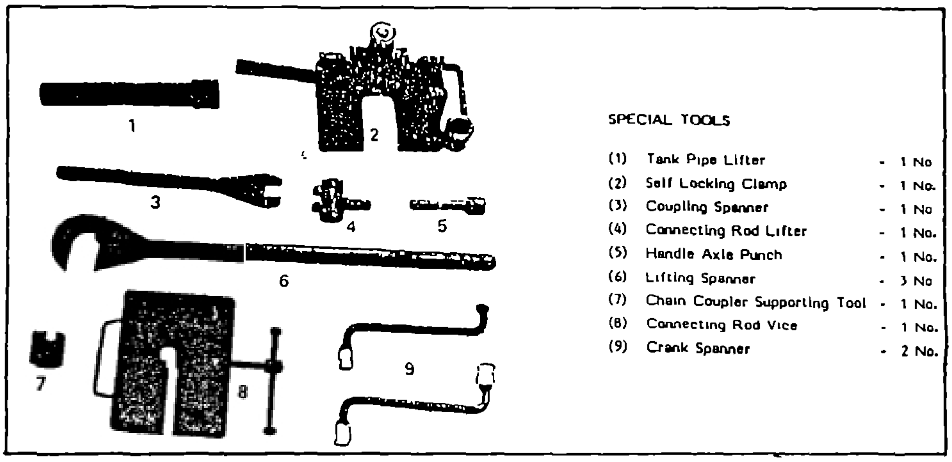


Table A.8 Handpump Spareparts (Recommended Qnty per 10 Pumps for 2 Years)

ITEM No.	PART/TRACER No.	DESCRIPTION	QNTY Set	UNIT PRICE (US$)
A	PUMPHEAD SPARE PARTS (ABOVE GROUND ASSY.)			
1.	SP0701-A001	Hex Bolt M12x1.75x40mm	50	0.15
2.	SP0701-A002	Hex Bolt M12x1.75x20mm(InspCover)	10	0.10
3.	SP0701-A003	Hex Bolt H/Tens M10x1.5x40mm	10	0.20
4.	SP0701-A004	Hex Nut M12x1.75mm GIm	50	0.05
5.	SP0701-a005	Hex Nut M10 x 1.5mm Nylock	10	0.15
6.	SP0701-A006	Hex Nut M12 x 1.75mm SS	10	0.30
7.	SP0701-a007	Washer M12x2mm	50	0.50
8.	SP0701-A008	Washer M12x4mm (For Axle)	10	0.08
*9.	SP0701-A009	Ball Bearing Handle Axle STD	20	5.00
10.	SP0701-A010	Handle Axle SS	5	2.00
11.	SP0701-A011	Spacer Handle Assy.	10	0.20
12.	SP0701-A012	Chain with Coupling	10	4.50
13.	SP0701-A013	Handle Bar Assy (W/O Brg /x Chain) Std	2	20.00
14.	SP0701-A014	Head Assy STD (W/O Handle & Brg)	1	30.00
15.	SP0701-A015	Water Tank STD 1 1/4"	5	25.00
16.	SP0701-A016	Inspection Cover	2	3.75
17.	SP0701-A017	Ball Brg Handle Axle Ex. Deep	6	5.00
18	SP0701-A018	Handle Bar Assy (w/o Brg/chain) EXD		25.00
B	CYLINDER SPARE PARTS			
1.	SP0701-B001	Plunger Rod M12x450mm GI	5	1.50
2.	SP0701-B002	Plunger Rod M12x450mm SS	2	3.50
3.	SP0701-B003	Plunger Rod M12x540mm SS	2	4.00
4.	SP0701-B004	Reducer Cap STD 1 1/4"	5	2.25
*5.	SP0701-B006	Sealing Ring, Leather	50	0.50
*6.	SP0701-B007	Sealing Ring, Rubber (Nitrile)	50	0.75
7.	SP0701-B008	Plunger Yoke Body STDO	2	3.80
8.	SP0701-B009	Rubber Seat Retainer Plunger Valve	2	1.85
9.	SP0701-B010	Rubber Seating,Plunger Valve(small	20	0.15
10.	SP0701-B011	Plunger Valve Guide	2	1.00
*11.	SP0701-B012	Cup Washer - Leather		1.00
*12.	SP0701-B013	Cup Washer - Nitrile Rubber	50	1.50
13.	SP0701-B014	Spacer, Plunger Valve	2	2.00
14.	SP0701-B015	Follower, Plunger Valve STD	2	4.00
15.	SP0701-B016	Cylinder Body W/Liner	2	15.00
16.	SP0701-A017	Brass Liner	see above	above
17.	SP0701-B018	Rubber Seat Retainer Chk Valve	3	1.00
18.	SP0701-B019	Rubber Seating,chk Valve (Large)	20	0.20
19.	SP0701-B020	Check Valve Guide	2	2.00
20.	SP0701-B021	Check Valve Seat	2	2.30
21.	SP0701-B023	Hex Coupling M12x50mm SS	5	2.50
22	SP0701-B024	Follower Plunger Valve Ex Deep	1	6.00
23.	SP0701-B025	Hex Coupling M12x50mm GI	3	1.00
24.	SP0701-B026	O-Ring Foot Valve (I.M.O. 2 1/2")	20	1.00

