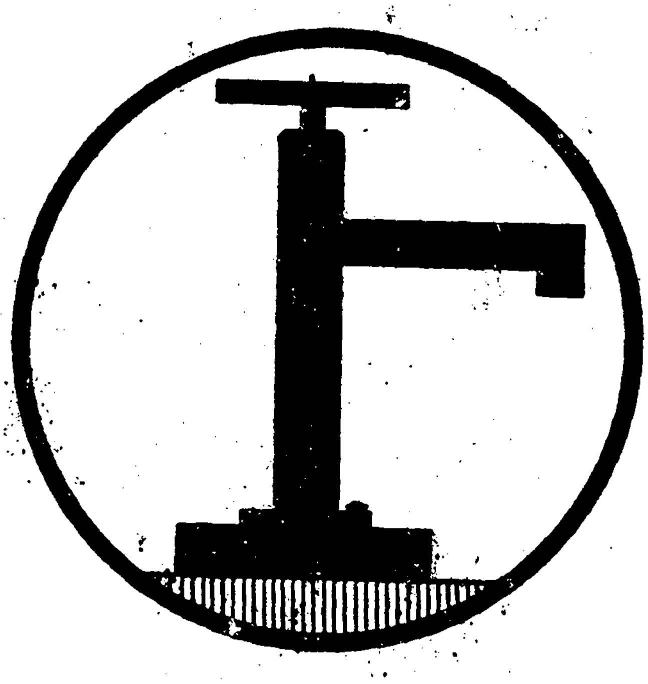
REPORT OF THE WORKSHOP ON THE DESIGN OF

THE TARA HANDPUMP

DHAKA, BANGLADESH, OCTOBER 13–17, 1985



DPHE
GOVERNMENT OF BANGLADESH
The World Bank
UNICEF
MAWTS

PART 1–MAIN REPORT

WORKSHOP ON THE TARA HANDPUMP

DHAKA — OCTOBER 13–17, 1985

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1. PREFACE

The workshop on the design of the TARA force–mode handpump took place in Dhaka, Bangladesh on the 13–17, October, 1985, sponsored by the United Nations Children's Fund (UNICEF) and the World Bank.

The main objectives of the workshop were to arrive at a final design for the 1986 production model, to identify components of the pump which require further development for future production, and to examine and make proposals on other aspects of the overall TARA handpump tubewell programme. These objectives were in line with the aims of the Government of Bangladesh to increase the coverage of hand tubewells in those rural areas that are affected by the lowering of static groundwater levels to depths beyond the limit of the suction–mode handpumps.

The participants of the workshop included handpump specialists working in Bangladesh, India, East Africa, the Americas and Switzerland.

The workshop organizers acknowledge the support of the Mirpur Agricultural Workshop and Training School (MAWTS) – the sole manufacturer of the TARA handpump to date, who provided samples of the TARA components and all drawings; the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), who made available their preliminary results from the sociological and technical performance study project surrounding the TARA handpump in Mirzapur; the Danish International Development Agency (DANIDA), who has been the main donor to the UNICEF/Government of Bangladesh research and development programme on the TARA handpump, and Dr . Keith Pitman of the National Water Plan Project, Bangladesh, who gave a lecture on the groundwater situation in Bangladesh.

The organizers also acknowledge the significant contributions made by the overseas participants to the workshop.

2. LIST OF PARTICIPANTS

OVERSEAS

1. David Grey – World Bank Handpump Testing Project, Nairobi
2. Andrew Karp – World Bank Handpump Testing Project, Washington.
3. Erich Baumann – SKAT, Switzerland; formerly of MAWTS,Dhaka.
4. A K Mudgal – Member, Indian Standards Institute, Manufacturer of India MKII handpump
5. Bent Kjellerup – Consultant to World Bank Handpump Project.

BANGLADESH

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3. SUMMARY OF PROCEEDINGS

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INTRODUCTION

Development of the TARA handpump was initiated in Bangladesh in response to the need for a cheaper tubewell/handpump deepset system which can be installed by the traditional "Sludger" method and be maintained by the users. The pump has been in the research and development stage for approximately four years; numerous prototypes have successively been developed, monitored and improved and over 300 of the latest prototype have been installed and their performance monitored in the field. The pump has also been tested under laboratory conditions. The encouraging results from the field and laboratory test have indicated that the time is ripe to move from a prototype to the first large scale production mode. This coincides with the requirement of the Government of Bangladesh to install large number of deepset handpumps under the Third Five Year Plan.

The principal objective of this workshop was, therefore, to finalize the design for the 1986 production model, of which 2000 are required for installation by July 1986. Even though the TARA is ready to go into mass production in 1986, certain components are known to require improvements. Although in many cases specific improvements have been proposed, they cannot be included in the 1986 specifications because they have not yet been fully tested. Therefore a secondary objective of the workshop was to identify components requiring further product development and to suggest specific improvements.

The workshop participants consisted of members of the design team based in Bangladesh and other handpump specialists from Bangladesh and overseas.

PROCEEDING

The first two days were a briefing period to ensure that all participants shared a common information base. The last three days were the productive part of the workshop.

DAY ONE

The workshop was formally opened by Mr M H Khan, Chief Engineer of DPHE, in the presence of representatives from the main sponsoring organizations. There was then a presentation on the Rationale and History of the development of the TARA, which discussed the need for a cheap deepset pump to cope with falling water tables in Bangladesh and gave some background on the development of direct action pumps, which was traced as far back as 1556. The design rationale was to :

(a) make extensive use of finished or semi–finished mass–produced standard items to reduce manufacturing to a minimum set of processes.

(b) ensure the tubewell module can be installed by the indigenous "sludger" drilling technique.

(c) provide adequate yield (approximately 1 litre per cycle at 12–15m lift) while keeping work requirement within range of children.

(d) eliminate hand tools for maintenance.

(e) maximise working life by minimising damage to moving elements by abrasion and corrosion.

This presentation was followed by a demonstration of an installed TARA pump, including withdrawal for inspection of components, and a demonstration of the traditional "sludger" system of boring tubewells, which must be one of the best examples of appropriate technology. After these demonstrations, participants were briefed on the present component specifications and production/installation cost of the TARA. Present materials used are standard "off the shelf" mild steel pipe and rod, bolts, nuts and washers and standard PVC pipes for cylinder and tubewell elements. The main "special" items are rubber ('O' rings and washers), aluminium plates, and nitrile rubber cup seals. The main processes can all be done with normal machine–shop tools (lathes, drilling, milling, welding) with the exception of PVC pipe extrusion and hot dip galvanizing, which are also common processes in Bangladesh.

The current cost of the complete TARA pump assembly is Tk. 1393 ($47). For a cylinder setting of 50 ft. and total tubewell depth of 120 ft., the material cost of PVC casing and pump rod and gravel pack is Tk. 2070 ($72). The drilling, platform construction and transport costs add a further Tk. 1300 ($45) making a grand total of Tk. 4763 ($164) for the complete installation. (This compares with Tk. 7,755 ($267) for an equivalent setting and depth of the traditional deepset pump).

For the final session a presentation was made of the latest draft report of the Consumers Association Testing and Research (CATR) Laboratory in U.K., who are currently testing the performance of the pump. CATR reports that the TARA is easy to install and maintain; the forces are approximately 20 kgf on up and down strokes at 21 cycles per minute at 12m piston setting with a 7m water level. At an extreme setting of 20m with 15m water level the up and down forces are 30 and 25 kgf respectively at 16 cycles per minute. The discharge per cycle varied betwen 1.16 and 1.22 litres. In the endurance test, the pump operated at 15m simulated head in clean water for 2000 hours (approximately 3 years normal use) without failure or significant loss of performance, though the rubber flap on the footvalve showed signs of wear. After introduction of a special abrasive mixture to the water, the pump seized after about 150 hours, apparently due to slivers of PVC gouged from the cylinder and jammed behind the leather cup seal. When the leather seal was replaced by a nitrile rubber seal, the pump continued without failure for a further 2000 hours. There was some discussion on the apparently superior performance of the nitrile rubber cupseal over the leather seal; it was generally agreed that laboratory testing is indicative but not definitive, and the only real test is performance in the field. (Pump performance after 2000 hours pumping the abrasive mixture had not yet been measured at the time of the workshop, but preliminary results have subsequently been received indicating no significant wear or reduction in flow rate. The nitrile rubber seal and cylinder has successfully withstood 2000 hours in abrasive mixture and the rest of the system has successfully withstood over 4000 hours of pumping except for the footvalve body which was found to be jammed in the taper seat).

DAY TWO

The second day was spent on a field trip to the Mirzapur Field Study, an epidemiological research project implemented by the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). 128 TARA pumps have been installed in the study area and their performance closely monitored. After initial briefing on the aims and results of the project, participants visited several installations and witnessed female caretakers servicing the pumps. In the afternoon, the Technical Field Test Data on the TARA Performance under this project and under the DPHE/UNICEF pilot programme were presented. The data from Mirzapur showed that "interventions" were made on average once or twice per quarter on each pump, and that the most common components replaced were the leather piston seal, the foot valve 'O' ring and the foot valve body. Data from the 115 DPHE/UNICEF pilot installations showed similar problems. However, while the data was useful in indicating the relative scale of the problems, the actual numbers were considered misleading from both Mirzapur and DPHE/UNICEF studies, because the pumps were being regularly inspected (and thus "disturbed") and parts were often changed before they had completely failed. So the field test data, while indicative of problems, was not based on a "real life" situation in which a caretaker would only "intervene" if the pump ceased to yield water, or yielded significantly less water than expected. Therefore the actual number, cost and time taken for interventions, all of which were recorded, gave a distorted picture of pump performance. It was generally agreed that the monitoring system needed to the redesigned.

There was also some limited user–response data presented, based on questions asked regularly by field monitors in the DPHE/UNICEF area and by a special study conducted in Mirzapur. The data showed that the pumps are being widely used and there appear to be no major negative user–actions to the TARA pumps. It was pointed out that the sociological data collection was even more difficult than technical data collection and it is possible that users may have withheld criticisms when asked by someone associated with the donation of the free pumps. While this effect would tend to exaggerate the magnitude of the positive response, major negative user reactions would still have shown through. It was concluded that beneficiaries needed to be prepared and taught how best to use the TARA pump and that there was a need to continue to monitor user response.

Health and epidemiological data collected so far by the Mirzapur Field Study was also presented, though this does not relate exclusively to the TARA. There is a wealth of data on the relationships between the incidence of child diarrhoea and handpump user group size, water consumption, sanitation and health education. The study is not yet conclusive, though preliminary data suggest a positive trend toward lower incidences of enteric diseases in the study area.

On the return from Mirzapur, participants briefly visited a Rower irrigation suction handpump installation, from which many of the TARA components have been derived.

DAYS THREE AND FOUR

The method adopted to decide on the 1986 specifications and identify items for further development was to divide the handpump tubewell system into three portions and assign each portion to a working group. To ensure that groups did not work in isolation, all major components of the system were first presented and discussed in detail by all participants. The working groups then formed and discussed their portion of the system, using the component drawings and analysing every item in turn. On the fourth day, each group reported its discussions and recommendations in plenary session and all participants were able to discuss the group reports. Each group then modified its recommendations, if necessary, in the light of the discussions and a consensus was reached. Recommendations were put in three categories :

Category A–	definite 1986 specifications
Category B–	relatively simple improvements that could be introduced in 1986 after some testing
Category C–	more difficult but important improvements that require longer period for development and testing.

A Category A recommendation was required for every item. In most cases the recommendation was "no change", except where minor changes could be made without requiring extensive testing. The 1986 (Category A) specifications were finalized in the last session of the fourth day.

DAY FIVE

Category B and C recommendations were further discussed to assign priorities and to fix a time frame to ensure maximum "retrofittability". The only pump components (i.e. excluding the tubewell) that cannot be retrofitted are the cylinder and the footvalve housing, which at present form one unit. Any changes to these would have to be included in the specifications for the 1986/87 installation year, when 5,000 pumps are planned; this means that although these recommendations are Category C, they are very high priority for accelerated product development and take priority over most Category B recommendations.

The Category A, B and C recommendations with the revised drawings form the main part of this report and represent achievement of the workshop objectives.

After finalizing recommendations for further product development, a presentation was made on Quality Control and Materials Specification, in which the experience of the India Mark II Handpump was described. It was pointed out in discussion that production techniques and quality control norms were relatively underdeveloped in Bangladesh compared to India and, while it is essential to insist on proper specifications and quality control, the specifications for the TARA should fall within the capacity of some Bangladesh manufacturers. It was also pointed out that quality control is as important for storage,handling and installation as it is for production.

There followed a presentation and discussion on Performance Monitoring and Data Collection. There was a recognized need to improve on the previous data collection exercise and concentrate on a) specific component testing for product development and b) overall performance in a "real life" situation (intervention only on breackdown). It was decided that Terms of Reference and procedures for data collection should be developed urgently, by the TARA development team (DPHE, MAWTS, World Bank, UNICEF).

A brief presentation was then given of the hydrogeological situation in Bangladesh, particularly the lowering of water tables due to present and planned extraction for irrigation, and the nature and depth of suitable aquifers for handpump tubewells. This was followed by a presentation and discussion on tubewell design, which indicated that current practice in Bangladesh is at variance with normally recommended practice concerning, particularly, water entrance velocities into the filter. This, along with poor tubewell development may account for the frequent rapid choking of tubewells experienced in the country. The higher yield of the TARA may aggravate the problem. Recommendations for improvement include a longer sand trap, more open area at the filter and vigorous development followed immediately by desand ing of the sand trap.

The final session was attended by Mr M H Khan, Chief Engineer of DPHE and Mr A A Kennedy, UNICEF Reprsentative, to whom a summary of the proceedings and recommendations of the workshop was presented.

RECOMMENDATIONS FOR TARA HANDPUMP DESIGN

4.1 Workshop Recommendations
4.2 Subsequent Modifications

CATEGORY A : 1986 PRODUCTION SPECIFICATIONS

CATEGORY B : CHANGES FOR IMMEDIATE INVESTIGATION

CATEGORY C : HIGH POTENTIAL MODIFICATIONS FOR LONG TERM

4.1 WORKSHOP RECOMMENDATIONS

ITEM 1 : PUMP HEAD ASSEMBLY

DRAWING NO : 1300

COMMENTS ON OVERALL CONCEPT :

A fabricated galvanised steel pump head is relatively easier to produce than a metal casting or other more specialised processes. Semi–finished standard items may be cut, drilled and welded into the final assembly. A pump head which is detachable from the tubewell and platform, while still providing a sanitary seal and robust construction, is better than the earlier model, which had to be anchored in concrete. This provides the option for replacement of the pump head with a minimum of difficulty, but may be vulnerable to pilferage of the anchor nuts.

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. No. 1301 : **Pump body assembly** – Cut slots to accommodate lugs on handle retainer.

DRG. No. 1302 : **Pump body** – Changes as per 1301

DRG. No. 1303 : **Spout** – No change.

DRG. No. 1304 : **Flange (top)** – No change.

DRG. No. 1305 : **View showing angular location of flange** – No change.

DRG. No. 1306 : **Rubber grommet** – No change.

DRG. No. 1307 : **Bottom flange assembly** – No change.

