2213/63

REPORT TO NORAD

ZAM 007
DESK STUDY ON HANDPUMPS

SEPTEMBER 1984

Norconsult

TABLE OF CONTENTS

Chapter 1

INTRODUCTION

This desk study has been carried out at the request of the Royal Norwegian Ministry of Development Corporation (NORAD). It is intended to meet two basic objectives, namely:

a) Provide a digested overview of handpumps available on the commercial market, and

b) Provide guidance to handpump selection for the NORAD-financed rural water supply project in Western Province, Zambia (identified as ZAM 007), where problems relating to corrosion, mechanical wear and frequent piston seal servicing have been experienced,

within the limits of on-hand or readily available information, and available time for study (80 man-hours).

The digested overview of handpumps is included in Chapter 2, which contains tabulated information concerning 53 available makes and models. Comments relating to ZAM 007 are included in Chapter 3.

Terms of reference for this desk study are included in Appendix 1.

Chapter 2

OVERVIEW OF AVAILABLE HANDPUMPS

2.1 INTRODUCTION

It is estimated that five to seven million handpumps must be manufactured and installed if the goals of the International Water Supply and Sanitation Decade are to be met. This represents tremendous capital investment. Further, in that handpump installation culminates the costly process of planning, hydrologic and hydrogeologic investigations, drilling or well digging, engineering, and well and platform construction activities already carried out, proper selection, installation and maintenance of handpumps is of vital importance; failure of the handpump can negate all previously successful activities. On a larger scale, repeated and multiple failures will doom any chances for rural water supply programme success.

A wide array of handpumps is currently available. Often, however, it is difficult to draw comparisons between different makes and models owing to lack of reliable and comparative design, performance and cost data.

The purpose of this document is to assimilate as much comparative data as possible, presenting them in brief form. It must be cautioned, however, that data reliability varies significantly, in some cases being based on exhaustive, independent study findings and in other cases on manufacturers' claims or brief references in books or articles. Cost information cited is for indicative purposes only; figures cannot be compared due to different bases for estimating (e.g. with/without pipes and rods, complete to varying depths, different price levels, fluctuating currency exchange rates, F.O.B./C.I.F/ installed at site prices, etc.)

2.2 BACKGROUND

The most authoritative and detailed information presently available on selected handpumps is that compiled under the British Overseas Development Administration (ODA) Hand/Foot-Operated Water Pumps Project and the UNDP Rural Water Supply Handpumps Project (executed by the World Bank).

The ODA project involved the laboratory testing of 12 deep-well handpumps of traditional and newer designs, i.e. the Petro, Vergnet Hydropompe, Dempster, Mono, Climax, Godwin, Abi, GSW, Monarch, Kangaroo, India Mark II and Consallen. Tests were conducted at the Consumers' Association Testing and Research Laboratories (CATR), UK, and the final report issued in January 1981. Several manufacturers, on the basis of testing programme results and further field information, modified their pumps to improve weaknesses identified.

The UNDP Handpumps Project, still ongoing, carries the initial ODA efforts further, involving laboratory testing, controlled field testing in some 15 developing countries, and technological development. The broad aims of the laboratory tests are to, one, examine and assist in the selection of a wide range of handpumps for further field trials, and two, to provide information to manufacturers, allowing them to produce more efficient, reliable pumps.

To date, results have been reported for 18 shallow and deep-well models tested under the UNDP project: the Korat, Dragon, Moyno, Nepta, Kenya, New No. 6, Nira, Ethiopia, VEW, Jetmatic, Bandung, Sumber Banyu, Abi-Vergnet, Petro, Funymaq, Maldev, Rower and Volanta. A further batch of six pumps (the Monolift ES 30, Mono rotary direct drive, Kardia, Turni (2 models) and Sikalase) are currently under test. Results are expected to be available in late 1984.

Further details concerning the scope of the UNDP Handpumps Project are presented in Appendix 2.

2.3 METHODOLOGY

Readily available information on 53 makes and models of handpumps was gathered from a variety of sources - books, reports, documents, magazine articles and manufacturers' literature - and basically categorised to three classes:

a) General, i.e. name/model, type of pump (deep or shallow), manufacturer/supplier (by no means a complete list in some cases, e.g. the India Mark II), approximate indicative price and price level, country of origin, and primary source of information.

b) Performance, i.e. brief description, maximum lift or operating range, typical yield and typical power requirements.

c) Materials used in construction of principal components, i.e. pump stand, connecting rod, rising main, cylinder and plunger body.

Pump nomenclature used throughout this study, identical to that adopted under the UNDP Handpumps Project, is shown in Figure 2.1.

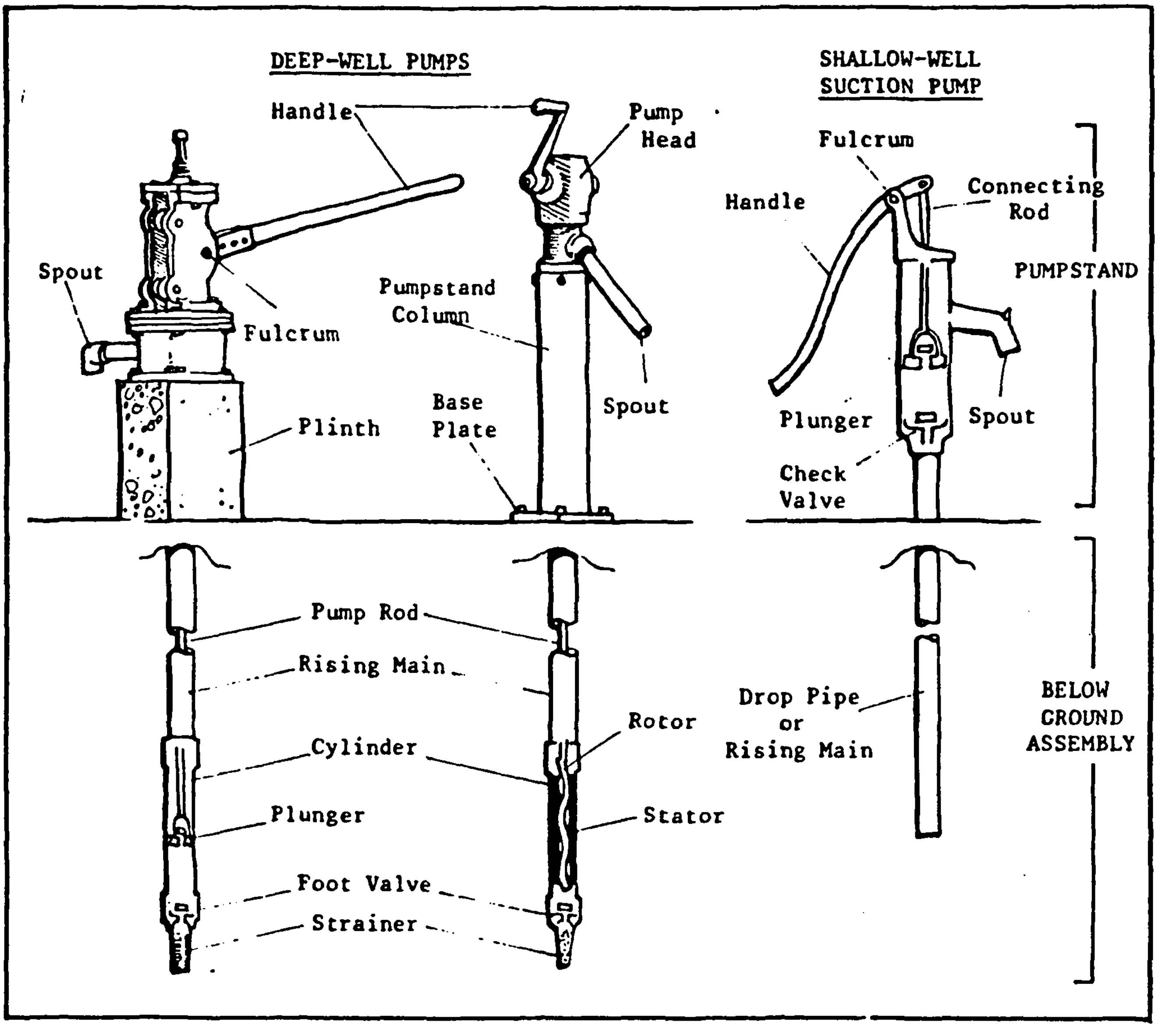
2.4 PRESENTATION OF RESULTS

Tables 2.1, 2.2 and 2.3 present, respectively, general, performance-related and materials-related information for different makes and models of handpumps. The "n.a." designation is used where information is not available.