*Rubber (Nitrile) preferred

A.7 CHECKLIST FOR HANDPUMP MAINTENANCE OPERATORS

The following should be useful in guiding the Maintenance Teams/Handpump Caretakers in their functions:

A.7.1 Routine Inspection - Once a Month

1. Carry out Flow Test for correct discharge from the Pump.
2. Open the Inspection Cover, clean inside the head.
3. Clean the chain assembly and Grease.
4. Check the chain anchor bolt for proper fitment, tighten, if necessary.
5. Tighten all loose bolts and nuts.
6. Find out whether the pump base is loose in the foundation. If loose, arrange for fresh foundation.
7. Check Bearing play on Handle Assy.
8. Record Water Quality-visual.
9. Record complaints from Handpump users.
10. Clean drainage & environs.

A.7.2 Routine Service - Once A Year (10 - 12 Months)

A. Examine the pump carefully and check whether:

1. Discharge is satisfactory (carry out Flow Test)
2. Check Bearing Play on Handle Assy.
3. Guide bush has excessively worn out.
4. All bolts, nuts and washers are in position.
5. Chain has worn out.
6. Roller chain guide is excessively worn out.

B. Pull out the pump and follow the instructions given below:

1. If chain, bearing and spacer are damaged, replace worn out components accordingly.
2. If roller chain guide is badly worn out, replace handle assembly.
3. Dismantle Pump Cylinder - inspect and replace worn out metal Parts. Replace all Cup Washers, Seal Rings & Rubber Seating.
4. Check all sub-assemblies for crack in weld and other visual defects. If defects are serious, replace them.
5. Look for rust patches. If seen, clean them with a wire brush or sandpaper and apply anti-corrosive paint.
6. Clean all Connecting Rods and Riser Pipes with soap and water.
7. Repair/Replace damaged Connecting Rods and Riser Pipes.
8. Check (measure) Total Depth of BH. and Static Water Level.
9. Re-install the pump as described in the manual and carry out Flow Test.

A.7.3 Reporting Formats

Two formats, generated on computer (and available for use) on A3 size sheets have been reduced to A4 and attached for reference. The first, entitled "Platform Construction and Handpump Installation" should be used when the handpump is first installed while the second, entitled "Handpump Maintenance Report" must be used when undertaking routine servicing or overhauling of handpumps.

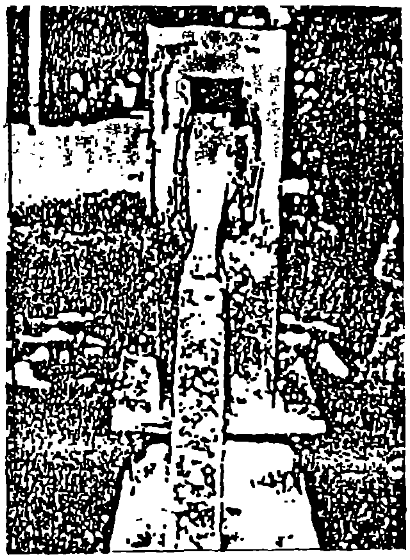
Table A.7 presents a checklist to guide the Caretaker in his work.