DRG. No. 1308 : **Bottom flange** – No change.

DRG. No. 1309 : **Stud** – No change.

DRG. No. 1310 : **Lug** – No change.

DRG. No. 1311 : **Guide Bush Assembly** – Revert to moulded PVC housing with wooden sleeve. Mould change required. Add GI ring around bottom to prevent creep. GI ring should have circular recesses of sufficient diameter and depth to accommodate 360 degree rotation of lugs on handle retainer.

DRG. No. 1312 : **Guide Bush** – Revert to wooden sleeve used for PVC housing.

DRG. No. 1313 : **GI Sleeve** – Dimension change to fit PVC housing and addition of circular recesses to accommodate lugs of handle retainer,

DRG. No. 1314 : **Handle retainer** – Material change to spring steel. Add lugs on end to fit slots in pump body so as to permit removal only in single position.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY B :

SPOUT : Add 5 mm high barrier to prevent insertion of debris into the tubewell from the front end of the spout.

FLANGE NUT : Add cylinderical washer with drain port to prevent removal of nut except with socket spanner.

WOODEN GUIDE BUSH SLEEVE :

Recess 2 mm below level of PVC housing if necessary to prevent handle from driving it through support legs of housing

CATEGORY C : Shorten pump stand by 300 mm and substitute concrete pedestal contiguous with standing platform.

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ITEM 2: HANDLE ASSEMBLY

DRAWING NO : 1320

COMMENTS ON OVERALL CONCEPT :

A stiff T–bar handle is necessary for the upper part of the pump rod of a direct action pump. Standard MS pipe is easily available, relatively inexpensive and easy to cut and weld. Galvanising protects the welded surfaces from corrosion, but is soon lost to abrasion on the guide bushing and from peoples' hands.

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. No. 1321 : **Handle Assembly** – Add length of plastic end plugs to T–handle, round off sharp edges and delete plugs.

DRG. No. 1322 : **Handle Rod** – No change.

DRG. No. 1323 : Change as per 1321.

DRG. No. 1324 : **Handle Nut** – See discussion of 1330 (Top Connector Assembly) below.

DRG. No. 1325 : **Plastic end plugs** – Delete.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT

CATEGORY B : **Handle** – Investigate cladding of vertical shaft of handle with PVC 1 inch nominal diameter pipe to provide smooth running surface against wooden sleeve of guide bushing.

CATEGORY C : **Top connector nut**– Investigate non–threaded connector.
Gluide bushing– Investigate alternative materials for guide bushing, such as rubber.

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ITEM 3 : LOWER WELL CASING, 1–1/4 INCH NOMINAL DIAMETER BS–3505, CLASS D RIGID WATER GRADE PIPE

DRG. No. None at present.

COMMENTS ON OVERALL CONCEPT :

PVC well casings are relatively inexpensive and locally manufactured. No problems apart from quality control have been noted after over a decade of use in the national rural water supply programme for tubewells.

1986 RECOMMENDATIONS :

CATEGORY A : None.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY C : Investigation of cost and functional implications of substitution of 2–inch nominal diameter for lower well casing.

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ITEM 4 : FILTER ASSEMBLY

DRG. No. 1380

COMMENTS ON OVERALL CONCEPT :

See Appendix – V.

1986 RECOMMENDATIONS :

CATEGORY A : See Appendix – V
DRG. No. 1381 : **Filter**–No Change.
DRG. No. 1382 : **Socket**–No Change.
DRG. No. 1383 : **End Cap**–No change

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT

CATEGORY B :

See Appendix – V

Filter–Investigate longer filter to conform to open area and entrance velocity international norms. Investigte 2–inch nominal diameter filter and length for same reasons. Investigate deeper setting to increase probability of encountering coarser, less uniform sands.

Sand trap–Investigate length of sand trap and change to larger diameter. Investigate development techniques and desanding of sand trap as mandatory installation routine.

* * *

ITEM 5 : TOP CONNECTOR ASSEMBLY

DRAWING NO : 1330

COMMENTS ON OVERALL CONCEPT :

Threaded connector not ideal for application, as probability for damage from cross threading and fretting relatively high. However, this option necessary for 1986 model in view of limited alternative options which do not require hand tools for servicing. Any replacement should not introduce need for hand tools

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. No. 1324 : **Top nut**– Add 20 mm spigot extension to top nut for better location for welding; suggest flat or groove to clear pipe seam; blind hole to isolate space inside pump handle from water entry. Width of flat on nut to account for galvanising close tolerance check with lock ring during assembly.

DRG. No. 1330 : **3/4 nominal diameter GI pipe**– Check ID and tolerances. Check feasibility to locate spigoted top nut without reaming, machining or need for groove or flat on top nut.

DRG. No. 1331 : **PVC top connector bushing**– Machine groove for ‘O’–ring shaft seal.

DRG. No. 1332 : **M 14 galvanised bolt**– No change.
Add fibre washer, or equivalent compressible washer to take up any slack between two nuts of connector when tightened by hand.

DRG. No. 1334 : **GI washers × 2**– No change.

DRG. No. 1335 : **Rubber ‘O’–ring and groove**– Change from face seal to shaft seal by square cross section groove, but using same ‘O’–ring.

DRG. No. 1336 : **Bottom M 14 standard galvanised nut**– No change. Check tolerances and match finished top nut to average tolerances of bottom nut.

DRG. No. 1337 : **Metal circlip**– Delete.

DRG. No. 1338 : **Locking ring**– Remove sharp edges of long sides of ring to make sliding up and down over nuts easier. Improved QC with calibration plug and adjustment of ring width during assembly on handle to ensure tight sliding fit.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY B :

DRG. No. 1324 : **Top nut** :– Deeper groove to accommodate 'O'–ring retainer for locking ring in case field test prove need for stop movable by hand.

CATEGORY C :

DRG. No. 1330 : **Top connector assembly** :– Non–threaded connector development. Outside cemented connector preferred to inside connector.

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ITEM 6 : PUMP ROD, 1–1/4 INCH NOMINAL DIAMETER RIGID PVC WATER GRADE PIPE, BS 3505, CLASS D (NO DRAWING)

DRG. NO. None at present

COMMENTS ON OVERALL CONCEPT :

Sealed PVC pump rods of appropriate diameter are essential for proper functioning of a direct action low lift pump. The effect is to redistribute the forces between up and downstrokes. Ideally the buoyancy of the pump rod should equal the weight of the column of water being lifted to minimise the differential between up and downstrokes caused by annual water table fluctuations.

1986 RECOMMENDATIONS :

CATEGORY A :

Add nitrile rubber rod guide. Add also nitrile rubber bungs to isolate space in segments of pump rods from each other.

RECOMMENDATION FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY C :

Prepare alternative diameter options to match alternative cylinder diameter options.

Investigate alternative thermoplastic options for local extrusions if PVC proves to be unacceptable long term material choice.

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ITEM 7 : PUMP ROD CONNECTORS (BELL AND SPIGOT) :

DRG. No. None at present.

COMMENTS ON OVERALL CONCEPT :

Bell and spigot joints are easy to make at the factory and join in the field. But careful quality control is essential to ensure minimum departure from axiality on the bells. PVC solvent cement has a relatively short shelf life and should be furnished only in tubes to prevent evaporation of the volatile solvents. Leakage of joints and joint slippage as a result of poor installation practices is a disadvantage of this type of joint.

1986 RECOMMENDATIONS :

CATEGORY A :

Strict QC requirement for axiality of bell. Add nitrile rubber rod guide above bell, using bell as bottom stop. If top stop proves necessary, add PVC split ring glued in place above guide. Add rubber bungs to isolate each joint from the space above and below the joint.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT

CATEGORY C :

Develop internal solvent cemented connector with groove for rubber rod guide if bell and spigot joints rejected.

Develop separable pump rod connectors not using threads to enable disconnection and reconnection of each segment, preferably containing rod guide on the connection

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ITEM 8 : RUBBER ROD GUIDE

DRG. No. 1384

COMMENTS ON OVERALL CONCEPT :

Departure from axiality of both the PVC casing and pump rods will cause the two members to come into contact in abrasion. Abrasion will eventually perforate the casing and the pump rods. It is unlikely that either casing pipe or pump rod pipe can be made or maintained perfectly straight until installation, or that, even if delivered perfectly straight, that differential soil pressure will be sufficient to cause sufficient non–axiality in the tubewell to cause abrasion problems. Therefore, sacrificial rod guides are considered necessary.

1986 RECOMMENDATIONS :

CATEGORY A :

Hard (95 Shore A) nitrile rubber ring, 2.5 mm thick with four 1 mm protrusions at 90 degree intervals. Protrusions to have radius of 3.5 mm from ID/Unstretched ID to be 40 mm, or sufficient to be able to install them without difficulty, but gripping tightly enough to stay in place. To be installed above bell. Top stop may be added if necessary by glueing split PVC ring above guide.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT:

CATEGORY C:

Incorporation of rubber guide into internal connector, or separable connector.

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ITEM 9: RUBBER BUNGS FOR PUMP ROD

DRG. No. 1385

COMMENTS ON OVERALL CONCEPT:

Leakage of solvent cemented joints is a distinct possibility and constitutes a major threat to the proper functioning of the system. Therefore, it is necessary to isolate the space above and below each joint of the pump rod with two simple, cheap rubber bungs.

1986 RECOMMENDATIONS:

CATEGORY A:

Two rubber bungs should be added, one above and one below each joint to confine any leakage to the small space in the joint itself. The bungs should be made from cheap rubber, conically tapered, with the large end slightly larger than the maximum ID of the pump rod. When pushed in the rubber will compress and make a static seal against the PVC ID.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY C :

Discontinuous cellular foam inside entire length of pump rod, but only if bungs unsuccessful.

****

ITEM 10 : UPPER WELL CASING, RIGID PVC, BS 3505 CLASS C.

DRG. NO : None at present.

COMMENTS ON OVERALL CONCEPT :

It is economical to use a single pipe to function as casing and rising main. However, the risk of destroying the entire system by perforating the casing by abrasion is greater than having a separable pump module. For purposes of Bangladesh, the former is preferred because of the limitations on maximum hole diameter possible to drill using the Sludger method.

1986 RECOMMENDATIONS :

CATEGORY A :

Strict QC on straightness and axiality of bells.

Strict guidelines for storage and handling from extruder to installation site.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY B :

Investigation of measures to obtain and retain maximum straightness of all PVC pipe used in system.

Survey of verticality of statistically significant sample of TARA pump tubewells installed to date.

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ITEM 11 : CYLINDER ASSEMBLY

DRG. No. 1370

COMMENTS ON OVERALL CONCEPT :

Using standard PVC pipe as the cylinder, integrated into the upper well casing is an economical approach to pump and tubewell construction in Bangladesh. The disadvantage is the vulnerability of the cylinder to wear and even perforation. If enough length is provided the piston may be moved to an unworn portion when necessary, but would require substantial investment in training of caretakers.

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. NO. 1370 : **Cylinder assembly**— Special surface finish, ovality and tolerance specifications for quality assurance. Check internal dimensions taper for conformity with specs.

DRG.NO. 1371 : Same as 1370.

DRG. NO. 1372 : **Bell connector** — no change.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY B :

Produce and test 50 mm ID × 60.3 OD PVC cylinder pipe.

Possible use of 2 × 1-1/2-inch bell adaptor as receiver for snap-fit footvalve.

CATEGORY C :

Design interchangable piston and footvalve assemblies.

Investigate radial sealing for footvalve combined with positive location of footvalve to separate the functions of static sealing and location of the assembly.

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ITEM 12 : PISTON ASSEMBLY

DRAWING NO : 1340

COMMENTS ON OVERALL CONCEPT :

A two-plate piston with a rubber flap valve is not the ideal solution for the TARA pump. The cup seal which is sandwiched between the two plates is considered a weak point subject to slackening and wear. The connector with threaded fasteners and a hair clip has the same shortcomings as the top connector. However,for 1986 no other tested option is available. Therefore, it was decided to retain for 1986 the present configuration with detail and material changes.

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. NO. 1341 : **Bottom connector bushing :** Delete countersunk recess and 45 degree chamfer. Add instead a groove for and'O'-ring. Increase bore diameter to 13 mm minus 0.2 mm to minus 0.3 for 1/2 inch deameter rod (or appropriate dimensions for 14 mm shaft if available).

DRG.NO. 1342 : **Connector rod**— Use 1/2 inch diameter bright steel shaft (subject to material availability, 14 mm diameter bright steel shaft would be preferable) as parent rod and weld on distance bushing before turning. Thus 1/2 inch BSW thread needed on upper end (or M 14 if 14 mm diameter rod used). Step turned on lower end to prevent axial movement of piston. Add radius R 0.5 mm to R 1 mm maximum on flap valve shoulder.

DRG. NO. 1343 : **Washer**— Two required instead of one. ID increased from 11 mm to 13.5 mm (or 14.5 in case 14 mm shaft obtained).

DRG. NO. 1344 : **'O'-Ring :** Increase to 1/2 inch diameter (or 14 mm in case of 14 mm shaft obtained). Acts as shaft seal.

DRG. NO. 1345 : **Nut**— Change to 1/2 inch BSW, or M 14 if available.

DRG. NO. 1346 : **Rubber Valve**— Change material to nitrile rubber. Material specification and testing procedures need to be defined immediately.

DRG. NO. 1347 : **Piston Plate**— Delete boss. Increase length to 18 mm. ID 12.8 mm. Plastic injection moulded of materials specification and quality control specifications to be defined immediately.

DRG. NO. 1348 : **Stiffener Plate**— Plastic injection moulded. Increase length to 18 mm. OD to 52 mm. ID to 12.8 mm. Increase width of ribs from 4 mm to 5 mm. Plastic material spec as per 1347.

DRG. NO. 1349 : **Cup Seal**— Either nitrile rubber of leather cup seal interchangeable on piston assembly. Proposed comparative field testing of 50% each type during 1986, and a quantity of 2000 each to be procured. Leather cup seal manufacturing specs as given in World Bank Technical Report No. 4 . Nitrile rubber cup seal material and quality control specs to be defined immediately. Wall thickness increased to 3 mm. Chamfer on lip remains 45 degrees, taper on wall remains same.

DRG. NO. 1350 : **Grapple Assembly**— No changes.

DRG. NO. 1351 : **Nut** — No change.

DRG. NO. 1352 : **Hook** — No change.

DRG. NO. 1353 : **Hairclip**—No changes.Quality assurance needed for procurement to assure spring steel is used. Galvanising preferred.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT:

CATEGORY C :

Bottom Connector — A design should be adapted which does not use threads as load bearing members. The connector rod preferably injection moulded into the connector bushing (similar to screwdriver handle). If successfully developed the connector should be considered for use in the top connector assembly and as part of pump rod segment connectors.

Piston — One piece piston to avoid sandwich design. Investigation of different seal configurations including diodic seal piston to reduce friction between the piston assembly and the cylinder. Introduce other valve system (poppet) to substitute for the rubber flap valve. Any changes need to ensure that no hand tools are needed for maintenance.

Grapple— Footvalve retrieval system should be redesigned to eliminate need for extension rod.