Information presented in the tables should be used with care. Any comparisons or conclusions drawn should be the result of close consideration since basis and level of accuracy of information presented often varies, sometimes significantly. For example, performance characteristics determined from exhaustive, independent, unbiased tests (such as those undertaken at CATR) must be considered more scientifically reliable than those obtained from biased or other

FIGURE 2.1

BASIC PUMP NOMENCLATURE



A <u>shallow-well</u> <u>suction</u> pump is one where the plunger is in the body of the pump, above ground. For practical purposes, the maximum operating depth of this type of pump is 7 metres.

A <u>shallow</u> <u>or</u> <u>deep-well</u> <u>force</u> pump is one where the plunger is below static water level, at the bottom of the rising main. Such pumps are self-priming. The maximum operating depth is limited only by the strength of the pump and its operator.

Table 2.1

Overview of Handpumps Surveyed - General Information

Name/Model	Deep/ Shallow	Manufacturer/ Supplier	Approx. Price*	Price Level (**)	Country of Origin	Primary Info. Sources (Code Below)
Abi Type M	Deep	Abi	GBP 358 (excl. pipe & rod)	1977/78	Ivory Coast	1
Abi-Vergnet ASM	Deep	Groupement Abijan Indus.	USD 836 (compl. to 20 m)	1982	Ivory Coast (pumpstand) France (pumping element)	2
Agricola	Deep	Polynergie	n.a.		Canada	3
AID/Batelle Shallow	Shallow	Battelle Laboratories	n.a.		USA	3
AID/Batelle Deep	Deep	Battelle Laboratories	n.a.		USA	3
Bamboo	Shallow	Inquiries to Development Tech. Center, Bandung	USD 6	ca. 1982	Indonesia	3
Bandung	Shallow	C.V. Malabar	USD 54	1981	Indonesia	2
Blair 60mm	Shallow	Blair Research Laboratories	USD 57	1980	Zimbabwe	3
Blair Prodorite	Shallow	Prodorite	USD 72	1982	Zimbabwe	3,4
Bonzer Mark II	Deep	March May Fluid Transfer Systems	GBP 181 (excl. pipe & rod)	1984	U.K.	4
Buba	Deep	Inquiries to Development Corporation, Netherlands	USD 450 (installed)	1981	Guinea-Bissau (pumphead only)	3
Climax	Deep	Barnaby Climax	GBP 731 (compl. to 21 m)	1977/78	U.K.	1
Consallen LD5	Deep	Consallen Pumps	GBP 297 (compl. to 20 m)	1977/78	U.K.	1

Table 2.1 (con't)

Name/Model	Deep/ Shallow	Manufacturer/ Supplier	Approx. Price*	Price Level (**)	Country of Origin	Primary Info. Sources (Code Below)
Consallen LD4	Deep	Consallen Pumps	GBP 280 (compl. to 20 m)	1984	U.K.	4
Deepset Mark I	Deep	Inquiries to UNICEF Dacca	USD 300	1982	Bangladesh	3
Demotech Rope	Both	DEMOTECH	USD 15	ca. 1982	Netherlands	3
Dempster 23 F(CS)	Deep	Dempster	GBP 57 (excl. pipe & rod)	1977	U.K.	1
Dragon No.2	Deep	Kawamoto	USD 362 (compl. for deep well use)	1982	Japan	2
DUBA Tropic II	Deep	DUBA	USD 2350 (compl. to 66 m)	1983/84	Belgium	4
DUBA Tropic VII	Deep	DUBA	USD 1550 (compl. to 36 m)	1983/84	Belgium	4
Ethiopia Type BP50	Shallow	E.W.W.C.A.	USD 75	1981	Ethiopia	2
Funymaq	Deep	Georgia Inst. of Technology	n.a.		Honduras	2
Godwin W1 H51	Deep	H.J. Godwin Ltd.	GBP 866 (compl. to 20 m)	1977/78	U.K.	1
GSW 1205	Deep	GSW Ltd.	GBP 163 (excl. pipe & rod)	1977/78	Canada	1
Hydropompe AC2	Deep	Vergnet	GBP 422 (compl. to 50 m)	1977/78	France	1,3,4
India Mark II	Deep	INALSA	GBP 65 (excl. pipe & rod) USD 435 (compl. to 30 m)	1977/78 1983/84	India	1,3,4
India Mark II (Modified)	Deep	INALSA	n.a.		India	4
pb-Mark	Deep	Pumpenboese (pb)	n.a.		W. Germany	4
India SW II	Shallow	INALSA	USD 165	1983	India	4

Table 2.1 (con't)

Name/Model	Deep/ Shallow	Manufacturer/ Supplier	Approx. Price* (**)	Price Level	Country of Origin	Primary Info. Sources (Code Below)
JAMPH	Deep	Kenman Corp.	USD 550 (compl. to 30 m)	1984	USA	4
Jetmatic	Deep	Sea Commercial Co.	USD 32 (excl. pipe & rod)	1982	Philippines	2
Kangaroo	Deep	Pijpers International	GBP 283 (compl. to 20 m)	1977/78	Netherlands	1,3,4
Kardia	Deep	Preussag	USD 990 (compl. to 30 m)	1984	W. Germany	4
Kenya	Deep	Atlas Copco	USD 669	1981	Kenya	2
Korat 608 A-1	Deep	Saha Kolkarn	USD 295 (compl. to 20 m)	1982	Thailand	2
Malawi PVC	Shallow	n.a.	USD 25	1980	Malawi	3
Maldev (Malawi Steel)	Deep (pumphead only)	Petroleum Services Ltd.	USD 135 (pumphead only)	1982	Malawi	2,3,4
Monarch P3	Deep	Monarch Industries	GBP 359 (compl. to 30 m)	1977/78	U.K.	1
Mono ES 30	Deep	Mono Pumps	GBP 370 (compl. to 10 m)	1977/78	U.K.	1,4
Moyno IV 2.6	Deep	Robbins & Myers	USD 739 (compl. to 20 m)	1982	USA	2
Nepta	Deep	Briau	USD 650 (compl. to 20 m)	1982	France	2
New No. 6	Shallow	Engineers Wood Steel Industries	USD 33	1981	Bangladesh	2,3
Nira AF76	Deep	Vammalan Konepaja	USD 203 (pump & cylinder)	1982	Finland	2,4
Petro	Deep	WellDrill Systems	USD 465 (compl. to 20 m)	1982	Sweden	1,2,4
			USD 600 (compl. to 30 m)	1984		
Rower	Shallow	Mirpur Agric. Workshop Train-School	USD 14	1982	Bangladesh	2,4

Table 2.1 (con't)

Name/Model	Deep/ Shallow	Manufacturer/ Supplier	Approx. Price*	Price Level	Country of Origin	Primary Info. Sources (Code Below)
			(**)			
Shinyanga	Shallow	Shiyanga Shallow Wells Project	USD 160	1978	Tanzania	3,4
Sumber Banyu ("SB")	Deep	P.T. Celco	USD 85	1981	Indonesia	2
SWN 80	Deep	Van Reekum Materials	USD 900 (compl. to 36 m)	1984	Netherlands	3,4
SWN 81	Deep	Van Reekum Materials	USD 1290 (compl. to 66 m)	1984	Netherlands	3,4
Turni	Deep	Preussag	USD 1490 (compl. to 30 m)	1984	W. Germany	4
VEW A18	Deep	Vereinigte Edelstahlwerke (VEW)	USD 1583 (compl. to 20 m)	1982	Austria	2
Volanta	Deep	Jansen Venneboer	USD 845 (compl. to 20 m)	1982	Netherlands	2,3,4
			USD 785 (compl. to 10 m)	1984		
Waterloo (IDRC)	Shallow	Inquiries to IDRC	USD 180	ca. 1982	Canada	3

* Indicative only. Prices cannot be directly compared since they are quoted in different years and often on different bases, e.g. complete with different lengths of rising mains and rods; exclusive of rising mains and rods; etc.