Table A.9: Guide to Trouble Shooting

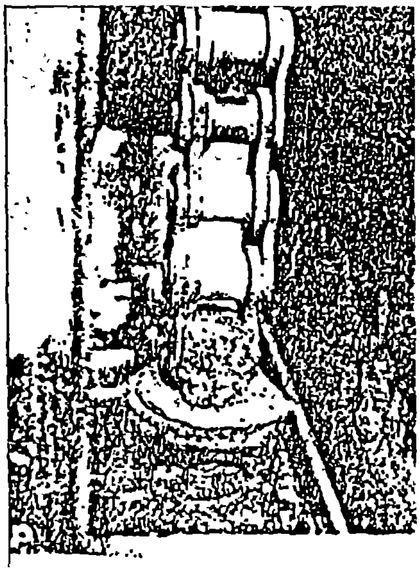
Trouble	Cause	Remedy
(1) Pump handle works easily but no flow of water	(a) Riser main cracked	(a) Replace the Rising
	(b) Cylinder cracked	(b) Replace cylinder
	(c) Valve seals worn out	(c) Replace valve seals
	(d) Piston cups damaged	(d) Replace the cups
	(e) Connecting rod or piston disconnected.	(e) Pull out the pump and join the connecting rod or the piston where necessary.
	(f) Foot Valve assembly dismantled.	(f) Refit the components, tighten and dot punch.
	(g) Plunger valve Assembly dismantled	(g) Refix the components, tighten & dot punch.
	(h) Water level gone down below cylinder	(h) Extend the length of riser pipes.
(2) Small Water Flow	(a) Valve seals worn out	(a) Replace valve seals
	(b) Piston cups damaged	(b) Replace the cups
(3) Delayed Water flow (i.e. water flow starts after several strokes)	(a) Leakage of foot valve	(a) Check seals on foot valve replace them if worn out. Tighten the nut firmly. Clean the valve seat.
	(b) Leakage in rising pipe assembly.	(b) Refit all joints on riser pipe, or replace damaged.
(4) Folding of chain during return stroke.	(a) Piston cups getting jammed inside cylinder	(a) Overhaul the the cylinder and replace piston cups
	(b) Connecting Rod length incorrect	(b) Check and follow Manual.
(5) Unusual noise during operation	(a) Stand assembly flange not levelled properly	(a) Level the flange
	(b) Bent connecting rod	(b) Change the defective rod.
(6) Shaky Handle	(a) Loose handle axle nut.	(a) Tighten handle axle
	(b) Worn out ball bearing	(b) Replace ball bearing
	(c) Spacer damaged	(c) Replace spacer
	(d) Bearing Seat on Handle Assembly Worn.	(d) Replace Handle Assembly
(7) Handpump loose in its foundation.	Cracked foundation	Repair damaged area and allow cement to set for one week.

The Caretaker must be on the look out for the following defects which can seriously interfere with the performance of the pump.

Fig. A.10: Common Defects That must be Quickly Corrected

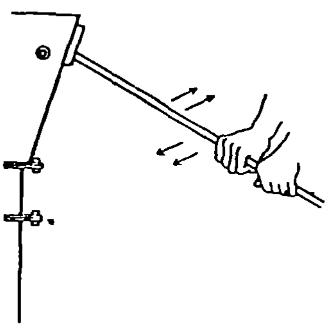


a) Worn out Handle Bar

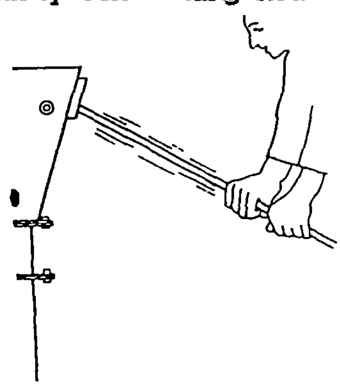


b) Rusty Chain

c) Rusty Connecting Rod



HANDLE SHAKY

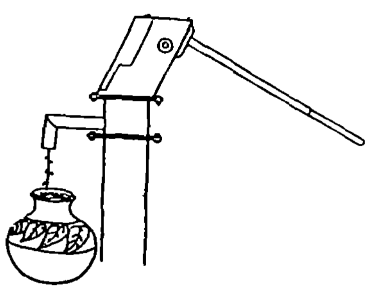


PUMPING DIFFICULT

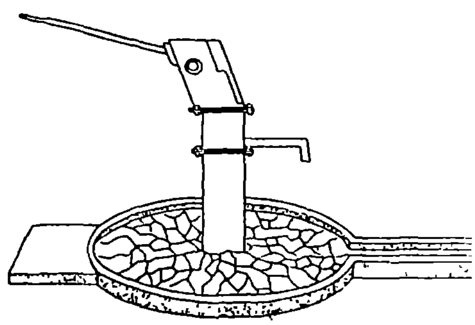
d)

WEAK FLOW OR NO FLOW

DELAYED FLOW (you have to pump many times before water comes)



e)



HAND-PUMP LOOSE IN ITS FOUNDATION.