****

ITEM 13 : FOOTVALVE ASSEMBLY

DRG. NO. 1360 :

COMMENTS ON OVERALL CONCEPT :

The present concept has three weak points :

(a) The O-ring has a double function, acting as a static seal and holding the piston in place.
(b) The longevity of the rubber flap valve is insufficient.
(c) The plastic body creeps under the load imposed by the 'O'-ring and water column.

Field tests have shown that these weaknesses are the cause of an unacceptable proportion of repairs. Results, however, were distorted by frequent removal of footvalves to measure the static water level in test wells, and undoubtedly induced many if not most problems. For 1986, due to the absence of other viable and tested optional designs, it was decided to retain the present concept. Dimensional changes will be introduced to prevent the 'O'-ring from rolling out and measures will be taken to prevent polymer creep.

1986 RECOMMENDATIONS :

CATEGORY A :

DRG. NO. 1361 : **Footvalve body** — New moulding die required. Dimensional changes to ensure that the gap between the cylinder taper and the footvalve body will be uniformly one mm. Increase height of boss. Insert a bolt with a shank and injection mould it with part of the shank projecting above the boss to prevent the nut on the T-bar tightening against the plastic body. Introduce a lock nut on the bolt. Relocate the position of the 'O'—ring groove to provide additional support from the ribs. Add radius of beween R 0.5 to 1.0 on flap valve shoulder to prevent creeping and cutting of valve.

DRG. NO. 1362 : **Footvalve guide**— No change.
DRG. NO. 1363 : **Guide rod** — No change.
DRG. NO. 1364 : **Rod** — No change.
DRG. NO. 1365 : **Guide** —No Change.
DRG. NO. 1366 : **Nut** — No Change.
DRG. NO. 1367 : **Valve seal** — material change to moulded nitrile rubber.
DRG. NO. 1368 : **Seal (O-ring)** — dimensional adjustment.

RECOMMENDATIONS FOR FUTURE PRODUCT DEVELOPMENT :

CATEGORY C :

A footvalve design needs to be developed which separates the functions of the static seal and retention of the assembly in its seat. A new footvalve concept should emphasise more reliable service over a longer period of time, accepting the possibility that it may be retrieved frequently for whatever reason. High priority should be given to designing interchangeable footvalve and piston components. This would provide the opportunity to exchange worn piston components no longer servicable in the dynamic mode, but usable in the static mode.

4.2 SUBSEQUENT MODIFICATIONS TO WORKSHOP RECOMMENDATIONS

Explanatory Notes :

1. On completion of the workshop, a complete set of drawings based on the recommendations of the workshop was sent to David Grey, Erich Baumann, and A. K. Mudgal from among the overseas participants, and the Consumers' Association Testing and Research Laboratory in England, for further comments.
2. The design team in Bangladesh examined all the comments received and discussed additional ideas of their own. Samples of certain components were manufactured and tested, based on the design alterations from the comments and additional ideas.
3. The modifications listed in this section represent the present design configuration of the TARA handpump, based on the more feasible suggestions from the overseas personnel and the local design team, including results of tests.
4. These modifications have been incorporated in the accompanying drawings to this Workshop Report, and should be read in conjunction with the Workshop Recommendations in 4.1 of the Report.

KEY

1.	Present Part/Drawing :	**STATUS :**	New — new drawing Mod. — modification to drawing from workshop recommendations.
		DATE :	The date referred to is either the drawing date or the checked date whichever is the later.
		Note :	All drawings were done by Peter Dempsey, Design Engineer, MAWTS.

2. Modifications : **SOURCE:** The initials of the source whose suggestions have been incorporated in the present design configuration and drawings.

HT — Home Team (Design team in Bangladesh)
AKM — A. K. Mudgal
EB — Erich Baumann
CATR — Consumers' Association Testing and Research.

SUBSEQUENT MODIFICATIONS TO WORKSHOP RECOMMENDATIONS

PRESENT PART / DRAWING				MODIFIED/REPLACED PART/DRAWING		MODIFICATIONS	
NUMBER	TITLE	STATUS	DATE	NUMBER	DATE	DESCRIPTION AND REASON	SOURCE
TP 1300A	Pump head assembly	mod	12/12/85	1300A	22/10/85	Altered pictorially to comply with modified top guide bush (TP 1311A), Handle Retainer (TP 1314A) and Bottom Flange (TP 1307A) as specified below.	HT
TP 1301A	Pump head,assembly of	mod	12/12/85	1301A	25/10/85	Altered pictorially to show hole instead of slot for handle retainer Galvanising specification (BS 729:1971) added.	HT AKM
TP 1302A	Body	mod	12/12/85	1302A	25/10/85	Dimensions of through hole (5 mm dia) added to allow drilling prior to assembly and welding of pump head.	EB
						Boring dia 70 mm increased from 69 mm dia. to ensure removal of weld seam from pipe of larger ID.	HT
						Material specification added.	AKM
TP 1303A	Spout	mod	12/12/85	1303A	11/03/85	Material specification added	AKM
TP 1304A	Flange,top	mod	12/12/85	1304A	04/03/85	12.7 mm was 1/2" dia; 152 mm was 6" dia; metric dimensions to be used throughout though raw materials might still be ordered in inch sizes.	EB
						14 mm dia was 13 mm dia; to allow for build up in hole due to galvanising and ensure clearance for 1/2" BSW stud.	EB
						Unnecessary machining of face deleted to reduce cost.	CATR
						(Suggestion to add shrouds to inhibit removal of nuts without special wrench still pending)	CATR

TP 1305A	View showing angular location of flange	mod.	12–12/85	1305A	11/03/85	Altered pictorially- nuts deleted because drawing incorrect,	EB
TP 1306A	Grommet	mod	12/12/85	1306A	11/03/85	Full material specification added, name changed from "Bush" to "Grommet"	EB AKM HT
						Cut -off size deleted:inappropriate	
						(Suggestion to increase hardness to 70°-75° Shore A rejected by home team. Performance satisfactory .)	AKM
TP 1307A	Bottom flange, assy of	mod	17/12/85	1307A	06/10/85	Galvanising and welding specifications added.	AKM
						(Suggestion that lugs (TP 1310A) be shifted by 30° to facilitate tapping of holes rejected by home team. Instead, protect threads during galvanising .)	AKM
						(Suggestion to use combined lug and stud rejected because stud must be removed/replaced when damaged.)	CATR
TP 1308A	Flange, bottom	mod	17/12/85	1308A	04/03/85	76.5mm dia was 70 mm dia. Similar standard preferred for top and bottom flange.	EB
						12.7 mm dia was 1/2". 152mm dia was 6". Metric units to be used throughout though raw materials might still be ordered in inch sizes	EB
						"Equispaced" added.	EB
						Unnecessary machining of face deleted to reduce cost.	CATR

TP 1309A	Stud		17/12/85			(Suggestion to use stud of fine and coarse thread rejected because of additional manufacturing required.)	EB
TP 1310A	Lug	mod	17/12/85	1310A	01/04/85	Chamfer specified 2x45° one end only.	EB
TP 1311A	Guide bush assembly	new	12/12/85	1311A	21/10/85	Wooden bush (TP 1312A) assembled with steel sleeve (TP 1313A) replaces PVC/wood/steel sleeve assembly recommended by workshop. The latter is too complicated to manufacture. New assembly already tried and tested satisfactorily.	HT
TP 1312A	Guide bush	new	12/12/85	1312A	25/10/85	See TP 1311A. Alternative materials of Teak and Shilkoroi being evaluated due to rising cost of shaal wood.	HT
TP 1313A	Sleeve	new	12/12/85	1314A	22/10/85	See TP 1311A	HT
TP 1314A	Handle retainer,assy	new	17/12/85			Simplified handle retainer (TP 1315A) assembled with cross brace (TP 1316A) to inhibit removal of assembly from pump head.	HT
TP 1315A	Handle retainer	mod	17/12/85	1318A	06/10/85	'Dogleg' removed: unnecessary in view of new top guide bush assembly (TP 1311A)	HT
						"Electro-galvanizing" instead of "hot dip"	AKM CATR
						Heat treatment specification added.	EB
TP 1316A	Cross brace	new	12/12/85			See TP 1314A	HT
TP 1320A	Handle, assy of	mod	17/12/85			Galvanising instruction added	AKM
TP 1321A	Rod	mod	12/12/85			Material specification added	AKM
TP 1322A	Handle	mod	17/12/85			Material specification added	AKM
TP 1323A	Handle nut	mod	17/12/85			Section view modified, projection incorrect.	EB
						Through hole specified for ease of manufacture	HT
						Counterbore eliminated because welding of top connector eliminated (see TP 1331A)	HT

TP 1330A	Top connector assy.	mod	17/12/85	1330A	22/10/85	Altered pictorially to show modified top connector (TP 1331A) and pumprod bung (TP 1385A)	HT
TP 1331A	Top connector, assy of	new	20/03/86			Sub-assembly drawing showing nut secured by centre punching at 3 corners after tightening. Supercedes previous method by tack welding.	HT
						Welding eliminated because penetration was poor and failed after machine facing of seat for fibre washer. Welding also spoiled galvanised surfaces.	HT
						Sealing with solvent cement in addition to use of pumprod bung (TP 1385A).	HT
TP 1332A	Top connector bush	mod	19/12/85	1331A	23/10/85	'O' - ring groove deleted as sealing bung (TP 1385A) provides adequate sealing. (We hope !)	CATR
TP 1333A	Bolt	new	20/03/86	1332A	23/10/85	Undercut for welding eliminated (see TP 1331A above)	HT
						General purpose steel was 'High tensile steel'. 4.6 was 8.8 to ISO 4016.	EB
TP 1334A	Washer	mod	17/12/85	1334A	23/08/83	31.7 mm dia (1-1/4") was 33 mm dia. washers available locally are of specified inch sizes.	HT
						Galvanising specification added	AKM
						"Stamp from 1/8" M.S. sheet" added.	EB
TP 1335A	Fibre washer	mod	17/12/85	1333A	24/10/85	14.2 mm dia was 14 mm dia : clearance for M14 bolt (TP 1333A)	EB
						1.6 mm dia was 2 mm : washers punched from fibre sheet graded in inch sizes.	
TP 1336A	Nut, M14	new	25/03/86			Standard part, electrogalvanizing, general purpose steel 4.6 to ISO 4016.	HT

TP 1337A	Locking ring	mod	17/12/85			Material specification added	AKM
TP 1340A	Piston assy, with bottom connector	mod	15/03/86	1340A	22/10/85	Altered pictorially to show modified bottom connector sub-assembly (TP 1341A) and pumprod bung (TP 1385A)	HT
TP 1341A	Bottom connector, assy, of	new	25/03/86			Sub-assembly drawing showing connector rod (TP 1343A) solvent cemented into bottom connector bush (TP 1342A) and secured by nut which is locked by welding.	
TP 1342A	Bottom connector bush	mod	17/12/85	1341A	24/10/85	'O' ring groove deleted as pump rod bung (TP 1385A) provides adequate sealing.	CATR
TP 1343A	Connector rod	new	10/02/86	1342A	24/10/85	Rod machined from solid bar replaces assembly of plain rod and bush welded together. Machining time is reduced and manufacture and quality control made easier.	HT
TP 1344A	Nut 1/2" BSW	new	25/03/86			Standard part, electrogalvanizing, MS	HT
TP 1345A	Flap valve	mod	25/03/86	1347A	24/10/85	Thickness reduced to 2 mm as 2.5 mm too stiff. Material specification : inner tube. Samples made of nitrile rubber are being tested.	HT
TP 1346A	Piston plate	mod	17/12/85	1348A	24/10/85	19 mm dia increased from 17 mm dia to increase strength and provide greater land for flap valve to improve sealing.	EB
						"Make from high impact Polypropylene" added.	HT
						(Suggestion to radius ports not incorporated due to production difficulty)	CATR
TP 1347A	Cup seal, nitrile rubber	mod	25/03/86	1349A	24/10/85	Material specification added	AKM
						Hardness reduced from 80-85 to 70°-75° shore A for ease of pumping	HT

						Tapered wall section introduced to provide pre-load	HT
						Lip diameter increased from 53.5 mm to 54.0 mm	HT
TP 1348A	Cup seal, leather	mod	17/12/85	1350A	24/10/85	53 mm dia-0 to-0.5 changed from 53 mm dia +/-0.4 to reduce risk of seizure.	AKM
TP 1349A	Follower plate	mod	17/12/85	1351A	25/10/85	19 mm dia increased from 17 mm dia to increase strength	HT
						Name changed from 'Stiffener plate	HT
						"Material high impact Polypropylene" added	HT
TP 1350A	Washer	mod	17/12/85	1352A	25/10/85	20 mm dia increased from 17 mm dia to suit follower plate (TP 1349A)	EB
						10.3 mm dia increased from 10 mm dia for clearance with M10 connector rod (TP 1343A).	EB
						Thickness 3 mm was 2 mm. "Stamp from 1/8" M.S. Sheet" added.	HT
						"Galvanizing" changed to "electrogalvanize"	HT
TP 1351A	Grapple, assy of			1353A	24/08/83	Drawing number changed.	HT
TP 1352A	Nut	mod	17/12/85	1354A	23/08/83	Counterbore 11 mm dia x 14 mm deep added to prevent damage to thread by slotting.	CATR
TP 1353A	Hook			1355A	24/08/83	Drawing number changed.	HT
TP 1354A	Hair clip	mod	12/12/85	1356A	06/10/85	Heat treatment specification added	EB
						"Hot dip galvanising" changed to "electro-galvanising"; less likely to affect mechanical properties.	AKM CATR
TP 1360A	Foot valve assembly	mod	17/12/85	1360A	25/10/85	Modified pictorially to represent modified foot valve guide (TP 1362A)	EB

						Thread runout shown above foot valve body.	EB
						Nut (old TP 1369A ND) eliminated. Unnecessary because of modified foot valve nut (new TP 1367A)	EB
TP 1361A	Foot valve, assy. of	new	19/12/85	1361A	25/10/85	Plan view included to show pattern of parts.	HT
						Groove for flap valve reduced from 2.5 mm to 2 mm to accommodate modified flap valve (TP 1368A)	HT
						'O' ring groove : i) Diameter increased from 39.5 mm to 42 mm dia to accommodate 5 mm dia 'O' ring.	EB CATR
						ii) Corners radiused to prevent cracking	CATR
						iii) Method of dimensioning changed. 19 mm dia increased from 17 mm dia to increase strength.	HT
						19 mm dia increased from 17 mm dia to increase strength	EB
						Material "High impact Polypropylene" and assembly note added.	HT
TP 1362A	Bolt 1/4"	new	25/03/86			Electrogalvanizing	HT
TP 1363A	Foot valve guide, assy. of	mod	19/12/85	1362A	15/05/85	Altered pictorially to show modified guide nut (TP 1367A). Galvanising specification added.	AKM
TP 1364A	Guide rod	mod	17/12/85	1363A	15/05/85	9.5 mm dia changed from 3/8" dia. metric units to be used throughout.	EB
TP 1365A	Rod	mod	17/12/85	1364A	24/08/83	9.5 mm dia changed from 3/8" dia. Metric units to be used throughout.	EB
TP 1366A	Guide	new	17/12/85	1365A	15/05/85	New drawing number	HT