** Additional price information supplied (in brackets) if available.

Code for Primary Information Sources:

1. ODA Report (January 1981)
2. UNDP/World Bank Handpumps Project Reports (March 1982, March 1983 and June 1984)
3. "Handpumps for Villages in Developing Lands", by D.M. Tam. Asian Water & Sewage (June 1984)
4. Norconsult files

Abbreviations: n.a. = not available
excl. = exclusive
compl. = complete

Table 2.2

Overview of Handpump Performance Characteristics

Name/Model	Deep/ Shallow	Brief Description	Approx. Max. Lift or Operating Range, m	Typ. Yield (and Power, if avail.) at 25 m Unless Otherwise Stated
Abi Type M	Deep	Hand-op. force pump	> 45	0.33 l/str
Abi-Vergnet ASM	Deep	Hand-op. hydraulic drive diaphram hose pump	> 45	0.26 l/str (194 J/str)
Agricola	Deep	Hand-op. force pump	50 max.	50 l/min at ? m
AID/Batelle Shallow	Shallow	Hand-op. suction pump	7 max.	n.a.
AID/Batelle Deep	Deep	Hand-op. force pump	46 max.	n.a.
Bamboo	Shallow	Hand-op. suction pump	7 max.	0.5 l/str at 7 m
Bandung	Shallow	Hand-op. suction pump	7 max.	0.96 l/str at 7 m (93 J/str at 7 m)
Blair 60mm	Shallow	Hand-op. force pump w/ discharge thru U-shaped handle	7 max.	20 l/min at < 7 m
Blair Pro-dorite	Shallow	Hand-op. force pump w/ discharge thru U-shaped handle	15 max.	20 l/min at < 15 m
Bonzer Mark II	Deep	Hand-op. force pump	90 max.	0.29 l/str at ? m
Buba	Deep	Hand-op. force pump	> 12 max.	n.a.
Climax	Deep	Hand-op. (flywheel) force pump	40 max.	0.10 l/rev
Consallen LD5	Deep	Hand-op. force pump	60 max.	0.54 l/str
Consallen LD4	Deep	Hand-op. force pump	60 max.	0.41 l/str at 60 m
Deepset Mark I	Deep	Hand-op. force pump	n.a.	n.a.
Demotech Rope	Both	Rope and bucket(s?) pump	24 max.	n.a.

Table 2.2 (con't)

Name/Model	Deep/ Shallow	Brief Description	Approx. Max. Lift or Operating Range, m	Typ. Yield (and Power, if avail.) at 25 m Unless Otherwise Stated
Dempster 23 F(CS)	Deep	Hand-op. force pump	> 45	0.45 l/str
Dragon No.2	Deep	Hand-op. force pump	> 45	0.54 l/str (252 J/str)
DUBA Tropic II	Deep	Hand-op. (flywheel) force pump	20 - 95	1.20 l/rev at 30 m, 90 mm dia cylinder
DUBA Tropic VII	Deep	Hand-op. (flywheel) force pump	7 - 60	0.63 l/rev at 30 m, 75 mm dia cylinder
Ethiopia Type BP50	Shallow	Hand-op. (push-pull tee handle) force pump	12 max.	0.62 l/str at 7 m (117 J/str at 7 m)
Funymaq	Deep	Hand-op. force pump	> 45	0.69 l/str (277 J/str)
Godwin W1 H51	Deep	Hand-op. (geared fly-wheel) force pump	60 max.	0.93 l/rev
GSW 1205	Deep	Hand-op. force pump	> 45	0.64 l/str
Hydropompe AC2	Deep	Foot-op. hydraulic drive diaphram hose pump	25 - 60	0.22 l/str
India Mark II	Deep	Hand-op. force pump	24 - 90	0.31 l/str
India Mark II (Modified)	Deep	Hand-op. force pump	6 - 25	0.31 l/str
pb-Mark	Deep	Hand-op. force pump	33 max.	0.32 l/str
India SW II	Shallow	Hand-op. suction pump	7 max.	0.78 l/str at < 7 m
JAMPH	Deep	Hand-op. hydraulic drive ejector pump	5 - 30	11.2 l/min
Jetmatic	Deep	Hand-op. force pump	> 45	0.27 l/str (103 J/str)
Kangaroo	Deep	Foot/spring-op. force pump	15 max.	0.50 l/str at 7 m
Kardia	Deep	Hand-op. force pump	40 max.	0.39 l/str at 25 m (126 J/str)
Kenya	Deep	Hand-op. force pump	> 45	0.77 l/str (300 J/str)

Table 2.2 (con't)

Name/Model	Deep/ Shallow	Brief Description	Approx. Max. Lift or Operating Range, m	Typ. Yield (and Power, if avail.) at 25 m Unless Otherwise Stated
Korat 608 A-1	Deep	Hand-op. force pump	> 45	0.35 l/str (159 J/str)
Malawi PVC	Shallow	n.a. (Guess: hand-op. suction pump)	n.a. (Guess: 7 m max.)	n.a.
Maldev (Malawi Steel)	Deep (pump-head only)	Hand-op. force pump	> 45	0.51 l/str (185 J/str)
Monarch P3	Deep	Hand-op. force pump	> 45	0.47 l/str
Mono ES 30	Deep	Hand-op. (crank) helical rotor pump	60 max.	ca. 0.35 l/rev (crank)
Moyno IV 2.6	Deep	Hand-op. (crank) helical rotor pump	> 45	0.20 l/rev (crank) (152 J/rev)
Nepta	Deep	Hand-op. force pump	> 45	0.39 l/str (123 J/str)
New No. 6	Shallow	Hand-op. suction pump	7 max.	1.20 l/str at 7 m (121 J/str at 7 m)
Nira AF76	Deep	Hand-op. force pump	> 45	0.65 l/str (209 J/str)
Petro	Deep	Hand-op. diaphram hose pump	50 max.	0.25 l/str (120 J/str)
Rower	Shallow	Hand-op. (push-pull tee handle) suction pump	7 max.	1.80 l/str at 7 m (192 J/str at 7 m)
Shinyanga	Shallow	Hand-op. force pump	20 max.	ca. 0.8 l/str at 10 m ca. 0.5 l/str at 20 m
Sumber Banyu ("SB")	Deep	Hand-op. force pump	> 45	0.81 l/str (293 J/str)
SWN 80	Deep	Hand-op. force pump	40 max.	(0.3 - 1.25 l/str, (depending on size
SWN 81	Deep	Hand-op. force pump	100 max.	(cylinder (at ? m

Table 2.2 (con't)

Name/Model	Deep/ Shallow	Brief Description	Approx. Max. Lift or Operating Range, m	Typ. Yield (and Power, if avail.) at 25 m Unless Otherwise Stated
Turni	Deep	Hand-op. (crank) helical rotor pump	1 - 60	0.24 l/rev (crank)
VEW A18	Deep	Hand-op. (crank) force pump	> 45	0.65 l/rev (266 J/str)
Volanta	Deep	Hand-op. (flywheel) force pump	4 - 80	0.33 l/rev (Cyl.1: 132 J/rev) (Cyl.2: 162 J/rev)
Waterloo (IDRC)	Shallow	Hand-op. force pump	10 max.	n.a.

Abbreviations:
- n.a. = not available
- op. = operated
- str = stroke
- Cyl.1 = Cylinder No. 1

Table 2.3

Overview of Handpump Materials

Name/Model	Pumpstand* (Principal Components)	Connecting Rods	Rising Main**	Cylinder***	Plunger Body
Abi Type M	CI w/ steel framework handle & angle steel stand	painted steel	GS pipe	brass	n.a.
Abi-Vergnet ASM	steel w/ CI top & MS handle	DNA	PE hoses (both riser & drive)	SS casing w/ rubber pumping element	gunmetal primary piston
Agricola	plastic	n.a.	n.a.	n.a.	n.a.
AID/Batelle Shallow	CI	DNA	n.a.	n.a.	n.a.
AID/Batelle Deep	CI	n.a.	n.a.	n.a.	n.a.
Bamboo	bamboo	DNA	bamboo	bamboo chamber	n.a.
Bandung	CI	DNA	PVC pipe	GI chamber w/ enamelled steel liner	CI
Blair 60mm	GS w/ steel spring	DNA	PVC pipes (both riser & "piston")	PVC pipe (same as rising main)	PVC w/ ball valve
Blair Prodorite	GS w/ steel spring	DNA	PVC pipes (both riser & "piston")	PVC pipe (same as rising main)	PVC w/ ball valve
Bonzer Mark II	plastic w/ reinforced plastic hood	GRP	GS pipe	GRP w/ Teflon lining	Delrine plastic
Buba	n.a.	n.a.	n.a.	n.a.	n.a.
Climax	CI w/ steel crank shaft	zinc-plated steel	GS pipe	brass	n.a.
Consallen LD5	GS	SS	ABS plastic pipe	SS w/ ABS plastic end caps	brass

Table 2.3 (con't)