A.8 **GUIDELINES FOR TRAINING OF VBW's**

The following functions should be clearly communicated during training of handpump Attendants. They should:

- **Explain to users the proper handling of handpumps as follows;**

    a) Stand directly behind the handpump

    b) Use long strokes, not short ones

    c) Do not block the spout by hand

    d) Do not force any objects into the openings of the head assembly

- **Channel the excess water into a garden, drain or soakage pit;**
- **Keep the handpump and the area around it clean and free of refuse;**
- **If the handpump breaks down inform the proper authority immediately;**
- **Maintain the handpump log book;**
- **Explain to users that water from a handpump is better for their health than water from a pond, river or open well;**
- **Advise the users to collect water from handpump with clean containers, and to keep it covered during transport to, and storage in, the house;**
- **Recommend a fine, through the Village Committee, on persons found littering premises or tampering with Handpump;**
- **Assist (and learn from) the Caretaker in Handpump servicing.**

A.9 **GUIDELINES FOR USERS**

Use of posters such as that shown in Figure A.11 could support the Attendants in performing their functions.

Figure A.11: Hints for Optimal Operation of Handpumps

A.9.1 Cost Items for Remuneration of Caretakers

Table A.10: Cost Items for Remmeration of Caretakers

	Estimated Time Required	Cost of Service (Naira)
A. ROUTINE INSPECTION (Once or Twice/Month)		
1. Inspection and Flow Output Test	1-3 hrs.	5-10
2. Clean & lubricate chain		
3. Check and Tighten all Bolts/nuts on Stand, Water Tank, Chain connection		
4. Check and repair Platform (cost excludes cement)		
5. Clean Surroundings		
6. Check Bearing Ply on Handle Assy.		
7. Record Water quality - visual		
8. Record complaint from user Community for further remedial measures		
B. YEARLY SERVICING (10 - 12 Months)		
1. Inspect and Record Flow output	1/2 hrs.	
2. Pulling out of Pump Installation	1 1/2-2 hrs.	40.00
3. Check Total Depth & S.W.L and Compare with original record	1/2 hrs.	5.00
4. Clearing of pipes and connecting rods.	1 hr.	
5. Take apart Pump cylinder; clean, replace worn out parts, reassemble and test.	1/2 - 1 hr	15.00
6. Re-install Pump, Test Flow output.	1 hr.	20.00
Sub Total	3 - 4 hrs	80.00
C. OTHER CHARGES		
7. Cut and Thread each Riser Pipe	1/4 hr.	5.00
8. Cut and Thread each connecting rod	1/4 hr.	5.00
9. Transport Installation Tripod and Riser Pipes/Connecting Rod from LGA store		*
D. BREAKDOWN REPAIRS		Rate as 2 and 3

*To be decided between Community and Caretaker

A.10 MONITORING OF VLOM IMPLEMENTATION

Success of any Maintenance system requires effective and efficient means of reporting so that variations from normal performance or breakdowns may be speedily addressed. For handpumps the need is great since by virtue of their limited service coverage a large number are required for extensive service, and unrepaired pumps may be a disbenefit to health because of reversion of Users to poor alternative water sources. Table 7 sets out the minimum data required for a well run maintenance system.

The single reporting format will:

a) Allow participation by Caretakers, LGA and Project. This will enable Project Management to continuously review and, if necessary, adjust the operations of VLOM.

b) Provide an inbuilt mechanism for physical, financial and performance monitoring.

c) Provide checklists for inspection by the Caretakers and VBW's.

It is so structured that literate (in English) Maintenance personnel will, with adequate training, be able to complete it using the instructions incorporated in the form. They must therefore form an integral part of any Handpump Maintenance Training course so they can be routinely used.