TP 1367A	Nut	mod	17/12/85	1366A	15/05/85	20.5 mm reduced from 27 mm to cause foot valve guide to bottom out on 1/4" dia bolt (TP 1362A) and prevent pressure being applied to foot valve body which may cause cracking. Eliminates requirement for nut (old TP 1369A see TP 1360A above)	HT
						1/4" BSW changed from M6 (drawing incorrect).	EB
TP 1368A	Flap valve	mod	25/03/86	1367A	25/10/85	2 mm changed from 2.5 mm. Inner tube rubber flap valve of thickness 2.5 mm too stiff.	HT
						"Made from inner tube" added. Inner tube flap valve found to be more successful during trials.	HT
TP 1369A	'O' ring	mod	17/12/85	1368A	25/10/85	5mm dia changed from 6 mm dia	EB
						40 mm dia changed from 39 mm dia	EB
						Material specification and hardness added.	AKM
TP 1370A	Cylinder, assy. of	-	-	-	-	No change.	
TP 1371A	Cylinder pipe	-	-	-	-	No change.	
TP 1372A	Bell connector	mod	17/12/85	1372A	02/02/83	Pipe class and specification added	AKM
TP 1380A	Filter, assy. of	-	-	-	-	No change.	
TP 1381A	Filter	mod	19/12/85	1381A	07/10/85	5.0/5.5 mm changed from 5+05.5 mm. Drawing incorrect.	EB
TP 1382A	Socket	-	-	-	-	No change.	
TP 1383A	End cap	mod	19/12/85	1383A	07/10/85	'PVC' was 'Plastic'.	AKM
						Internal dimensions added	EB
TP 1384A	Rubbing ring	mod	19/12/85	1384A	25/10/85	35 mm reduced from 50 mm. Extra length unnecessary.	AKM
						(Suggestion to increase hardness rejected because of difficulty in fitting on rod)	EB

FIGURES

APPENDIX I

History of TARA Handpump development and design rationale

by :

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HISTORY OF TARA HANDPUMP DEVELOPMENT AND DESIGN RATIONALE

BACKGROUND

Ground water based irrigation, if it continues to develop in Bangladesh toward maximum exploitation of the resource, will increasingly interfere with suction mode pumps by drawing down the water table below the barometric limit during the dry season, as is the present case in about 20% of the country. It may be assumed .that increased food production will be given higher priority by development planners than protecting existing suction handpumps, estimated to number on the order of one million. Therefore, there is clearly a need for a cheap, reliable, non-suction pump to substitute for existing .pumps when necessary, and to serve those areas already affected. Product development of the TARA pump will be finalised during the initial phases of implementation of the first 50,000 units over the next five years.

HISTORY OF DEVELOPMENT

The TARA pump represents the first principles of a reciprocating piston handpump, i.e., a tube in which a moveable valve (piston) reciprocates above a fixed valve (footvalve). The origin of the reciprocating piston pump is obscure, but is generally attributed to Ctesibius, a scientist of Ptolemaian Alexandria in the third century before the present era. A manually operated direct action piston pump is illustrated in "De Re Metallica", published by Georg Bauer (Georgius Agricola) in 1556.

Simple, direct action piston pumps have survived through time as bilge pumps for small boats. The first recorded application of this type of pump to rural water supply appeared in Tanzania around 1968, kown as the "Salawe" pump, which migrated to Malawi in the mid 1970's and was converted from mostly steel to mostly plastic, where it evolved into the Mark V in the late 1970's. The development of the Rower pump began in 1978 in Bangladesh, while the Ethiopia pump appeared in 1977. The PEK pump, a Canadian development, dates from 1980. The Blair pump of Zimbabwe was developed at the Blair Research Institute, beginning in 1979. The latest additions to the family are the Nira (Finnish) and Wavin (Dutch)direct action pumps, which, no doubt, will be joined by others. The TARA pump draws on the experience of the earlier pumps, especially the Rower and Ethiopia versions, and was built at MAWTS in early 1982 as a first generation prototype, followed by refinements up to the present. The common feature of all the pumps mentioned so far is extreme simplicity of design compared to conventional lever action piston handpumps.

DESIGN RATIONALE

The long term (engineering) objectives of TARA pump product development are to establish a locally manufactured pump/tubewell system which is adequate functionally, acceptable to users, reliable, inexpensive and maintainable by users with a minimum of external assistance.

The strategy adopted to meet engineering objectives for the TARA pump consists of the following :

(a) Extensive use of finished or semi-finished mass produced items, such as standard PVC pipe, steel pipe and standard fasteners for the majority of tubewell and pump components, the effect of which is to reduce the complexity of manufacturing to minimum set of processess. Put another way, high priority given to reducing to a minimum the number of speciality items in the system by substituting off-the shelf, locally available items which are used for a variety of purposes.

(b) Ensuring that the tubewell module is compatible with the indigeneous "Sludger" drilling technique.

(c) Provision for adequate pumping capacity per cycle (the present prototype yields up to 0.9/liter/cycle at 15 metres lift), while maintaining a work requirement for pumping within a range acceptable to users, including children.

(d) Elimination of the need for hand tools to service the pumping elements (valves and seals), to maximise the potential for caretaker conducted maintenance.

(e) Protection of moving parts from damage from abrasion and corrosion to ensure an adequate working life (so far the most difficult aspects of the design problem).

PRESENT SYSTEM SPECIFICATION

The TARA system consists of two modules, the tubewell and pump. The tubewell comprises of a lower well casing with a filter and sand trap, all of which are 1—1/2" nominal diameter British Standard PVC extrusions. The filter is a continuously slotted, internally ribbed PVC extrusion. The upper well casing is 2—inch nominal diameter British Standard PVC pipe, whose length is sufficient to place the piston and footvalve below the minimum annual static water table (up to 15 meters). The pump discharge head is made of 2—1/2 inch nominal diameter steel pipe with a 2—inch nominal diameter discharge spout and is connected to the concrete platform by means of flanges. Three quarter inch nominal, diameter steel pipe is used for the T-bar handle, connecting to the 1—1/4" nominal diameter British Standard PVC pipe pump rod. The T-bar handle is guided through a wooden guide bushing at the top. The PVC pipe pump rod is sealed with a captive air chamber, the effect of whcih is to lessening the workload on the upstroke and adding the same amount of work to the downstroke. The cylinder is presently a standard Class C BS PVC pipe, and the piston cup seal is made of nitrile rubber. The footvalve is seated at the lower tapered end of the cylinder, and is captured for removal by means of a bayonet grapple on the end of the piston. The valves of the piston and footvalve assemblies are stamped from automobile tire inner tubes.

APPENDIX II

MATERIAL AND PRODUCTION COSTS FOR TARA HANDPUMP

by :

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Mirpur Agricultural Workshop and
Training School (MAWTS)
Mirpur, Bangladesh

MATERIAL ESTIMATE FOR PRODUCTION OF 1000 NOS. TARA PUMP

February 18, 1986

Sl. No.	Description	Unit Qty	Total Qty	Rate	Total Price
	A. STANDARD RAW MATERIAL (Off-the-shelf)				
1.	M S Plate pipe 2-1/2" dia BSP (13 pcs per 20 rft)	450 mm/1.5"	1,540 rft	Tk.53.00	81,620.00
2.	M S Pipe 2" dia BSP	313 mm/1.03"	1,030 rft	30.04	30,942.00
3.	M S Flange 1/2" thick 6" dia	2 pcs.	2,000 pcs	34.00	68,000.00
4.	M S Rod	300 mm/1 ft.	1000 rft	4.47	4,470.00
5.	M S Pipe 2-1/2" dia 68.5x75 mm x 1 mm sleeve	75 mm/0.25"	250 rft	30.00	7,500.00
6.	M S pipe 3/4" dia	990 mm/3.25"	3250 rft.	10.10	32,825.00
7.	M S Bar 1-1/4" dia	52 mm/2"	167 rft.	45.58	7,613.00
8.	Bright M S Rod 3/4" dia	180 mm/7"	585 rft.	13.80	8,073.00
9.	M S Rod 1/4" dia	130 mm/5"	417 rft.	1.43	597.00
10.	M S Rod 5/8" dia	65 mm/3"	250 rft.	6.81	1,702.00
11.	M S Rod 3/8" dia	2135 mm/7"	7000 rft.	2.47	17,290.00
12.	M S flat bar (10 mmx1/8") 1"x1/8"	60 mm/2.4"	200 rft.	3.73	746.00
13.	M S pipe 1" dia	25 mm/1"	85 rft.	16.00	1,360.00
14.	Spring wire, 16 SWG x 4"	4"/0.33"	1000 pcs.	Tk. 20/1b.	Tk. 100.00
					Tk. 262,838.00
	B. FASTENERS (Commercial Items)				
1.	Threaded stud 1/2" BSW x 1-1/2" with 1/2" nuts and washers	3 nos.	3000 nos.	Tk. 3.00	Tk. 9,000.00
2.	Seasoned wood, shaal/teak (3"x3")	0.03 cft.	30 cft.	550.00	16,500.00
3.	Spring wire 1/8" dia, 4 mm	22"	1835 rft.	8.00	14,680.00
4.	Inner tube 2.2 mm thick	LS	5 tubes	38.00	190.00
5.	Nut 1/2" BSW	1 no.	1000 nos.	2.00	2,000.00
6.	M S Washer 20x10.3x3	1 no.	1000 nos.	1.00	1,100.00
7.	G I bolt 1/4"x1-1/2"	1 no	1000 nos.	1.00	1,000.00
8.	M S bolt M14x80	1 no	1000 nos.	6.00	6,000.00
9.	Washer G I 15x3x3	2 nos.	2200 nos.	1.00	2,200.00
10.	Washer, fibre 14x30x2	1 no.	1000 nos.	3.00	3,000.00
11.	Nut M14	1 no.	1000 nos.	4.00	4,000.00
12.	Locking ring (screw type)	1			
					Tk. 59,670.00

1 US $ - Tk. 30 (approx.)

Sl. No.	Description	Unit qty.	Total Qty	Rate	Total Price
C.	SUB-CONTRACTED SPECIAL ITEMS				
1.	Rubber Grommet dia 94 x59x17 mm	1 no.	1000 nos.	10.00	Tk. 10,000.00
2.	Plastic piston plate	1 no.	1000 nos.	5.00	5,000.00
3.	Plastic follower plate	1 no.	1000 nos.	5.00	5,000.00
4.	Nitrile rubber seal	1 no.	1000 noos.	25.00	25,000.00
5.	PVC round bar dia 45 mmx2	90 mm/4"	330 rft.	100.00	33,000.00
6.	Foot valve plastic body	1 no.	1000 nos.	4.75	4,750.00
7.	Rubber O'ring dia 47x6 mm	1 no.	1000 nos.	4.00	4,000.00
8.	Rubbing guides	4 nos.	4000 nos.	15.00	60,000.00
9.	Rubber bungs	4 nos.	4000 nos.	10.00	40,000.00
10.	Cylinder dia 2" PVC pipe, Class 'C'	2m/6.56'	6560 nos.	13.50	88,560.00
					Tk. 275,310.00

Grand Total: (A + B + C) Tk.597,818.00

D.	PVC PIPE-BSS 3505 Extruded:				
1.	Cylinder dia 2" PVC pipe, class 'C'	2m/6.56'	6,560 rft.	Tk. 13.50	88,560.00
2.	Pump rod dia 1-1/4" PVC pipe, Class 'D'	50 ft.	50,000 rft.	.10.00	500,000.00
3.	Upper well casing dia 2" PVC pipe, Class 'B'	50 ft.	50,000 rft	12.50	625,000.00
4.	Lower well casing, dia 1-1/2" PVC pipe, Class 'B'	50 ft.	50,000 rft	8.75	437,500.00
5.	Roboscreen (dia 1-1/2" 8 ribbed PVC pipe) - 2 m	2m/6.56'	6,560 rft.	12.00	78,720.00
6.	Sand Trap, dia 1-1/2", Class 'B' PVC pipe	12.5 ft.	12,500 rft.	8.75	109,375.00

Total: Tk.1,839,155.00

PRODUCTION COST-TAPA PUMP

Production Processes	Pump head with guide bush	Pump handle Assy.	Piston Assy.	Bottom connector Assy.	Top connector Assy.	Foot valve Assy.	Cylinder assy.	Retrieving rod.	Total Time	Rate/hour	Total Cost
Material Preparation	15 mins.	20	10	5	5	15	10	10	90 mins.	TK. 15	TK. 22.50
Machine cutting sizing etc.	20 "								20 "	TK. 30	TK. 10.00
Lathe working	60	15+5	20	25	20	15		10	170 "	TK. 50	TK. 141.67
Milling		5	5						10 "	TK. 100	TK. 16.67
Drilling	25 "		15						-40 "	TK. 30	TK. 20.00
Welding	50 "	10	5			15			-70 "	TK. 40	TK. 46.67
Labour, Cleaning, Assembling	30 "	10	10	10	10	10	15	15	-110 "	TK. 20	TK. 36.67
Special * Process	TK. 10.-						TK.30		-TK. 40.-		TK. 40.00
Galvanising, Electro-plating	TK. 90.-	34.30	3.80	4.80	5.30	3.00			TK. 141.38		TK. 141.38

Total Production and Labour Cost: TK. 475.56

* Special processes like PVC thermo-moulding, jig bending, etc.

SUMMARY COST - TARA PUMP

(1986 model)

One set of Tara pump assembly consisting of:

- a) Pump head with top guide bush
- b) T-handle
- c) PVC cylinder, 2 meter
- d) Piston and foot valve assembly
- e) Top and bottom connectors
- f) Retrieving rod

1.	Raw material	TK.	597.81
2.	Material procurement overhead		59.78
		TK.	657.59
3.	Production cost	TK.	475.56
		TK.	1,133.15
4.	+ 40% overhead of item 3	TK.	180.00
		TK.	1,31.15
5.	Cleaning materials and consumables- 5% of (1-4)	TK.	64.45
		TK.	1,377.15
6.	Profit-10%	TK.	135.00
		TK.	1,512.15

February 18, 1986

APPENDIX III

QUALITY CONTROL

By :
A. K. Mudgal
Deputy General Manager
Richardson & Cruddas (1972) Ltd., India
Convenor, ISI Sub-Committee on Handpumps

QUALITY CONTROL

By :
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Deputy General Manager,
Richardson & Cruddas (1972) Ltd.,
Convenor, ISI Sub-Committee on Handpumps

1. QC (Quality Control) is a two-letter abbreviation, but covers a wide spectrum of activities. The ultimate aim is to get a product of acceptable quality as defined in the specification. Implementation of quality control systems is often a cumbersome process, more so with a product which has a number of components which are manufactured in large numbers. To achieve good quality products the following steps are considered to be of fundamental importance:

SPECIFICATION

2. Only if the product is defined adequately will a quality control system be definable. This would mean specifying the product, keeping in view the following:-
   (a) Component details-materials, dimensions, tolerances;
   (b) Assembly details clearly defined;
   (c) General requirements not covered in (a) and (b);
   (d) Routine tests;
   (e) Performance requirements
   (f) Sampling plan- carefully selected according to the importance of the product;
   (g) Packing requirements;
   (h) Marking of the product to distinguish it from untested, uninspected products.