Name/Model	Pumpstand* (Principal Components)	Connecting Rods	Rising Main**	Cylinder***	Plunger Body
Consallen LD4	GS	SS	ABS plastic pipe	SS w/ ABS plastic end caps	brass
Deepset Mark I	GS	n.a.	n.a.	n.a.	n.a.
Demotech Rope	n.a.	DNA	DNA	DNA	DNA
Dempster 23 F(CS)	CI	GS	GS pipe	CI w/ brass lining	n.a.
Dragon No.2	CI w/ steel handle & enamelled steel column liner. Mounting plinth req'd	MS	GS pipe	brass w/ CI end caps	cast gunmetal
DUBA Tropic II	CI	wood	GS pipe	copper	bronze
DUBA Tropic VII	CI	wood	GS pipe	copper	bronze
Ethiopia Type BP50	steel w/ wood handle	PVC pipe	PVC pipe	PVC pipe (same as rising main)	HDP w/ rubber valve
Funymaq	CI w/ steel column	steel	GS pipe	PVC w/ CI end caps	cast gunmetal
Godwin W1 H51	CI w/ steel flywheel & steel column	wood	GS pipe	brass and gunmetal	n.a.
GSW 1205	CI w/ steel flywheel & steel column	GS/zinc-plated	GS pipe	brass w/ CI end caps	n.a.
Hydropompe AC2	GS w/ SS foot pedal assembly	DNA	HDP hoses	SS casing w/ rubber pumping element	polyurethane primary piston
India Mark II	GS	GS	GS pipe	CI w/ brass lining	gunmetal
India Mark II (Modified)	GS	GS	GS pipe	CI w/ brass lining	gunmetal

Table 2.3 (con't)

Name/Model	Pumpstand* (Principal Components)	Connecting Rods	Rising Main**	Cylinder***	Plunger Body
pb-Mark	GS	MS	GS pipe	CI w/ brass lining	gunmetal
India SW II	steel	DNA	GS pipe	steel chamber	gunmetal
JAMPH	CI w/ steel handle & GS column	DNA	PE pipes (both riser & drive)	polypropylene ejector assembly	n.a. (primary piston)
Jetmatic	CI w/ steel handle. Pumphead mounted on protruding end of rising main	MS	GS pipe	brass	cast gunmetal or bronze
Kardia	GS w/ SS handle	SS w/ brass connectors	PVC pipe	PVC	PVC
Kangaroo	steel w/ SS spring	PVC pipe	PVC pipe	PVC	n.a.
Kenya	MS w/ wood fulcrum & wood handle	GS pipe	GS pipe	brass w/ gunmetal end caps	gunmetal w/ SS ball valve
Korat 608 A-1	CI w/ wood handle. Mounting plinth req'd	MS	GS pipe	brass	cast gunmetal and brass
Malawi PVC	PVC	DNA	PVC pipe	PVC chamber	n.a.
Maldev (Malawi Steel) (above ground assembly only)	steel	DNA	DNA	DNA	DNA
Monarch P3	CI w/ wood handle	GS	GS pipe	brass	n.a.
Mono ES 30	CI (including gears). Mounting stand or plinth req'd	steel	GS pipe	steel tube w/ rubber stator	chrome-plated steel rotor
Moyno IV 2.6	cast steel w/ CI gears & GS column	GS	GS pipe	steel tube w/ moulded elastomer stator	chrome-plated hard steel rotor

Table 2.3 (con't)

Name/Model	Pumpstand* (Principal Components)	Connecting Rods	Rising Main**	Cylinder***	Plunger Body
Nepta	steel w/ GS handle, GS counterweights, & nylon-coated column	SS w/ polyester cable coupling at top	GS pipe	brass	cast gunmetal or brass
New No. 6	CI	DNA	GS pipe	CI chamber	CI
Nira AF76	CI w/ MS handle & GS column	SS	GS pipe	brass w/ soft-soldered end spigots	cast bronze w/ brass valve seat
Petro	steel	(same as rising main)	GS pipe	reinforced rubber pumping element	DNA
Rower	PVC w/ GS pipe angled connector, steel handle & alum. surge chamber	DNA	PVC pipe	PVC chamber	alum. w/ rubber valve
Shinyanga	wood & steel w/ GS pipe column	GS pipe	GS pipe	PVC w/ malleable end caps	steel pipe w/ SS ball valve
Sumber Banyu ("SB")	CI w/ steel column	MS	GS pipe	PVC w/ CI end caps	gunmetal
SWN 80	GS	SS	PVC pipe	PVC	brass
SWN 81	GS	SS	PVC pipe	PVC	brass
Turni	CI w/ steel gears, steel crank handles & GS column	GS	PVC pipe	steel tube w/ rubber stator	chrome-plated steel rotor
VEW A18	SS w/ MS handle & MS crankshaft	SS cable	GS pipe	brass w/ hard chrome lining	SS body w/ brass rod

Table 2.3 (con't)

Name/Model	Pumpstand* (Principal Components)	Connecting Rods	Rising Main**	Cylinder***	Plunger Body
Volanta	steel	steel tubing	PVC pipe	nylon (Type 1) GRP (Type 2)	SS (both Types 1 and 2)
Waterloo (IDRC)	n.a. (but original concept defined as one allowing for local fabrication using locally available materials)				

* Unless otherwise noted, principle components, i.e. pump head, handle or flywheel, and column, are principally made/fabricated from the first material specified.

** In many cases where GS pipe rising main is specified, PVC or ABS pipe could be substituted. It is recommended, however, that the manufacturer be consulted first before any substitutions be carried out.

*** Or pump body chamber in the case of shallow suction handpumps

Abbreviations:

n.a. = not available
DNA = does not apply

ABS = acrylonitril butadiene styrene
alum. = aluminum
CI = cast iron
GRP = glass-reinforced plastic
GS = galvanised steel
HDP = high-density polyethylene
MS = mild steel
PE = polyethylene
PVC = polyvinyl chloride
SS = stainless steel

sources, yet too simplistic a comparative approach might unfairly accord too much weight to less scientifically reliable figures. Cost figures especially, must be treated carefully for the reasons already cited in Section 2.1.

2.5 GENERAL OBSERVATIONS AND ADDITIONAL COMMENTS

The UNDP Handpumps Project's final report on laboratory testing [1]) includes general observations relating to the CATR testing programme. These observations are reproduced and included in Appendix 3 of this report since they also serve as a very valuable checklist of points to consider when selecting or ordering handpumps for installation in developing countries.

The conclusions of the review of available information undertaken as part of this desk study may be generally summed up by paraphrasing the conclusions of the UNDP Handpump Project final report:

a) No pump presently available is considered to be satisfactory in every respect that may be established as important. All designs represent some compromise between reliability, performance, ease of installation and maintenance, user convenience, etc.

b) The selection of most appropriate pumps for community use in developing countries depends on local conditions. In different applications, particular parameters will be of greater or lesser significance. It is therefore very important to define these conditions before deciding which pumps to use.

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1) "Rural Water Supply Handpumps Project", UNDP Project Report No. 3, The World Bank, Washington DC, 1984.

Nonetheless, given most applications and present designs, it is suggested that choices of potentially suitable pumps should most often be made from the following makes, listed alphabetically:

Shallow-Well Handpumps

- Blair/Blair Prodorite
- Ethiopia BP 50
- New No. 6 (Bangladesh)

Deep-Well Handpumps

- Consallen
- DUBA Tropic II/Tropic VII
- India Mark II Deep/Modified
- Kardia
- Maldev (known also as Afridev)
- Mono ES 30
- Nira
- SWN 80/81

The handpumps listed above, particularly in the case of deep-well pumps, were selected primarily on the basis of durability, reliability, performance, overall design, proven performance and safety. Ease of installation, maintenance and use, local reproduction, and initial and ongoing cost considerations were also taken into account, but to a lesser degree. Some specific comments relating to the above-mentioned handpumps are offered below:

SHALLOW-WELL HANDPUMPS

Blair/Blair Prodorite

Popular, simple-to-operate pump requiring little maintenance. Easy to install. All moving parts water-lubricated and working parts easily removed for inspection and servicing. Most below-ground parts made of PVC. Low initial and ongoing costs. Local production of pump and spares possible.

Ethiopia BP 50

Self-priming shallow-well force pump. Not very robust. Awkward for shorter children to operate. Easy to install and maintain. Most below-ground parts made of plastic. Suitable for manufacture in developing countries; satisfies many VLOM (village-level operation and maintenance) requirements. Inexpensive.

New No. 6

Very simple, high-output, sturdy suction pump. Priming required, meaning pump susceptible to contamination and abuse. Likely to wear considerably under heavy use. Easy to install and simple to maintain. Suitable for manufacture in developing countries with foundry skills. Inexpensive.

DEEP-WELL HANDPUMPS

Consallen

Highly rated in ODA tests in terms of overall design, low frequency of maintenance and breakdown, corrosion resistance and safety. Continuous length ABS rising main and extractable piston concept simplifies installation, and repair and maintenance of below-ground parts. Local manufacturing of pump head and other parts probably quite limited. Moderately priced.