3. In the absence of the above noted steps neither the manufacturer would know exactly what is expected by the buyer, nor would the buyer or the buyer's inspection agent know on what basis the product is to be accepted or rejected. The specification document in essence provides quality control guidelines for the manufacturer and quality assurance (inspection) guidelines for the buyer.

VENDOR SELECTION

4. Having clearly specified the product, the next task is to identify vendors capable of making the product as specified. The following factors should be considered in the process and carefully verified by an experienced inspection agency before placing a trial order:
   (a) Technical ability;
   (b) Infrastructure availability and type;
   (c) Financial capability;
   (d) Past performance;
   (e) Internal quality control.

5. **Internal Quality Control System**

   Quality Control in industry falls broadly into three categories :
   (a) Industry with quality assurance and quality control department.
   (b) Industry with a Chief Inspector who controls quality assurance and supervises quality control inspectors.
   (c) Industry with no Quality Control. These industries are generally interested in fast production keeping aside the quality aspect.

Selection of industries falling under either category (a) or (b) is of utmost importance. Industries falling under category (c) should never be selected even if they satisfy all requirements stated in para (4) above.

6. In case the vendor satisfies the criteria given in paras (4) and (5) above "Works Inspection" may be carried out by an experienced "Inspection" agency to check the following :
   (a) Goods inwards — how are goods accepted ? How are rejected/accepted goods accounted ?
   (b) If all slip gauges, ring and plug gauges, measuring instruments, etc. are available.
   (c) If jigs and fixtures are available to ensure consistency in production.
   If only the inspection agency gives positive recommendation, a 'Trial Order' may be placed on the prospective vendor.

7. During trial production visits should be made by the inspection agency to ascertain:
   (a) If quality control system is in operation. This should comprise:
      i) Goods inwards
      ii) Stage by stage inspection
      iii) Sub assembly clearance
      iv) Assembly inspection and testing.
   (b) If mould dies, jigs and fixtures are being used for manufacture of trial batch. If they are not adequate suggest improvement.
   (c) Study process and carry out checks in detail.
   (d) Discuss specification and drawings and indicate acceptance standards and accuracies/finish expected.

8. Once the 'Vendor' goes through the exercise as given in (7) above and supplies the material duly approved by the Inspection Agency, he could be registered as a "Potential Supplier"

9. The process outlined in para (4), (5), (6), (7) and (8) would ensure proper selection of vendor.

10. After framing the specifications and selecting vendors, a check is imposed on the manufacturer by introducing external quality inspection. An independant inspection agency should ensure conformity to the specifications through inspection. In no case should inspection be carried out by the buyer himself.

11. A great deal of experience in quality control and quality assurance systems for handpumps has been gathered in the rural water supply programme of India, most notably in large procurements of the India Mark-11 Deepwell Handpump.

12. The handpump is a very important component of the rural water supply sector of India, where handpumps must be reliable and durable. The government of India and UNICEF attached high priority to quality control and quality assurance for handpump procurements.

13. To qualify, as a manufacturer, of the India Mark-11 Handpump, in India, is no easy task, since the prospective manufacturer, must undergo a series of qualification checks before becoming an approved manufacturer. Apendix 'A' briefly describes the procedures followed by the Indian Standards Institution and UNICEF for approving a manufacturer. All purchases by UNICEF and State Governments are made only from approved manufacturers. As a matter of policy, even tender documents are not issued to the unapproved manufacturers for purchase of pump. This system filters out doubtful manufacturers.

14. The Appendix 'B' gives broadly functions of Indian Standards Institution. The 'ISI' marked product apart from ensuring quality also ensures free replacement of product/component found to be defective or not conforming to the specification.
In essence the India Mark-11 undergoes the following checks:
(a) Internal Quality Control at Manufacturer's works- Records of test and checks carried out are to be kept.
(b) Batch inspection of product by ISI inspector.
(c) Inspection by external inspection agency like Crown Agents, before dispatch.

15. All purchases made by State Governments, Municipalities, Central Governments are covered by external inspection and inspection charges are entirely borne by UNICEF. All the State Governments have welcomed this scheme and they utilise this scheme to ensure receipt of good quality pumps.

16. The specifications should be drawn carefully keeping in view the local conditions i.e. material availability and skills. In no case the word "as available in the country" or as manufactured by so and so" should be incorporated in the specifications. The specifications should clearly specify material and if possible process also. There should be no ambiguity in the specifications. In case material/ components, to the desired specifications are not available within the country, import of such raw material/components should be allowed till the local manufacturers are able to meet the specification requirements

17. Quality control costs money as it involves extra expenditure due to the following:
(a) Extra manpower
(b) Inputs become costlier as suppliers of raw materials/ components know that the supplies shall undergo check before acceptance.
(c) Rejection rate goes up which adds to production cost.
(d) This slows down the production resulting in higher overheads.
But the increase in cost is worth paying as this ensures supply of goods free of defects.

18. All our actions, whether it is framing of specifications for selection of vendor / or selection of external inspector or import of component/ process / process guidelines should be governed by the sole aim, i.e. procurement of a product which conforms to the specifications.

BUYER (UNICEF)

↓

APPLICATION RECEIVED FROM PROSPECTIVE MANUFACTURER.

↓

QUESTIONAIRE SENT TO THE APPLICANT.

↓

IF SATISFIED WITH DETAILS, WORK INSPECTION BY AN INSPECTION AGENCY IS ARRANGED.

↓

IF WORKS INSPECTION CONFIRMS THAT MANUFACTURER IS
CAPABLE OF MANUFACTURING, HE IS GIVEN A TRIAL ORDER.

↓

IF HE COMPLETES THE TRIAL ORDER SATISFACTORILY, HE IS PUT ON APPROVED LIST.

↓

THE MANUFACTURER APPLIES TO I.S.I FOR LICENCE.

↓

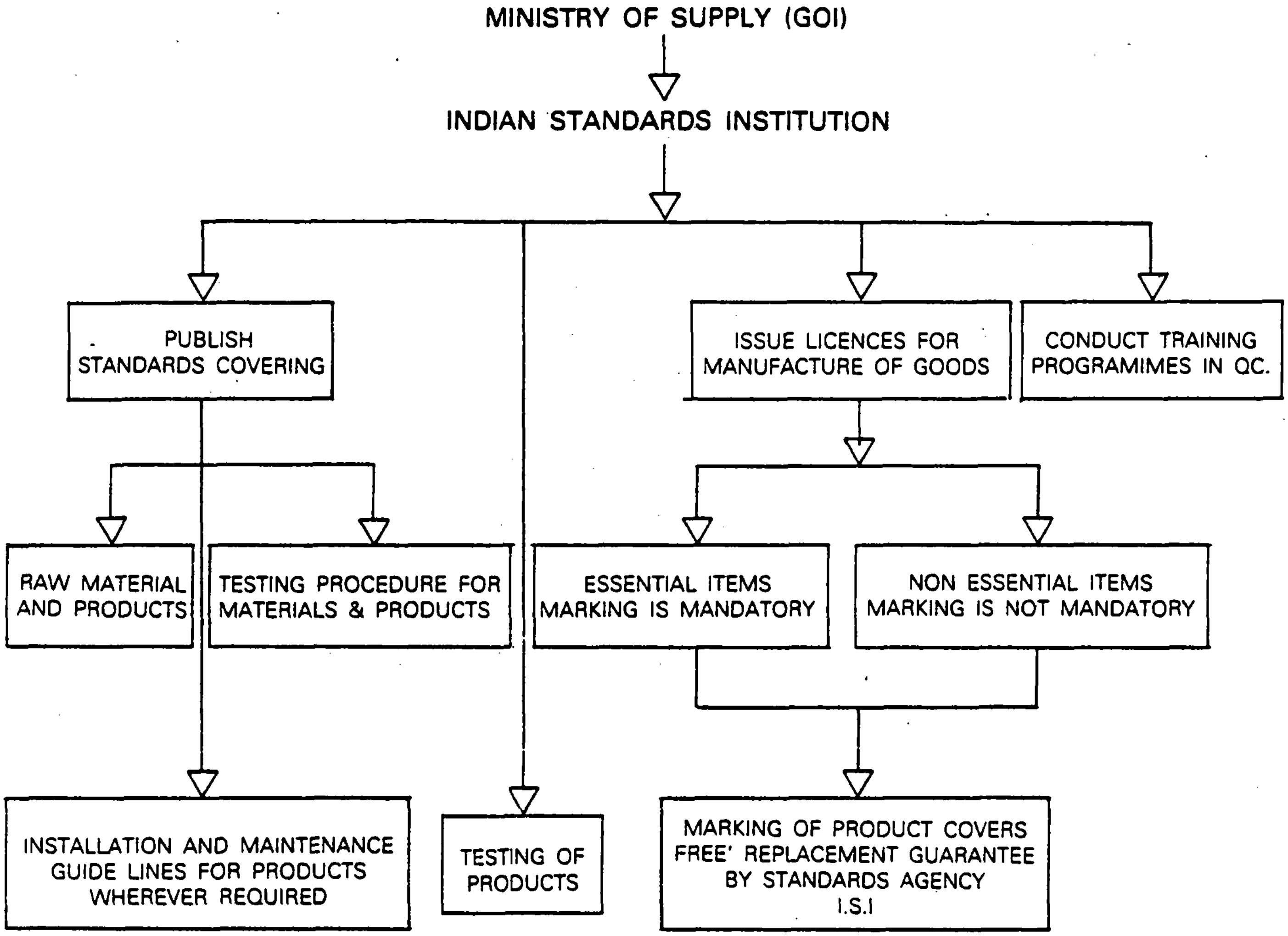
IF 'I.S.I IS SATISFIED LICENCE IS GIVEN.

↓

EACH LOT IS INSPECTED BY I.S.I' AS WELL AS BY AN OUTSIDE INSPECTIONS AGENCY.

NOTE:1) All Govt. purchases of pumps are covered under "UNICEF Inspection Scheme"
2) UNICEF bears entire cost of inspection.

APPENDIX 'B'



NOTE: 1) The fee charged by 'I.S.I for 'ISI' marking is very nominal i.e.Rs. 1-50 per pump.
2) Each batch of hand pump is inspected by 'I.S.I' inspector.
3) Govt. gives Purchase & Price preference to 'I.S.I' marked products.

APPENDIX IV

MIRZAPUR FIELD STUDY : TARA PUMP FIELD TEST DATA

by :
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Bent Kjellerup, World Bank Handpump Project, Dhaka
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MIRZAPUR FIELD STUDY : TARA PUMP FIELD TEST REPORT

BACKGROUND

The Mirzapur field study is located in an area of approximately 1.2 square kilometers within which are two villages with a total population of around 4,500. The inhabited space, "baris" is elevated two to three meters above field level and is very congested, approaching the population density of an urban slum. A bari consists of several houses whose doors face inward toward a common area. Several baris may occupy a contiguous piece of elevated land, while many are isolated. During the monsoon period May — September baris may be cut off from each other by the flood, which may reach to an elevation of as little as one meter below the inhabited area.

Thirty two No. Six suction pumps were present in the study area when 128 TARA pumps were installed. The No. Six wells are set at about 20—25 meter settings in an upper aquifer moderately to heavily contaminated with iron (between 4 and 6 mg/1), while the TARA wells are set from 50 to 60 meters in a lower aquifer below a dense clay horizon which isolates the two aquifers. The lower aquifer shows low (up to 0.5 mg/1) iron contamination. Two meters of continuously slotted PVC screen, with 0.2 mm slots, are installed on each well with sand traps below the filter. The wells were drilled with the indigenous "Sludger" technique, and were naturally developed by backwashing and surging. Packing of the screens with coarse sand was attempted, but it is unclear whether the pack actually reached the screen. Sandy alluvial aquifers of medium to fine, highly uniform micaceous sands are interspersed with clay and silt horizons. Well logs were kept and samples were placed in glass tubes to provide a scale model of the various layers of each well.

Figure 1 is a hydrograph of a Bangladesh Water Development Board observation well (at bari level) in Basail Upazila, a few kilometers north of the study area. It can be seen that the aquifer piezometry is a direct function of the amount of rainfall percolating into the alluvial soil. The hydrograph from Basail Upazila closely resembles the hydrograph of the study area displayed in Figure 2, which was syntnesised from piezometric measurements taken from wells during intervention. The shift downward in the study area may represent competition during the months December — April from the three high capacity (2 cusec) irrigation wells surounding the study area. The water table may be slightly higher than the piezometric levels of the TARA wells because of the clay horizon at about 25 meters. It is clear that non-suction pumps are indicated for the study area now, and for the long term the amplitude of the current 9.5 meter fluctuation may increase. Construction of TARA wells was begun in May 1984, but the majority were installed between August and September of the same year. Consequently, most of the pumps have been in service for at least four quarters, as of mid-August 1985.

FIELD TEST DATA

1. TARA PUMP PERFORMANCE

Table 1 summarises the history of TARA pump performance from field test data collected in the study area as of mid-August. Interventions, when something was done to the pump, are classified into two main categories : Essential interventions and non-essential interventions. In the former case the pump either was out of service or performing to a substantially reduced capacity. In the latter case preventive maintenance or other adjustments were made to normally operating pump. A total of 595 interventions were recorded. Essential interventions totalled 353, of which five were to repair breakdowns and 348 were to correct poor performance. Non-essential interventions totalled 242, of which 17 were preventive maintenance and 225 were "other", which consisted of filing the tack weld on the top connector on all 128 pumps to make the faces of the two halves of the connector mate firmly. The remainder dealt mostly with adjusting the set screws on the top guide bushing.

Table 2 summarises the information contained in Table 1 and gives a quarterly record of the type and number of interventions and the number of pumps affected.

2. MAINTENANCE AND REPAIRS BY COMPONENT

Table 3 attributes the cause of maintenance and repairs by component and shows the number of pumps involved, as well as the number of pumps grouped by calendar age in quarters. Leather piston cup seals accounted for 51% of replacements, followed by footvalve parts (0-rings and body) at 37%. Figure 3 displays this information graphically.

3. SPARE PARTS COST BY COMPONENT

Table 4 shows the distribution of spare parts costs by quarter. It can be seen that footvalve problems accounted for 65% of replacement parts cost, demonstrating the weakness of the current design. Part of the problem may have been induced by removing a functioning footvalve to measure the water level in the well. However, a sound design should be able to withstand repeated and frequent removal for any purpose, though it is sensible practice to leave a normally functioning component undisturbed until it needs service. Plans are to install eight piezometry test wells in the study area to avoid excessive withdrawal of footvalves. Leather seals account for only 15% of the spare parts costs, but represent 51% of parts replaced. Pump rods were repaired for leaks, accounting for 14% of total spare parts costs, but only 4% of the number of replacement parts. Figure 4 displays the information in Table 4 graphically, while Figure 4A shwos the average cost parts replaced per operating pump per quarter.

4. MANPOWER REQUIREMENTS

Table 5 shows the distribution of man hours for all interventions, the parts involved, the time per quarter and the total time as of the sixth quarter of the field test. It would have been better to separate the preventive maintenance time from active repair time (parts replacement and additional repairs), since two items, the top and bottom connector, were adjusted for almost every pump. No top connectors have failed. However, for each of 128 pumps the tack weld on the top connector bolt was filed to ensure a tighter fit between the upper and lower nuts. All bottom connectors were retrofitted with washers below the follower plate. If these two categories of interventions are removed from the table, then actual repair time is represented by less than half of the total intervention time to a more representative figure of around 230 hours, or an average of 1.8 hours spent repairing each pump over the entire test period. Referring to Table 1, where 380 breakdowns were recorded and 91 additional repairs done during the same site visit, the time spent for each of the 380 visits averages around 0.6 hours, or about 36 minutes per repair intervention. Figure 5 displays the allocation of time for all interventions by quarter, the majority of which occurred during the second, third and fourth quarters. Figure 5A displays the allocation of intervention time by component.

5. EASTIMATED WATER CONSUMPTION

The national rural water supply programme's objective for service level for handpumps is currently 75 users per pump. The working hypothesis of the study is that there are certain combinations of deployment variables which may be manipulated to induce greater consumption of ground water and less use of water from other sources.

Table 6 gives the estimated water consumption from TARA pumps as a function of the size of the user group. Figure 6 displays the information in a bar chart. The method of estimation of water volume collected was observation in June/July of selected pumps by persons from the community, trained and hired for the purpose. Spot checks were made by project staff to verify the accuracy of estimates. Observations began at 0600 hours and continued until 2100 hours for three consecutive days per pump.Even-numbered pumps were chosen, and almost 50% of test pumps were included in the sample. Table 6 extrapolates the information to all pumps and all seasons (seasonal use is likely to vary), according to the size of the user group. It can be seen that the smallest user groups (average number 12) use an average of 66% more water then the next larger group (averaging 28 users), and almost double the consumption of the next larger group (averaging 43). The difference between the usage of the smallest and largest user groups is 180%. An hypothesis explaining the relationship between higher water consumption and small user group size may be a combination of the following factors :

- (a) Closer proximity of the pump to smaller groups;
- (b) Less competition for use of the pump when water is wanted;
- (c) Absence of, or reduction of impediments to using the pump, which may consist of physical barriers (surface water in the monsoon period), social barriers (personal, religious, political, differences in economic status, education, etc.)
- (d) Stronger feeling of ownership resulting from having to share the pump with fewer people.

PRELIMINARY CONCLUSIONS

1. CUP SEAL

The cup seal is the most frequently replaced item. Lab testing at CATR demonstrated that the leather cup seal caused catastrophic failure of the test pump when 6 grams/liter of abrasive material was added. The nitrile rubber backup seal, however, survived the test uneventfully. This represents an improvement, but ideally, a sealless piston would be a better choice.

2. FOOTVALVE

The footvalve assembly is the item second in replacement frequency. The footvalve body is made of injection moulded HDPE, and an O-ring groove is machined into the lower skirt. The footvalve asssembly is seated in a taper at the lower end of the cylinder. The taper is made by heat forming the cylinder pipe in a mould. Initial problems were noted in 1983 when the taper in several test wells appeared to creep open because of the sustained radial pressure of the footvalve in the taper, which allowed the footvalve assembly to fall through the taper with no possibility for extraction. The taper in subsequent cylinders was reinforced with fiberglass, and the problem was solved. However, it now appears that, the footvalve body creeps, reducing the diameter of the O-ring groove, causing the O-ring to roll out during extraction. The bottom flange formed by the groove is too weak and frequently shears off. A better design would not stress the PVC cylinder radially and would not require forming or reinforcement. A design recomended for discussion is that of Goh Sighyau, which uses a double lip rubber grommet for the stataic seal and will fit into a plain end cylinder. Ideally the piston assembly would be usable as the footvalve for the simplify production and spare parts inventories.

3. PISTON ASSEMBLY

Bimetallic corrosion is evident between the aluminium piston plates and the mild steel shaft. This was expected, but the original Rower pump assembly was used because of good experience with the material and the fact that it was already in production. Now that the TARA pump concept has been firmly established, it is time to change to a material which is immune to corrosion.

4. TOP GUIDE BUSHING

The original top guide bushing was solid wood, but tended to jam in the pump head because of swelling in contact with water. A second design consisted of a wooden sleeve inside a moulded PVC housing. The finger trap guard was almost the same diameter as the wooden sleeve and tended to drive the sleeve through the PVC feet retaining the sleeve. However, the problem was eliminated by removing the finger trap guard. The earlier designs of the top guide bushing were retained by a grub screw, which was not effective in holding the PVC housing because of polymer creep.

The third design for the top guide bushing reverts to a solid wooden dowel which is sleeved with a galvanised tube to restrain the expansion and is held in place by the feet of a wire latch, which also serves to retain the bushing. Consideration is now being given to a wire latch whose feet secure the guide bushing.

Wear on the top guide bushings of the second design appears to stabilise after an initial period of relatively rapid wear. This may be because the rough zinc coating of the handle quickly gets polished off resulting in a smooth surface. A PVC tube (1 inch nominal diameter) could be put over the galvanised surface to provide a smooth running surface on the wood. However, the PVC tube might need to be ultraviolet light stabilised for long term survival.

5. TOP CONNECTOR

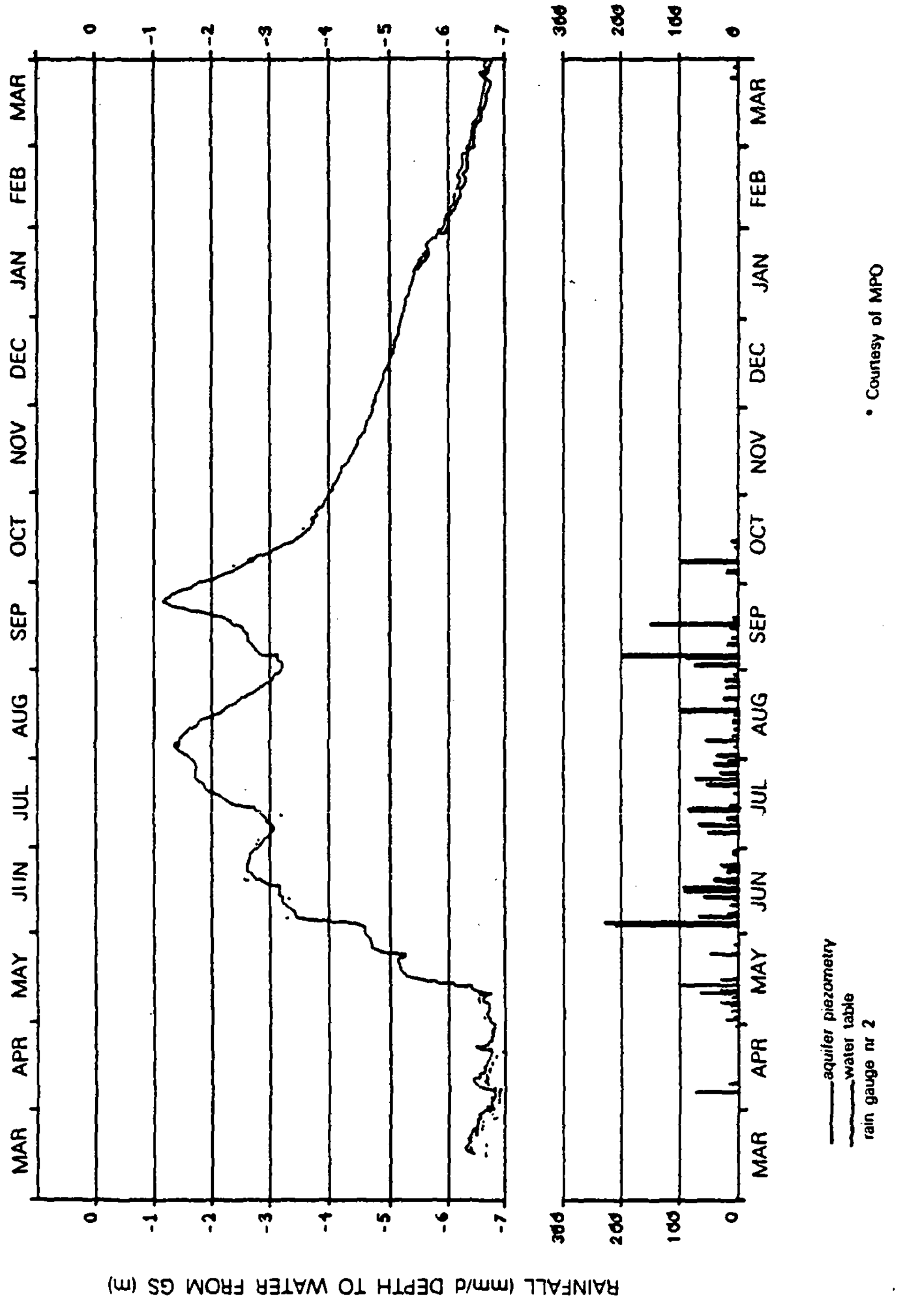
The top connectors have been relatively free of failures, but tend to fret and corrode because it is difficult to tighten the two halves of the connector sufficiently by hand while at the same time aligning the faces of the two nuts to allow the retainer sleeve to be slid over the nuts. This problem may be relieved by inserting a compressible fiber washer between the two nuts.

6. PUMP ROD AND UPPER WELL CASING

Symptoms of a major long term problem have appeared in several well failures due to perforation of the upper well casing by consistent abrasion between the pump rod and upper well casing. The larger diameter of the bell of the pump rod comes into contact with the upper well casing more frequently than other parts of the pump rod. Bowing of both pipe diameters appears to be common and certainly, sufficient to prevent perfect verticality in the well. Differential soil pressure on the well casing would seem enough to prevent perfect verticality even with perfectly straight pipe. The solution to the problem would seem to be guided rods. Guides or centralisers of nitrile rubber may be a reasonable choice, but the geometry remains an open question.

Figure 1 •

HYDROGRAPH FOR SPECIAL STUDY AREA WELL Basail Upazilla

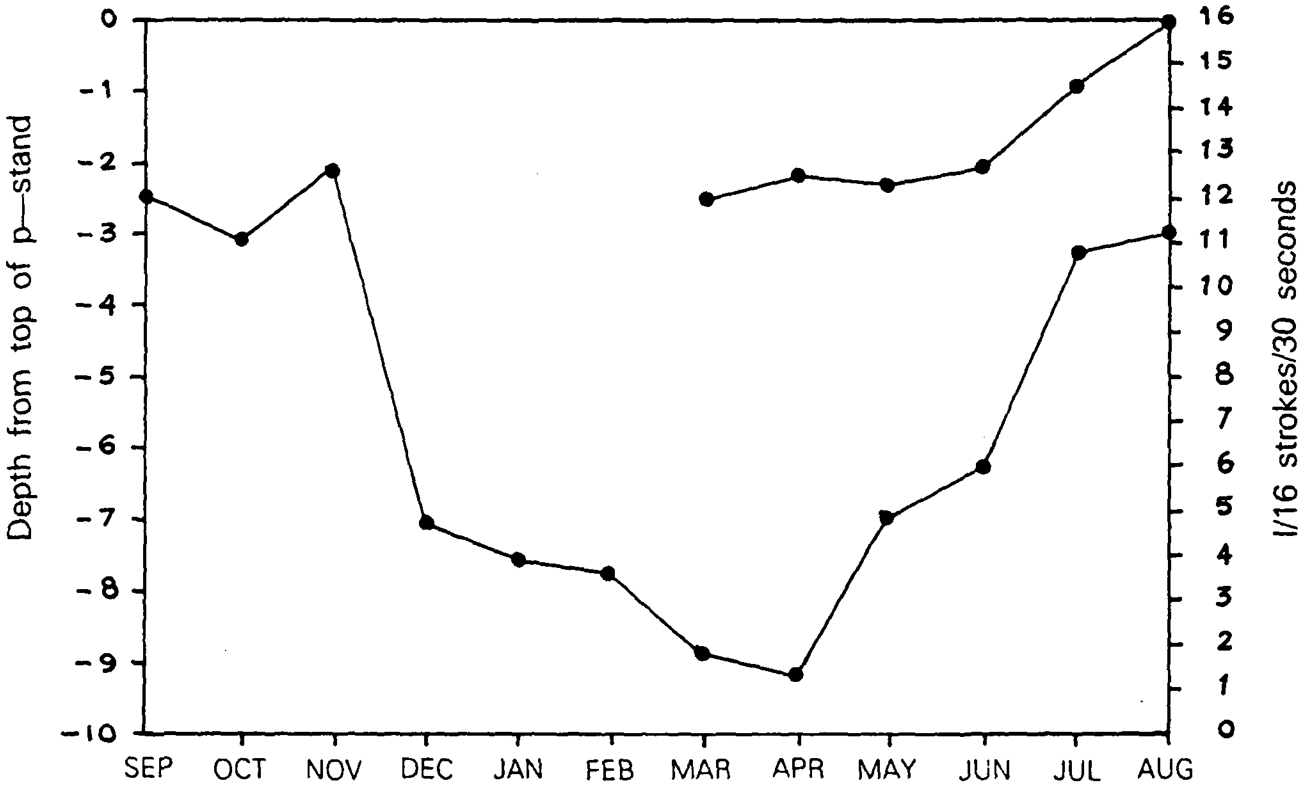


• Courtesy of MPO

HYDROGRAPH & AVERAGE DISCHARGE

FOR STUDY AREA

Figure 2



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Summary of all Interventions
TABLE NO. 1

Pump ID Number	Reason for intervention				Row Total	Design Change
	EIBD	EIPP	PM	OT		
1	0	6	0	3	9	2
2	0	6	0	4	10	3
3	1	4	0	2	7	2
4	0	4	0	2	6	2
5	0	5	0	3	8	2
6	0	3	0	2	5	2
7	0	2	0	3	5	3
8	0	6	0	4	10	4
9	0	5	0	2	7	2
10	0	2	0	3	5	3
11	0	2	0	3	5	2
12	0	4	0	2	6	2
13	0	0	0	0	0	0
14	0	3	1	2	6	2
15	0	3	0	2	5	2
16	0	6	0	3	9	3
17	0	2	0	3	5	3
18	1	5	0	4	10	3
19	0	5	0	3	8	2
20	0	4	0	3	7	3
21	0	4	0	4	8	3
22	0	3	0	2	5	2
23	0	4	0	3	7	3
24	0	2	0	3	5	3
25	0	2	0	4	6	3
26	0	3	0	3	6	3
27	0	2	0	3	5	3
28	0	4	0	3	7	3
29	0	4	1	5	10	4
30	0	0	0	0	0	0
31	0	1	0	2	3	2
32	1	2	1	3	7	3
33	0	3	0	2	5	2
34	0	3	1	2	6	2
35	0	2	0	2	4	2
36	0	1	0	2	3	2
37	0	2	0	3	5	2
38	0	2	0	0	2	0
39	0	1	0	0	1	0
40	0	3	1	0	4	0