DUBA Tropic II/Tropic VII

Sturdy, massive handpumps of extremely robust construction. Tropic II is high-lift, high-capacity model while Tropic VII is more limited. Both models easy to operate, but installation considered difficult due to heavy weight. Low maintenance requirements, but maintenance, if required, considered relatively difficult. Additionally, for below-ground repairs with Tropic

VII model, pump stand must also be lifted away to gain access. Long record of proven performance in Africa. Both models expensive. Spare parts also expensive.

India Mark II Deep/Modified

Proven durable, sturdy, very popular, high-quality hand-pump. (Modified version with solid instead of chain link is designed for moderate depth applications.) Fully enclosed pump head eliminates contamination possibilities. Easy to operate. Straightforward to install and maintain, but heavy equipment required for below-ground repairs since complete removal necessary. Local production possible in advanced developing countries with good fabrication and machining skills if product quality can be assured. Moderately priced.

Kardia

Newly developed pump that looks quite promising. Unpublished CATR Batch 4 handpump test results indicate, "A reliable handpump in which a conventional plunger action has been realised using modern materials. Easy to maintain and repair, and suitable for manufacture in some developing countries". Relatively expensive.

Maldev

Presently consists of above-ground assembly only; designed for use with 2½ inch PVC or GS pipe rising main. Robust and reliable. Suitable for manufacture in developing countries. Within low-to-moderate price range when down-the-hole components included.

Mono ES 30

Robust, reliable pump requiring little maintenance. Straightforward to install and maintain, but heavy equipment required for below-ground repairs since complete removal necessary. Particularly suitable if water to be pumped is sandy or silty. Track record includes thousands of installations in Africa, Middle East and Far East. Not suitable for local manufacture and all spares must be imported. Relatively expensive.

Nira

Reasonably robust pump. Straight-forward to install and maintain, but heavy equipment required for below-ground repairs since complete removal necessary. Simple design. Note that different cylinders are recommended depending on depth. Local production possible, but only in countries with highly developed manufacturing skills. Relatively inexpensive.

SWN 80/81

Sturdy, reliable, high-quality pumps. (SWN 80 pump head for depths to 40 m; SWN 81 pump head for depths to 100 m.) Extremely solid pump head mechanisms utilise top-quality, oversized bearings. Straight-forward installation and maintenance. Various size cylinders available, depending on particular needs. Pumpstand can be fabricated locally, but pump head and cylinder unsuitable for manufacture in developing countries.

2.6 SUPPLEMENTARY READING

Much information on handpumps exists. For those interested in a more thorough treatment of handpumps generally and the ODA and UNDP projects specifically, the following documents are recommended as valuable references:

a) "Handpumps for Use in Drinking Water Supplies in Developing Countries". Technical Paper No. 10, International Reference Centre for Community Water Supply and Sanitation, Rijswijk, (The Hague), The Netherlands, July 1977.

b) "Hand/Foot-Operated Water Pumps for Use in Developing Countries", Final Report, Consumers' Association Testing and Research Laboratory, UK, January 1981. (Summary Report available through the Manager, UNDP Handpumps Project, The World Bank, Washington, D.C.).

c) "Rural Water Supply Handpumps Project", Final Technical Report, UNDP Project Management Report No. 3, The World Bank, Washington DC, 1984.

Chapter 3

HANDPUMPS FOR WESTERN PROVINCE, ZAMBIA

3.1 INTRODUCTION

Terms of reference for this desk study (see Appendix 1) indicate that problems relating to durability of handpumps have been experienced in the rural water supply project in Western Province, Zambia, noting that corrosion and wear are significant. However, more specific information (e.g. types and extent of corrosion and wear problems encountered, particular pump parts and materials most subject to corrosion and/or wear, etc.) necessary to develop recommendations regarding possible suitable handpumps for Zambia, is not available through NORAD, and possibly not at all.

This being the case, it is believed more useful at this point to outline the types of problems that could be present based on what is alleged and define an approach leading to an action programme, than recommend specific handpumps that may or may not overcome the actual problems being encountered. The two sections that follow, then, discuss possible problems and causes (Section 3.2), and recommended approach for future action (Section 3.3).

3.2 GENERAL CONSIDERATIONS

There are many potential causes for wear and corrosion-related problems. As a very first step, the overall problem must be defined. By this, it is specifically meant that

a) Particular problems be identified by type, extent and prevalence

b) Particular pump parts and materials subject to excessive wear or corrosion be analysed to determine nature and extent of damage.[1)]

c) Possible causes and sources of problems be identified and considered for further action (or study, if necessary) or rejected as not applicable for the case at hand.

3.2.1 Wear

Where wear of particular pump parts is a problem, when defining nature and extent, it is also important to identify cause(s) as well. Table 3.1 lists possible causes that may ultimately lead and/or contribute to excessive wear.

3.2.2 Water Quality

Quality of water being pumped can also be significant when it concerns wear or corrosion of pump parts. Table 3.2 indicates some of the phenomena that can occur and their results. (Since the waters in Zambia have been described as acidic, encrustation (a possible problem in alkaline waters) is not included.

1) It is expected that moving parts and parts in contact with other surfaces and/or the water being pumped, e.g. bearings, pins, plungers, leather cups, seals, cylinders and linings, valves, filters, etc., will be most prone to problems.

Table 3.1

Possible Causes Leading/Contributing to Excessive Wear of Pump Parts

Possible Cause
- Overall unsuitability of pump for given application, i.e. pump designed for single family, not community, use
- Poor design features
- Use of poor quality or inappropriate materials
- Poor manufacturing or fabricating techniques
- Damage during transport
- Damage occuring as result of improper storage (e.g. exposure to climate, incorrect stacking, etc.)
- Damage during installation
- Improper alignment resulting from poor or insufficiently supervised installation
- Improper well development and/or preparation (e.g. incorrect materials used for gravel pack, faulty gravel pack, wrongly-sized well screen slots, etc.)
- Pumping of sand
- Failure to provide necessary routine maintenance, e.g. lubrication, as required
- Incorrect and/or insufficient maintenance, repair or replacement of worn parts
- Abnormal use and/or abuse of pump

Table 3.2

Possible Causes and Impacts of Wear or Corrosion
Resulting from Water Quality

Realm	Condition	Possible Result
Physical	. Sand being pumped [1)]	Abrasion, excessive wear
	. Excessive flow velocity (caused by incorrect gravel packing, too large screen openings, corroded and enlarged screen openings, etc.)	Removal of protective corsion and products from metal parts and greater exposure of exposed surfaces to further corrosion
	. Dissimilar metals	Bimetallic corrosion at or near junction of the two dissimilar metals
Chemical	. "Bad" water quality, e.g. low pH, low or high dissolved oxygen (DO), high carbon dioxide (CO_2), high total dissolved solide (TDS), high electroconductivity (EC), high hydrogen sulfide (HS), and/or low iron (Fe) content	Corrosion
Bacteriological	. High iron content	Deposition of iron, production of slimy jelly - like material on pump parts. Jelly can also block well screen openings and aquifer pore spaces

1) It has been indicated that many wells in Zambia are sunk in Kalahari sand, an extremely fine-grained sand that might be expected to cause problems.

3.2.3 Corrosion

Corrosion is a chemical process that results in destruction of metals. It can affect both above and below-ground pump components. Water in contact with metal often accelerates the process. Various forms of corrosion are indicated in Table 3.3.

Table 3.3

Types of Corrosion

Type
- General rusting or other uniform loss of metal, with occasional perforation in some areas.
- Dezincification or loss of one element of an alloy leaving a weakened residue.
- Bi-metallic corrosion near the juncture of two different metals.
- Highly localized pitting and perforation, with little loss of metal outside pitted areas.
- Stress-corrosion cracking induced at highly stressed areas.
- Corrosion in crevices, in sockets, and under gaskets or washers.

In analysing corrosion it is important to determine which types of corrosion are present so that causes and remedial measures can be identified.

In addition to pump parts, corrosion can also occur in metallic well screens and well casings. Though it is not known if this is also a problem in Zambia, it is mentioned nonetheless, since corrosion of either, particularly screens (causing enlargement of screen openings) can have particular consequence in that sand may then be allowed to enter the pump and cause abrasion of parts.

3.2.4 Corrosion Resistance

Ordinary steel and iron are not corrosion-resistant, but a number of metal alloys with varying degrees of resistance are available, including stainless steels (which combine nickel and chomium with steel) and copper-based alloys such as brass and bronze (which combine traces of silicon, zinc and manganese with copper).