41	0	4	0	3	7	1
42	0	4	1	1	6	1
43	0	2	0	1	3	1
44	0	1	0	1	2	1
45	0	0	0	1	1	1
46	0	2	0	1	3	1
47	0	2	0	1	3	1
48	0	6	0	2	8	2
49	0	4	0	4	8	2
50	0	2	1	1	4	1
51	0	3	0	2	5	2
52	0	2	0	1	3	1
53	0	3	0	2	5	2
54	0	1	0	2	3	2
55	0	2	0	3	5	3
56	0	1	0	1	2	0
57	0	2	0	2	4	2
58	0	3	1	2	6	2
59	0	1	0	2	3	2
60	0	1	0	2	3	2
61	0	1	0	2	3	2
62	0	2	0	2	4	1
63	0	1	0	0	1	0
64	0	2	1	2	5	2
65	0	5	0	1	6	1
66	0	0	0	0	0	0
67	0	3	0	2	5	2
68	0	2	0	2	4	2
69	0	2	0	1	3	1
70	0	5	0	2	7	1
71	0	1	0	2	3	1
72	0	1	1	1	3	1
73	0	4	0	1	5	1
74	0	4	0	1	5	1
75	0	2	0	2	4	1
76	0	2	0	1	3	1
77	0	0	0	0	0	1
78	0	3	0	1	4	1
79	0	4	0	1	5	1
80	0	4	0	2	6	1
81	0	1	0	2	3	1
82	0	2	0	1	3	1
83	0	2	0	2	4	1
84	0	1	0	0	1	0
85	0	5	0	2	7	1
86	0	1	0	1	2	1
87	0	6	0	2	8	1
88	0	2	1	2	5	1
89	0	3	0	2	5	2
90	0	3	0	0	3	0

91	0	1	0	1	2	1
92	0	2	1	1	4	1
93	0	1	0	1	2	1
94	0	2	0	1	3	1
95	0	2	0	2	4	1
96	0	4	0	0	4	0
97	0	2	0	3	5	2
98	0	5	0	2	7	2
99	0	2	0	1	3	1
100	0	4	0	1	5	1
101		4	0	2	6	1
102	2	2	0	1	5	1
103	0	3	1	1	5	0
104	0	2	0	1	3	1
105	0	3	1	1	5	1
106	0	3	0	2	5	1
107	0	6	0	1	7	1
108	0	4	0	2	6	1
109	0	2	0	1	3	1
110	0	4	0	2	6	1
111	0	1	0	1	2	1
112	0	2	0	1	3	1
113	0	1	0	1	2	1
114	0	3	0	1	4	1
115	0	2	0	3	5	2
116	0	1	0	1	2	1
117	0	2	0	1	3	1
118	0	2	1	1	4	1
119	0	2	0	1	3	1
120	0	1	0	1	2	1
121	0	2	0	1	3	1
122	0	9	1	2	12	2
123	0	2	0	1	3	1
124	0	3	0	1	4	1
125	0	5	0	3	8	3
126	0	2	1	0	3	0
127	0	2	0	2	4	1
128	0	3	0	2	5	1
Col. Total	5	348	17.	225	595	191

Table no. 1 include data collected before mid Aug. 1986

TABLE —2

D : 06.04.86

Attribution of Interventions by Quarter

	Intervals						
Observations	1	2	3	4	5	6	Total
EIBD	0	1	1	2	1	0	5
EIPP	10	85	142	91	18	2	348
PM	1	2	5	8	1	0	17
OT	1	40	127	52	4	1	225
DC	1	35	111	40	3	1	191
Total No. of Intervention	13	163	386	193	27	4	786
Number of pumps in operatiion	128	127	127	121	59	3	

Table no. 2 include data collected before mid Aug. 1986

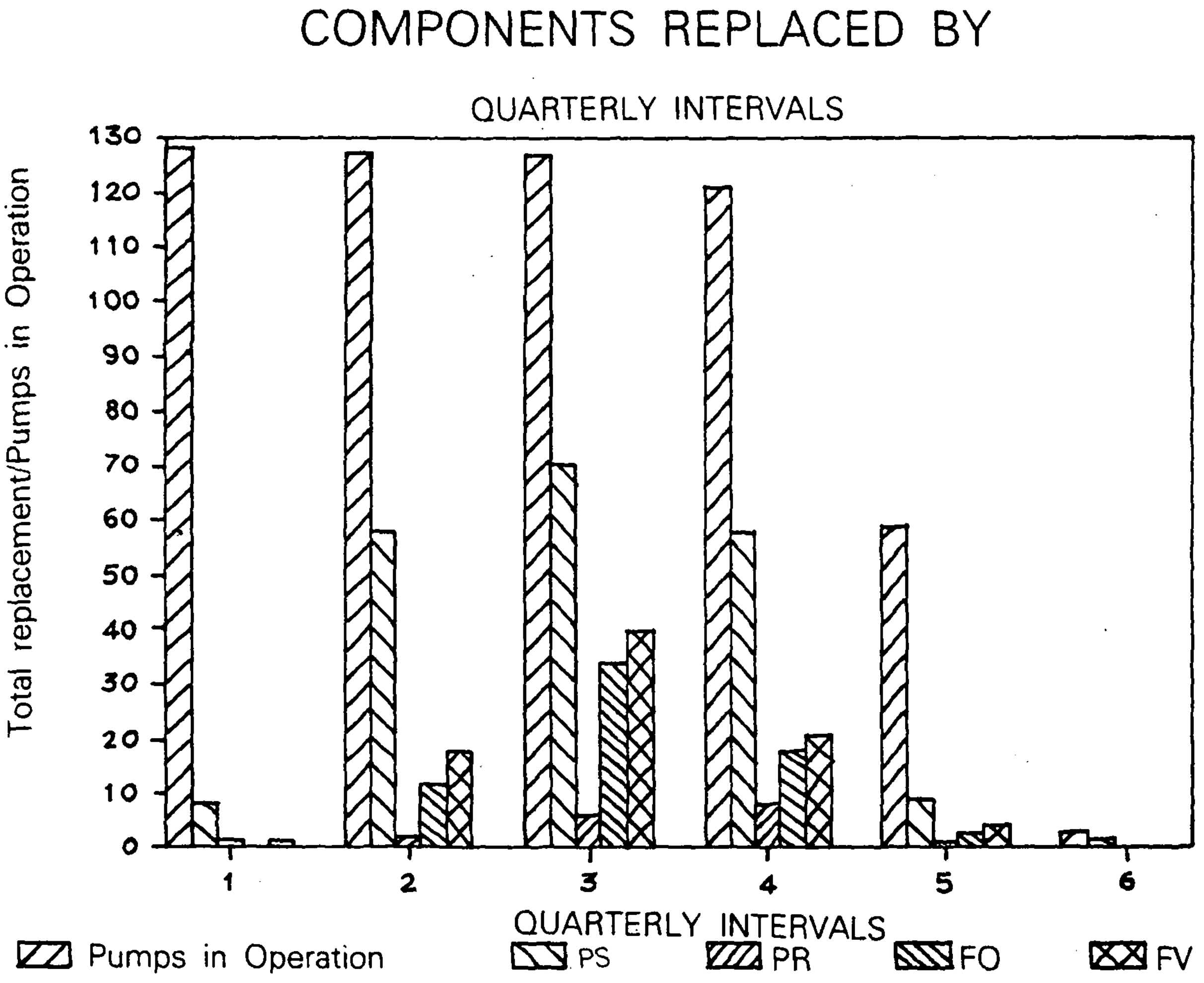
D : 06.04 86

Components Replaced by Quarterly Interval
Table no. 3

	Intervals							
Observations	1	2	3	4	5	6	Total	%
Fulcrum	0	0	1	1	0	0	2	1
Rod Hanger	0	0	4	3	1	0	8	2
Pump Rod	1	2	6	8	1	0	18	4
Rising Main	0	0	0	0	0	0	0	0
Piston Seal	8	58	70	58	9	2	205	50
Pumping element	0	0	5	1	1	1	8	2
Foot valve	1	30	74	38	8	0	151	37
Other	1	5	4	3	0	0	13	3
							405	100
Pumps Operation	128	127	127	121	59	3		

Table no. 3 include data collected before mid Aug. 1986

FIGURE 3



COMPONENTS REPLACED BY QUARTERLY INTERVALS

D :06.04.86

COST OF PARTS REPLACED
Table no. 4

Parts Replaced	Intervals						Total (TK)	%
	1	2	3	4	5	6		
Fulcrum Rod Hanger	0.00	0.00	250.00	200.00	50.00	0.00	500.00	4.4
Pump Rod	85.00	170.00	510.00	680.00	85.00	0.00	1,530.00	13.5
Rising Main	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Piston Seal	68.00	493.00	595.00	493.00	76.50	17.00	1,742.50	15.4
Pumping Element	0.00	0.00	250.00	50.00	50.00	50.00	400.00	3.5
Foot Valve	80.00	1,440.00	3,200.00	1,680.00	320.00	0.00	6,720.00	59.3
Foot Valve 'O' ring	0.00	72.00	204.00	108.00	18.00	0.00	402.00	3.5
Other	2.50	12.50	10.00	7.50	0.00	0.00	32.50	0.3
Total Part Cost/ Intervals	235.50	2,187.50	5,019.00	3,218.50	599.50	67.00		
Total Part Cost		11,327.00						

Table no.4 includes data collected before Aug. 1986

Figure 4.

Total Cost of Parts Replaced

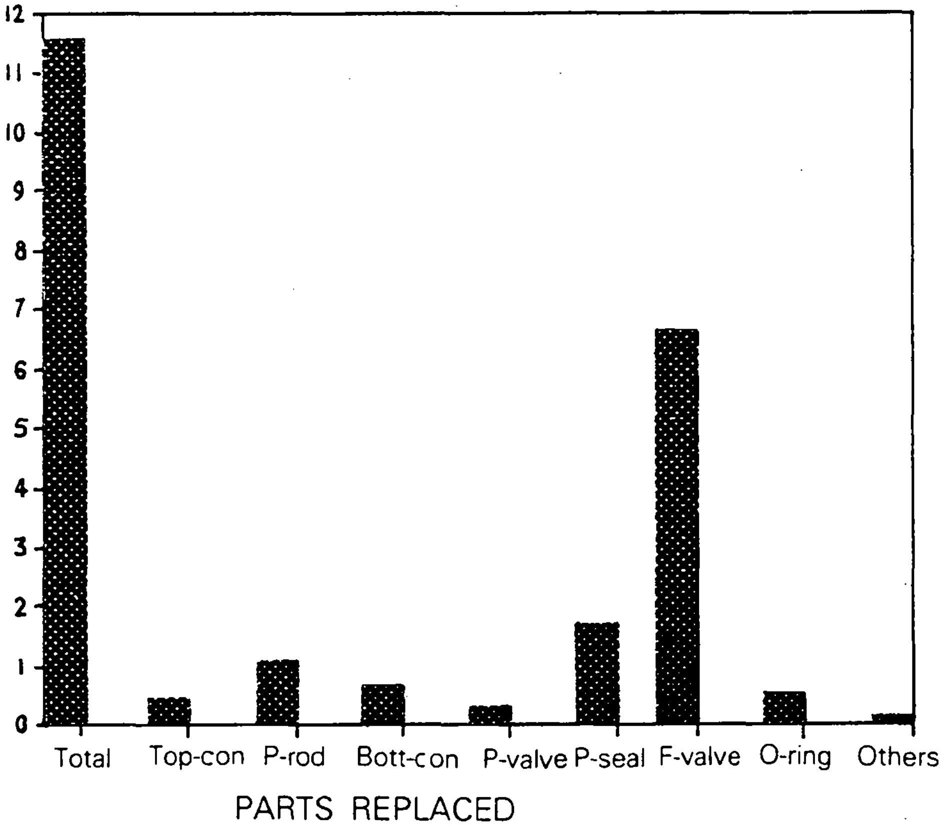
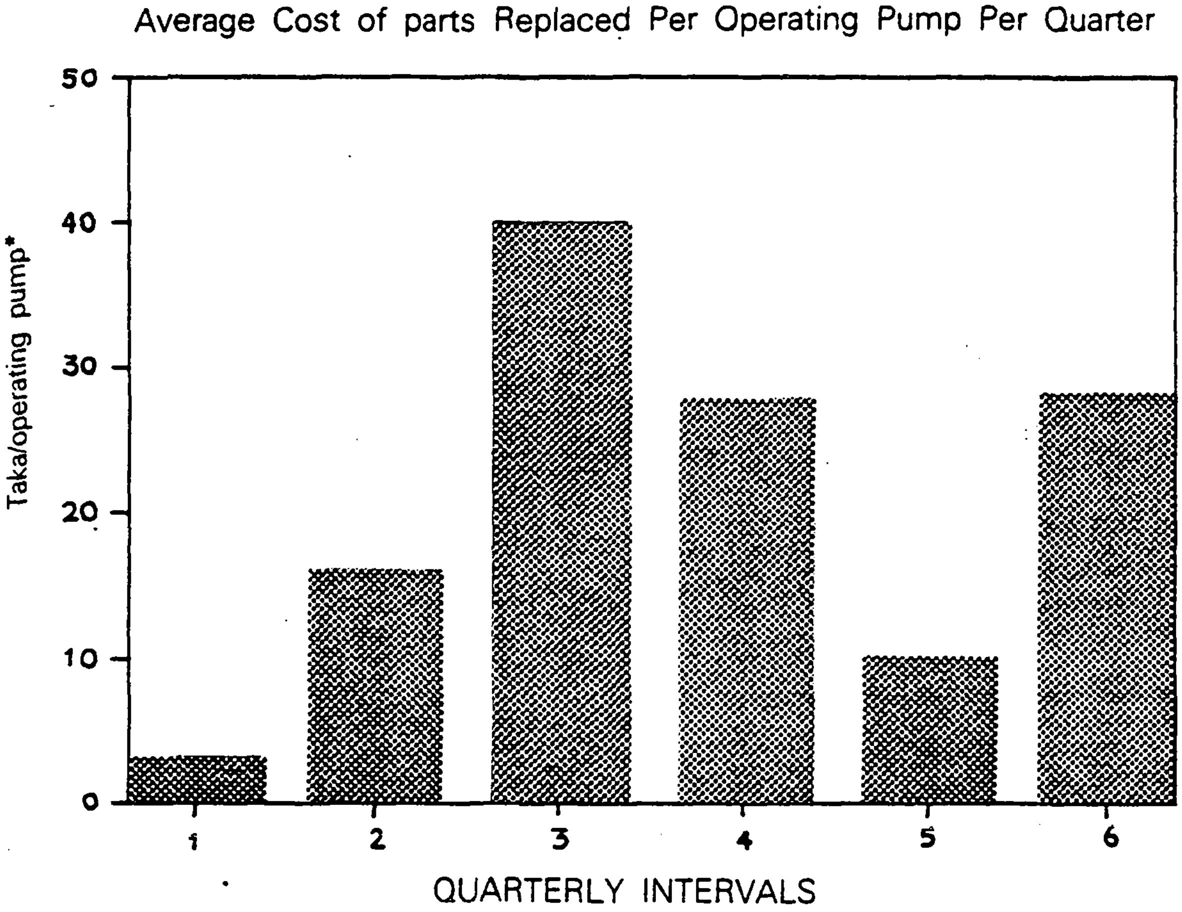


Figure 4 A



*"operating pump" refers to the number of pumps which have attained the calendar age of a certain number of quarters. For *example, all 126 pumps have been in operation for at least three quarters, 124 for four quarters, 61 for five and 3 for six* quarters.