Plastic materials, e.g. polyvinyl chloride (PVC), glass-reinforced plastic (GRP), polyethylene (PE), nylon, acrylonitril butadiene styrene (ABS), etc. are corrosion-resistant and particularly suited to corrosive conditions, provided that strength and economic criteria are satisfied.

3.3 PROPOSED APPROACH

As is clear from Section 3.2, the solution to handpump durability problems in Zambia is not necessarily simple nor straight-forward. At the same time, it may also not be so complicated as it appears. In order to begin considering solutions, however, it is essential to first define the problem.

Thus, it is proposed that a phased programme be adopted. To maximise cost-effectiveness and relevance of results, this programme should be:

a) Well-planned
b) Systematic
c) Carried out by technically qualified persons
d) Flexible enough so that
   i) Necessary data or further studies, if required, can be generated/commissioned/carried out
   ii) Necessary professional expertise, when required (e.g. a corrosion expert, a water quality specialist, a qualified mechanical or industrial engineer, etc.), can be engaged.

A three-phase approach comprising

a) Phase 1 - Diagnostic
b) Phase 2 - Detailed Study (as required)
c) Phase 3 - Implementation of Action Plan

and shown schematically in Figure 3.1, is recommended for consideration. Each phase is briefly described below, with principal Phase 1 activities designated by letter.

Phase 1

Phase 1 is basically a problem definition exercise. It can be informally or formally conducted, but should involve at least one or two technically qualified persons on a full-time basis for the duration of work (probably one to four weeks, depending on available information). The individual(s) assigned should be generally well-experienced in the overall field of rural water supply and, equally important, well-enough versed in the areas of handpump selection, installation and construction techniques, corrosion and water quality that he/she/they can gather information, assimilate it and decide what further data or information is required in order to develop recommendations and budgets for future actions.

It is anticipated that the diagnostic phase should include, but not necessarily be limited to:

Activity A: Review of available maintenance logs containing such information as type of repairs, date of repairs, parts replaced, repair worker's comments, etc.[1)]

Activity B: Review of present selection, shipment, storage, transport, installation and maintenance procedures, being particularly watchful for possible problem areas.

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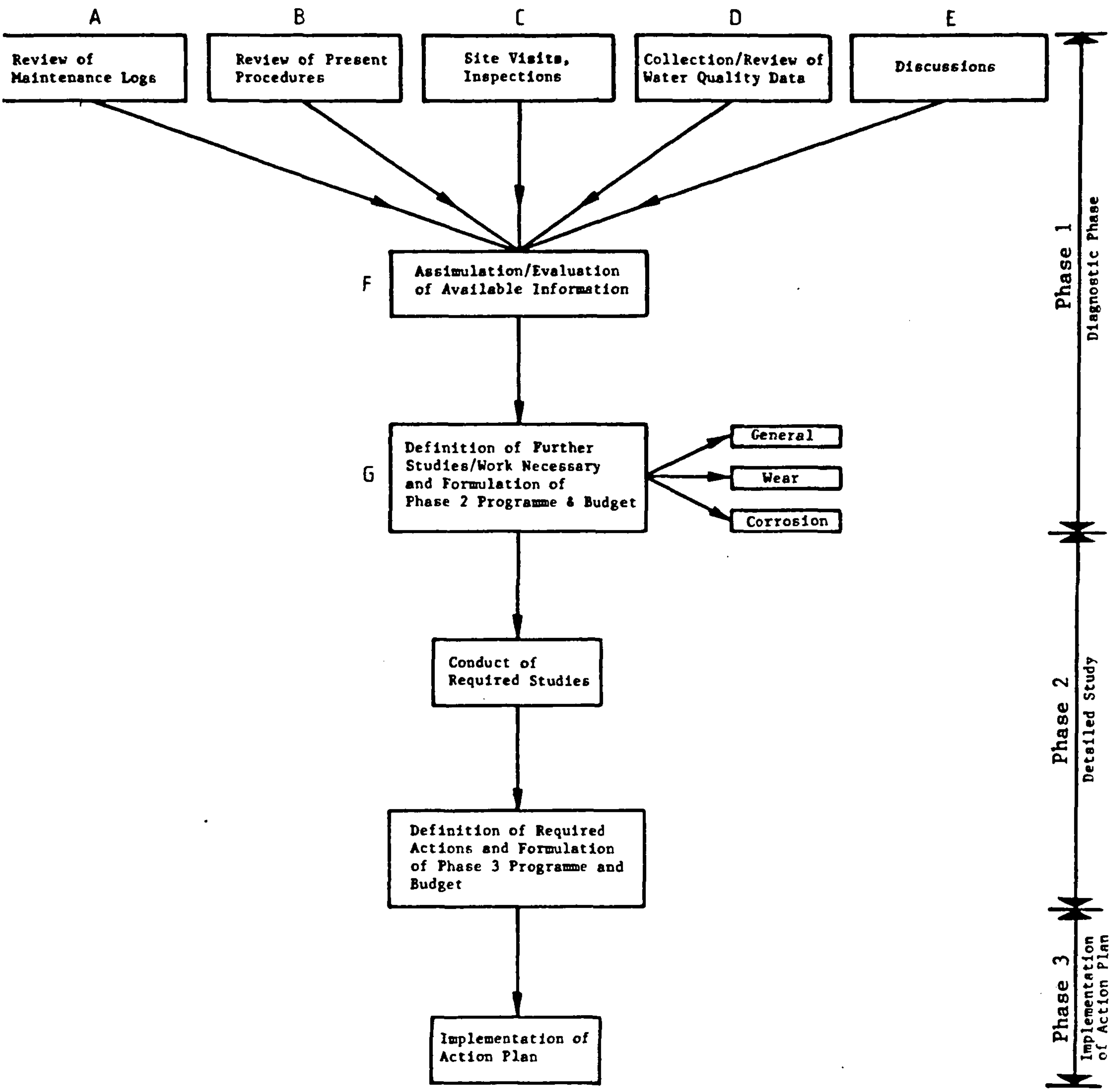
1) If no records exist, immediate establishment of a proper records system should be recommended.

FIGURE 3.1

PROPOSED APPROACH



Legend: (A) = Designated Phase 1 activity (Typical). See Section 3.3 for brief activity description.

<u>Activity C</u>: Site visits, where pump heads are disassembled and below-ground components removed for inspection; use and abuse of handpumps can be observed; etc.

<u>Activity D</u>: Collection and review of available water quality data, particularly as relates to pH, dissolved oxygen, CO_2, TDS, electroconductivity, iron and hydrogen sulfide.

<u>Activity E</u>: Discussions with relevant persons.

<u>Activity F</u>: Assimilation and evaluation of all available information.

<u>Activity G</u>: Definition of:

i) Either, problems (their nature, extent, frequency, impact, long-term cost, etc.) relating to wear and to corrosion
ii) Or, further study that needs to be carried out in Phase 2 to properly identify/define problem areas

and formulation of Phase 2 programme and budget.

Phase 2

Phase 2 activities will be determined by the outcome of Phase 1. If the situation regarding wear and corrosion is clear at the close of Phase 1, Phase 2 need only comprise preparation of a Phase 3 action programme and budget, probably a simple exercise requiring little time.

Otherwise, Phase 2 should comprise necessary studies and work, e.g. corrosion analysis, water quality testing, etc., required for development of recommendations for a Phase 3 action programme.

Phase 3

Phase 3 will stem from Phase 2. In its simplest form, it will involve selection of suitable handpumps and down-the-hole components for Zambia. In its most complex form it could involve a variety of activities, including, possibly, revision of Government stores and logistics procedures, training of craftsmen to properly install handpumps, developing workable maintenance and repair structures, introducing maintenance procedures and record-keeping systems, training village mechanics for maintenance/repair duties, working directly with manufacturers to develop handpump components suitable for Zambian conditions, etc.

APPENDICES

TERMS OF REFERENCE

DESK STUDY ON AVAILABLE HANDPUMPS - SURVEY AND RECOMMENDATIONS

Objective

The desk study shall provide a digested overview of handpumps available in the commercial market. The study report will present the findings in a tabulated form with brief characteristics of the jobs and conditions each pump is suited for. The information thus presented will be disseminated to relevent NORAD projects as an "easy- to- read" guide on available handpumps.

Scope of Study

The consultant will review material which is easily available from funding agencies, manufactures, etc. Most of the background material will already be available with the consultant and only minor additional data collection will be required.

The material will be studied systematically with a view to compile the characteristics of each type. The information thus derived will be presented in a brief report, mostly in a tabulated form. The criteria applied to the various categories of handpumps will be described.

Within the listed handpumps subjected to study, a search for types to suit conditions in Western Province, Zambia will be made. Recommendations within the broad criteria available will be made.

Handpumps Characteristics

The criteria for classifiction of handpumps can be divided into 3 broad groups:

- Performance (e.g. yield, head, power-requirement, etc)
- Quality (e.g. materials specification, corrosion protection, durability, service/maintenance requirement, etc)
- Cost (e.g. procurement, installation, spare parts, maintenance, etc)

After appropriate criteria have been established the specifications of each pump can be compared and the characteristics be described in an organised manner. It is hoped that this can provide a tool for evaluation and selection of pumps on NORAD financed projects.

The report will list the handpumps on which information is available and present their characteristics. The consultant should also endeavour to give his own qualified comments on features of the specific handpumps where appropriate.

Handpumps for Western Province, Zambia

The Norad financed rural water supply project in Western Province, Zambia has experienced problems on durability of handpumps. The problems relate to corrosion attacks, mechanical wear and frequent servicing of piston seals, etc.. The project will need a better quality of handpumps to be installed in the future.

Two distinctly different categories of handpumps will be required:

- For shallow wells, mounted on 3-6 m deep, covered ring wells.

- For medium deep wells, fitted on gravel-packed tube wells, up to 40 m deep.

The wells are sunk in fine sand (Kalahari sand) and the water is aggressive with pH in the range of 4-5. Most of the tube wells are placed in the deposits with a gravel pack. However, some will also be in hard bedrock.

The pumps will be installed partly in remote locations. The general technical know-how is very limited and even semi-skilled pump caretakers would only be available as a result of a project-specific training programme. Thus the handpumps should be of excellent durability and/or need very simple servicing such as seal replacement, etc.

The consultant will give recommendetions as to the availability of suitable handpumps for the two types of wells mentioned above. Apart from being of specific use for ongoing NORAD projects the search/selection will serve as an illustrative case study for users of the report.

UNDP—Rural Water Supply Handpumps Project

Laboratory Testing, Field Trials and Technological Development (GLO/79/010, INT/81/026)

The World Bank — Executing Agency (July 1981)

The Drinking Water Decade

More than seventy-five percent of the over two billion people in the developing countries do not have access to adequate supplies of safe water and adequate sanitation facilities.[1] The more than 1.5 billion who lack these basic services include 1.2 billion people in rural areas.[2]

The importance of providing safe water to these people has been repeatedly stressed by national governments and international agencies. Recognizing the urgent need for improved water and waste management, the United Nations has declared the 1980s the International Drinking Water Supply and Sanitation Decade (IWSSD). Among the activities of the Decade are the United Nations Development Programme (UNDP) Global and Interregional Projects for laboratory testing, field trials and technological development of handpumps, executed by the World Bank.

The first project, Laboratory Testing and Selection of Rural Water Supply Handpumps, is designated by the number GLO/79/010. The second, Field Testing and Technological Development of Rural Water Supply Handpumps, is designated by the project number INT/81/026. Work on the project began in July 1981, and is expected to be completed by the middle of 1985.

Why Handpumps?

An ambitious goal has been established by the United Nations to provide drinking water to about 1,200 million rural people who presently do not have access to adequate safe water. Handpumps installed in wells where groundwater is easily available provide one of the simplest and least costly methods of supplying the rural population with water. Therefore, the program of the Decade has placed special emphasis upon handpump installation. Meeting the goals of the Decade would require the manufacture and installation of about five to seven million handpumps.

[1] People's Republic of China is not included for lack of data.
[2] Report on Community Water Supplies for the UN Water Conference, World Health Organization and World Bank (1979).

Second edition

[illegible] capital investment in engineering, hydrology, bore-hole drilling, well digging, and pump installation. The effectiveness of this massive investment ultimately depends on the proper performance of the handpumps installed.

Despite research and development of handpumps already undertaken by manufacturers, governments, bilaterals and international agencies, a number of serious technological problems remain. These problems are manifested in poor design, unsatisfactory performance, shortened working life, and often in pump failure. There is also a lack of reliable data on handpump performance and on the comparative performance of different handpump designs. This data is required to facilitate selection from among the array of available handpumps.

What the Handpump Project Will Do

The new UNDP/World Bank program for laboratory, field testing and technological development of handpumps will address these problems. The main objective of the program is to improve the dependability and reduce the cost of rural water supply systems that employ handpumps, so that the majority of people in developing countries can have access to safe drinking water. The program will provide the necessary technological basis for the development of new low-maintenance and cost-effective handpumps for installation in developing countries.

The first project provides for laboratory testing for the selection and evaluation of a limited number of handpumps. Pumps being tested include established and innovative designs produced in developing as well as developed countries. Hand and foot operated pumps with different pumping mechanisms are being tested. Laboratory testing began in 1980 and will be concluded in 1982.

The second project, started in 1981, provides field trials for a variety of handpumps, including those pumps and components found most promising in the first project.

Extensive field trials will be conducted in approximately fifteen countries in various regions of the developing world with the testing of some 2,000 pumps. Each test site will encompass a defined area and include twenty-five to fifty pumps each of three to four different types, for a total of about 100 to 200 pumps per site. Handpumps will be monitored by the project staff and the local project participants. Detailed data will be collected, analyzed and disseminated.

One of the main objectives of the project research will be the development of Village-level Operation and Maintenance (VLOM) pumps, which can be manufactured in the developing countries and repaired by trained village operators. Unlike the conventional pumps, these light, simple pumps can be repaired without incurring the delay and expense of employing heavily equipped, highly skilled mobile maintenance units.

International Agencies Will Participate

The pumps to be field-tested will be procured through funds provided for handpump programs supported by international, bilateral and national agencies, because the UNDP funds are intended mainly to cover the technical assistance and project management expenditures.

To provide maximum impact and to encourage continuing support for the project objectives, the World Bank, as executing agency, will cooperate with other international organizations [illegible] major bilateral agencies, and others. In particular, the Project will coordinate with the WHO/UNDP Water Supply and Sanitation Programs, the UNDP/World Bank Project on Low-Cost Sanitation and the UNICEF Rural Water Supply Programs.

Developing Countries are the Beneficiaries

It is expected that the Projects will make significant contributions to the programs for low-cost water supply in developing countries. The Projects will develop a standard methodology for handpump testing leading to identification of effective pumps. The Projects will provide local training and technical assistance to district-level handpump operation, maintenance and monitoring teams. Manuals will be prepared to assist in the selection, installation and maintenance of pumps. The Projects will promote and assist in the development and local manufacture of appropriately designed handpumps.

It is anticipated that the Projects will enable governments to obtain greater benefits from funds available for rural water supply. Moreover, by improving the effectiveness of handpumps, the Projects are also expected to encourage increased investment in rural water supply during the Decade and thereafter.

Contacts with host governments and bilateral organizations interested in participating in field trials are underway. For more information, please contact:

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WORLDBNK WSH
Cable: INTBAFRAD

The following pages of this brochure provide excerpts of the interim laboratory report, as well as of the proposed monitoring forms for the handpump field trials. These samples are included in this brochure in order to give an indication of the form and content of the information that we anticipate will be made available by the project.

Laboratory Testing and Analysis

Eighteen handpumps, each produced by a different manufacturer, are being examined by an independent laboratory, and tested in accord with the following criteria:

1. Time required to order and deliver
2. Cost of pumps
3. Suitability of packaging for export and overland transportation
4. Engineering assessment
   - 4.1 Safety
   - 4.2 Resistance to contamination
   - 4.3 Resistance to abuse
   - 4.4 Ease of maintenance and repair
   - 4.5 Degree of skills required for manufacture
   - 4.6 Suggested design improvements

5.

6. Endurance

As an example of the laboratory tests, the table below shows the laboratory's assessment of a first batch of six pumps with respect to the degree of skill required for each activity in the pump manufacturing process, based on the following 5-point scale:

Very High Skill				Very Low Skill
5	4	3	2	1

In the table the pump names are coded with letters A–F.

Manufacturing Activity	Pump Name					
	A	B	C	D	E	F
Iron Foundry	3	4	—	2	4	3
Brass/Gunmetal Foundry	3	—	3	—	2	—
Steel Forging and Welding	—	3	4	2	4	3
Hot Brass Pressing	—	—	—	—	3	—
Sheet Metal Forming	—	—	3	—	—	3
Simple Machining (1)	2	—	3	2	3	3
Complex Machining (2)	—	5	3	—	—	—
Leather Cutting and Forming	2	—	—	2	—	—
Rubber/Plastics Moulding	—	5	1	2	2	3
Woodwork	1	—	—	—	—	—
Soft Soldering	—	—	—	—	2	—
Hard Chrome Plating	—	5	—	—	—	—
Specialized Processes	—	5	—	—	—	—
Total Score	11	27	17	10	20	15

(1) Turning, drilling, tapping, etc.
(2) Gear cutting, etc.

Along with the results of other laboratory tests, this table will assist decision makers in choosing a pump type suitable for local manufacture, operation and maintenance. It must be emphasized that this table shows only one of a number of evaluations, and therefore cannot be used independently to assess handpump suitability.

The results of the complete laboratory tests are being made publicly available.

Field Trials

The forms for the field trials request information on pump installation, maintenance and repair; pump operation; pump deterioration, damage and breakdown; some well and water characteristics; and sociological and cultural conditions related to pump use.

The forms have five parts, identified as Forms A through E. The first part, Form A, is to be completed by the Project's Country Officer. The form requests information on the well, the site, the water level, the quality of water, the pump and its installation.

Forms B, C and D are to be completed by the Project's Country Officer or the chief of the monitoring team during routine visits to ...e pu... te, ... visi... ...ire... ...ump... ...r. T... ...ms request information on the quantity of water pumped, the hours of operation, and on any operating problems.

Form E, to be completed by the Projects' Country Officer, requests information on socio-cultural issues, including the decision-making process preceding pump installation and the attitudes and behavior of women, men and children with respect to handpump use.

Excerpts of Forms A, B and D follow.

The information provided by the forms will be analyzed and made publicly available, along with the results and conclusions of the analysis.

Form A: SITE AND EQUIPMENT DATA — To be completed at the time of pump installation, or during the first visit to the site.

Q.2 Where is the pump situated?
Name of village:
Name of town nearby:
How far away is this town from the village?

Q.3 What is the type of well? Dug? Drilled?

Q.6 What is the total *depth* of the well? Please measure to the nearest half-metre from the top of the platform.

Q.7 What is the distance between the water surface and the top of the platform? Please measure to the nearest half-metre.

Q.9 What is the name of the pump manufacturer?

Q.10 What is the model name of the pump?

Q.12a What is the *material* of the rising main? Metal? Plastic? Other?

Q.12b What is the nominal rising main (internal) diameter?

Q.14a What is the *material* of the rod between pump stand and cylinder?

Q.15 Have there been *any* modifications to the pump as it was originally manufactured?

Q.16 What is the present monitor reading on the pump?

Q.20 What sources of water have been regularly used *before* the installation of the pump? Please write in all sources of *regular* use and include their approximate distances from the village centre.

Q.21 Approximately how far is the *new pump* from the village centre?

Form B: SITE INSPECTION REPORT — To be completed periodically.

Q.2 Where is the pump situated?
Name of Village:

Q.3 If the pump has a quantity monitor, what is its present reading? Please give the date, hours and minutes.

Q.4 What is the present water level? Please measure to the nearest half-metre.

Q.5 ...las t... been ... visib... ...nge... ...e pu...
Yes____ No____
If yes, please tick the appropriate box below.

- ☐ Wear
- ☐ Damage
- ☐ Missing Components
- ☐ Other______If Other, please give details.

Q.6 Please describe wear.

Q.7 Please describe damage.

Q.8 Please identify missing components.

Q.9 How many *full* strokes does it take to fill a standard container of x litres? (A *full* stroke is stop to stop and return, or one complete revolution.)

Q.10 Has there been any breakdown in the pump in the last month?

Q.11 For how many days was the pump out of use?

Q.12 What was the pump monitor reading when the breakdown occurred? Please give date, hours and minutes.

Q.13 Have there been any other difficulties or problems with the pump or its use in the last month? Please describe as fully as possible.

Form D: BREAKDOWN REPORT

Q.5 If the pump has a quantity monitor, what is its present reading? Please write in the date, hours and minutes.

Q.6 What was the symptom of failure; what first went wrong which caused the caretaker to report a breakdown?

Q.7 Which component(s) failed?

Q.8 Which part(s) were replaced?

Q.9 What is the distance from the top of the platform to the water surface?

Q.10 Why did the breakdown occur?
Mechanical failure? ____ Damage? ____ Missing components? ____ Other? ____

Q.13 How long was it from the time you began the repair to the time the pump was properly repaired and working again? Please write the number of days and/or hours.

Q.14 Please estimate how many hours were spent *only* in repairing the pump.

Q.15 Describe reasons for time taken between breakdown and final repair.

IMPORTANT POINTS TO CONSIDER IN HANDPUMP SELECTION

Literature

All pumps should be supplied with instructions for installation, maintenance and use. Plenty of clear illustrations are of particular value in overcoming language and literacy problems. In the majority of pumps the pump rod must be cut accurately to length during installation. In very few cases were adequate instructions provided by the manufacturer.

Skills required

All the pumps require basic mechanical skills for installation and maintenance, some needing considerable expertise.

Installation

Many pumps require lifting tackle for installation and maintenance because galvanised iron rising main is used. If uPVC or other plastic pipe could be used, the below-ground assembly could be installed or removed without lifting tackle.

Baseplate sealing

With some pumps, extra care is needed during the preparation of the base and subsequent installation to ensure an adequate sanitary seal.

Mounting Height

Many manufacturers give no indication of the correct height to which the pumps should be installed. The best pump designs are those which do not require a special pedestal built up on a wellhead. Pumps should have an in-built design feature which ensures that they are mounted at the correct height.

Spares

All the pumps may in time need manufacturer's spares, some of which can be costly. However the cost per unit of a stock of spares will fall the more pumps are installed in the field. Accent should be placed on development of the VLOM concept with regionally produced spare parts if possible.

Two-person Operated Pumps

Rotary pumps which can be operated by two people may have certain advantages. It may be necessary to investigate local cultural/sociological factors to assess the likely problems of this in practice. Throughout the Laboratory tests only one person was used.

Safety

Some manufacturers do not pay sufficient attention to the avoidance of safety hazards, even where this involves only a simple design change, i.e. long bolts with ragged ends, finger traps, tails of split pins.

Design Features

Handle: From observation of users operating reciprocating pumps, one potential cause of wear in the handle pivot could be eliminated by adding a "T" at the end of the handle where applicable. Cast iron is prone to breakage and difficult to repair. Handles should be of resilient material, steel bar or tube, or wood where available.

Valves: Some manufacturers give insufficient attention to the amount of valve lift. It is often excessive which lowers efficiency and introduces a risk of valves jamming open.

Pump rod Constraint: The test results suggest that where the design attempts to constrain the motion of the pump rod into a straight line, bending forces are generated which cause failure at the pump rod joints. (It would be helpful to obtain information from the field on this point).

Glands: These are not an ideal method of sealing the pump rod where it passes through the pumpstand, particularly if also used as rod guides. Wear is inevitable and the subsequent leakage apart from the loss of sanitary seal, could produce difficulties if tank filling is needed.

Faecal Contamination: Manufacturers should, whenever possible, look at the designs of the outlet spout to ensure that users cannot seal off the outlet with their left hand after defecating, to build up water in the body of the pump.

Fasteners: Few manufacturers have considered rationalising the variety of fasteners used on the pump. These could often be all one size or type, therefore needing only one tool.

Discharge Valve: In view of the few applications where tank filling facility is needed, the complication in pumpstand design that this introduces is unnecessary as a standard feature and often creates points of weakness. See also Glands.

Multiple Plunger Seals

Several manufacturers incorporate two cup seals on their pump plungers, possibly with the idea that the second one will provide a back-up seal in the event of failure of the first one, or perhaps to share the load.

Particularly in the case of leather cup seals, evidence obtained from the laboratory endurance tests shows that the top of the lower seal deforms inwards and becomes ineffective in the event of a top seal failure.

Unless clear evidence can be obtained from the field of the value of the second seal, it is considered to be an unnecessary complication and the plunger design can be simplified for only one seal.

Multiple Foot Valves

Unlike multiple cup seals, paired foot valves can share the work, since both must open and close in unison. The pump will continue to work when one foot valve has failed. However, we have evidence of one example where this was a disadvantage : broken parts of the failed foot valve became entangled in the plunger and severely damaged the cylinder.

Quality Control

All designs require a measure of quality control but some of the more complicated pumps need very strict quality control in manufacture, particularly in developing countries. Use of simple jigs and fixtures can greatly help the quality control situation and ensure both correct original construction and interchangeable replacement spares.

Efficiency

For most deep-well pumps, the efficiency at 25 or 45 metres is generally markedly greater than at 7 metres depth. This occurs because the relative contribution of friction to the total workload is greater at 7 metres than at the deeper settings. The effect is most pronounced for helical pumps of the Mono/Moyno type.

VLOM

Although some of the pumps satisfy the requirements for VLOM quite closely, none do so completely. Attention to the above points would go a long way towards meeting the VLOM concept.