Table 5

Man Hours Required for Parts Replacement, Additional Repairs Preventive Maintenance by Component

Quarters Observation	1	2	3	4	5	6	Total
PSL	1.3	17	21.3	19	3	0.3	61.9
PSR	—	—	—	0.7	0	0	0.7
FV	2	10	27.3	14	2.7	0	56
FO	—	8	24	12	2.7	0	46.7
PR	2	6	10	16	2	0	36
BC	0 3	9	96.3	49.7	4	0	159.3
TC	0	54.3	117	21.3	2.3	0	194.9
PV	0	0	2.7	2.7	0.7	0.7	6.8
OT	—	2	4.8	14	0.8	0	21.6
TOTAL	5.6	106.3	303.4	149.4	18.2	1	583.9

Figure 5

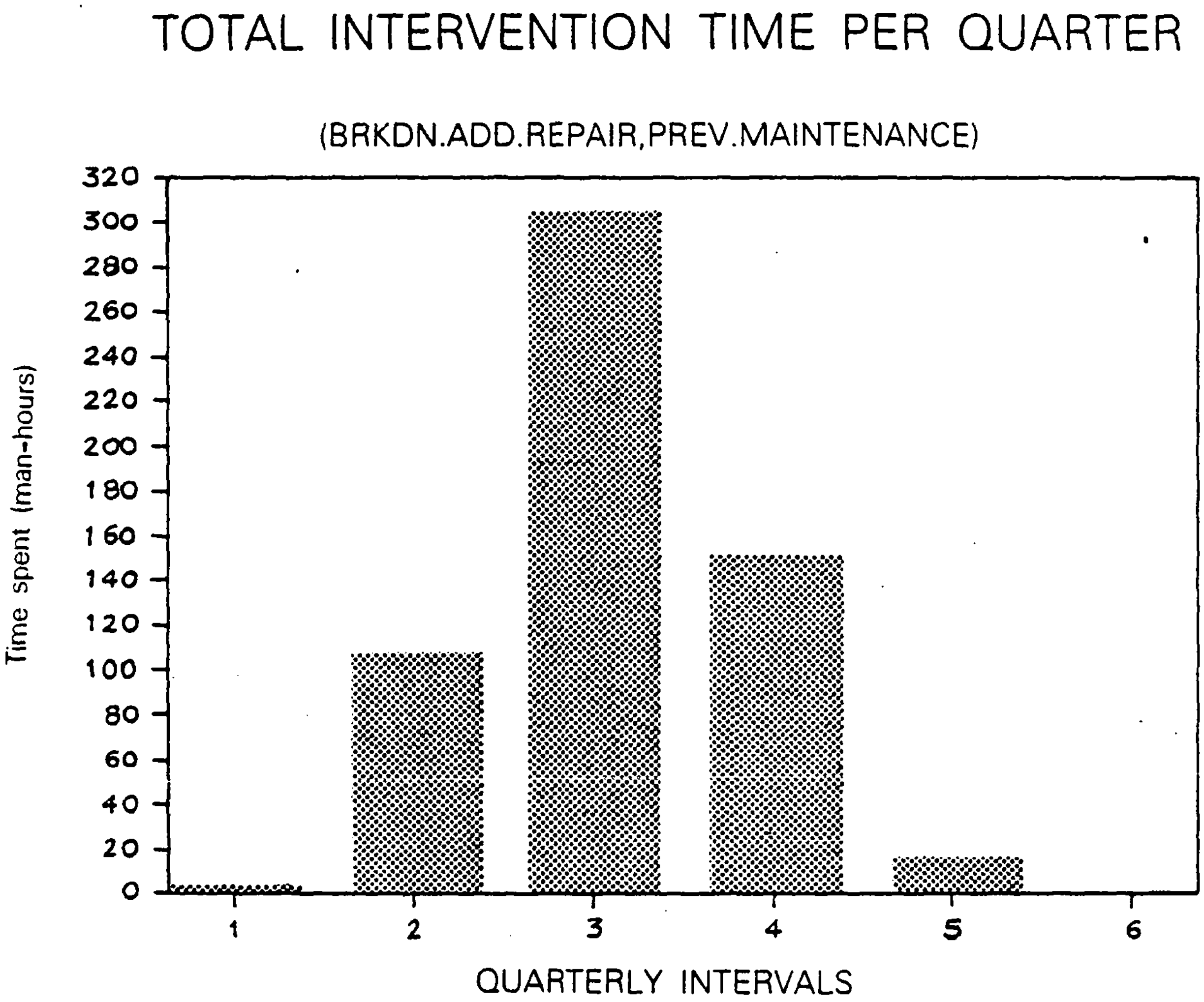

TOTAL INTERVENTION TIME PER QUARTER
(BRKDN.ADD.REPAIR,PREV.MAINTENANCE)
Time spent (man-hours)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
QUARTERLY INTERVALS

Figure 5A

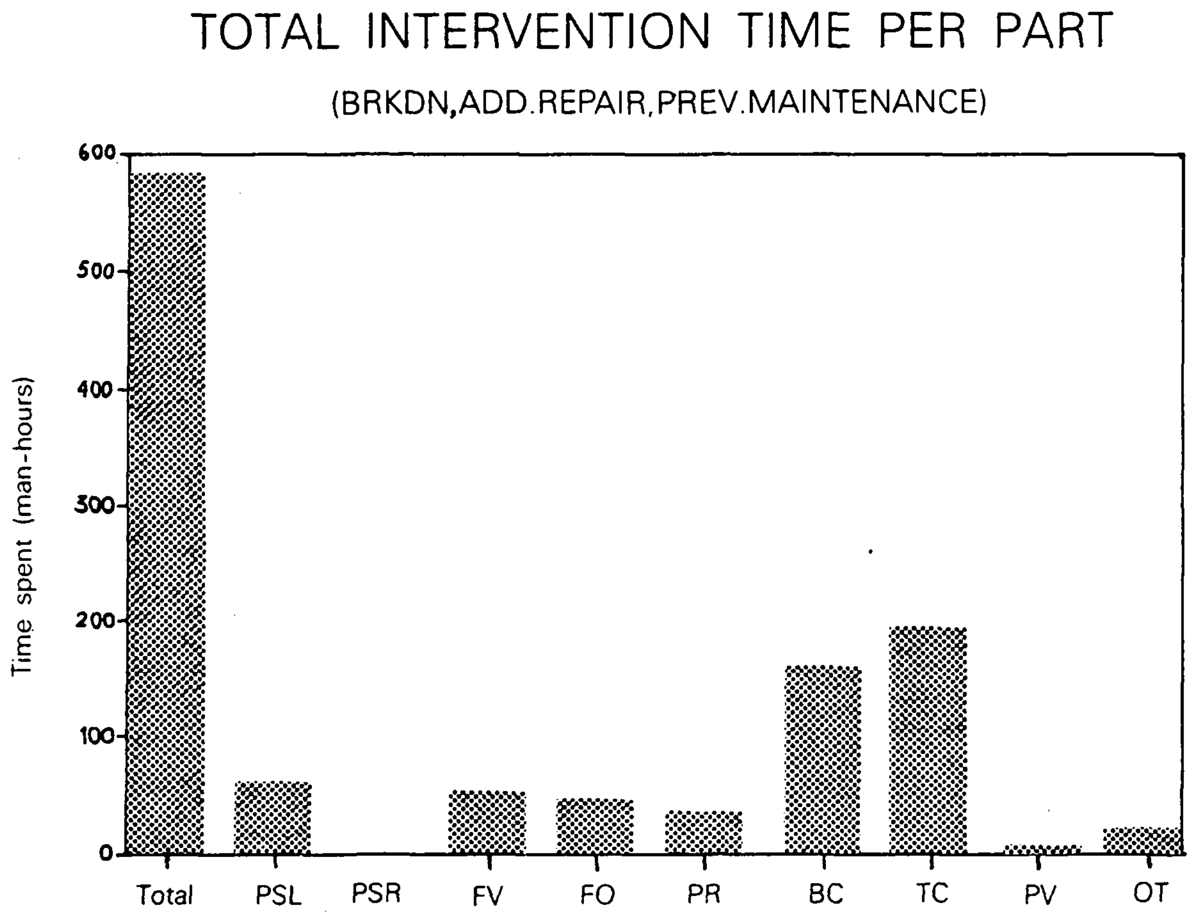
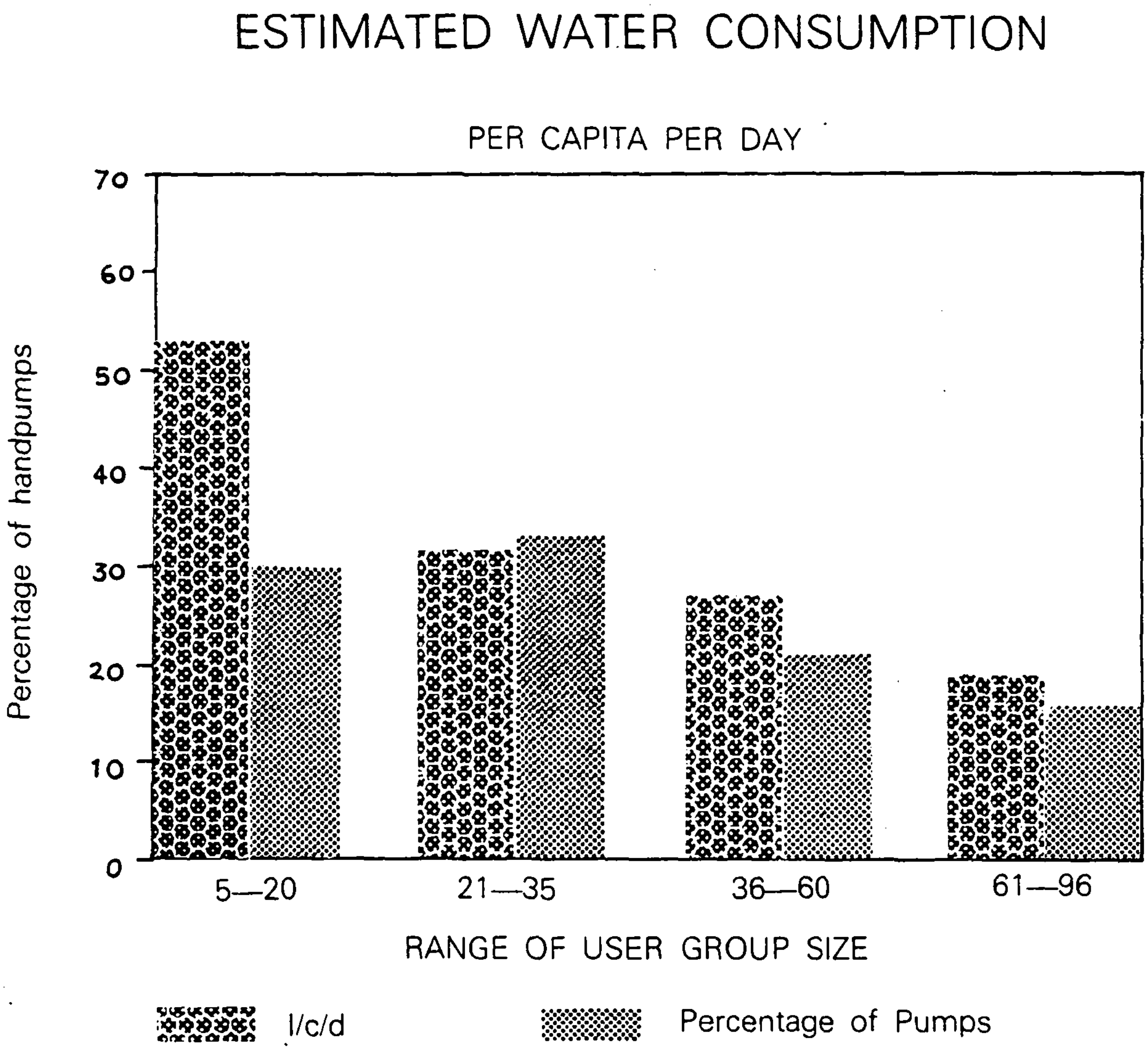

TOTAL INTERVENTION TIME PER PART
(BRKDN,ADD.REPAIR,PREV.MAINTENANCE)
Time spent (man-hours)
600
500
400
300
200
100
0
Total
PSL
PSR
FV
FO
PR
BC
TC
PV
OT

Table 6

ESTIMATED WATER CONSUMPTION				
	Observations			
Group of users	Avg User Group	Avg Consumption l/c/d	Avg. Discharge l/d	Number of Pumps
0 — 20	12	52.6	625	37
21 — 45	28	31.6	862	41
36 — 50	43	27	1066	27
51 — 96	82	19	1145	20

Data collected by hired monitors, 3 days/pump
from 06.00. to 21.00, in JUNE/JULY

Figure 6


ESTIMATED WATER CONSUMPTION
PER CAPITA PER DAY
Percentage of handpumps
70
60
50
40
30
20
10
0
5—20
21—35
36—60
61—96
RANGE OF USER GROUP SIZE
l/c/d
Percentage of Pumps

APPENDIX V

NOTES ON DESIGN AND CONSTRUCTION OF TUBEWELLS FOR HANDPUMPED WATER SUPPLIES IN BANGLADESH

by :
David Grey
Regional Project Officer
World Bank Handpump Project
East Africa.

A NOTE ON THE DESIGN AND CONSTRUCTION OF TUBEWELLS FOR HANDPUMPED WATER SUPPLIES IN BANGLADESH

By :
David Grey, Regional Project Officer,
World Bank, East Africa.

Introduction

1. The purpose of this note is to draw attention to the essential need for careful review of hand tubewell (HTW) design and construction practices in Bangladesh, in order to :
   - (a) Maximise HTW life and reduce handpump wear through prevention of sand pumping.
   - (b) Establish standard HTW designs that will best suit the range of hydrogeological conditions to be encountered in the country.
   - (c) Establish standard HTW construction and development routines within the capacity of small scale artisan drillers ('mistries') to implement with minimal additional training and equipment.
   - (d) Establish simple HTW acceptance tests that will encourage a continued high standard of tubewell construction and development practices through the rejection of poorly–constructed tubewells.
   - (e) Assist in maximising the benefits from the huge investments in HTW drilling in the country.

2. As a stranger to Bangladesh,the writer emphasises the very superficial nature of this note, as little time has been spent on study of the information available on the hydrogeology of the country's alluvial aquifers.

Current Well Construction Practices

3. The careful 'design' and construction of tubewells for handpumps is generally regarded to be unnecessary, due to the low yield of the pump and low cost of the well. It is emphasised here, however, that exactly the same basic principles apply whether a well is for major irrigation or for handpumped domestic supplies, and if these basic principles are overlooked then well (and pump) life could be drastically reduced,

4. In Bangladesh, HTWs are drilled using the 'sludger' method, an extremely effective, hand–operated technique employed by 'mistries' to drill wells to considerable depth (certainly up to 100 m) both quickly and cheaply. Water circulation is captured in a container allowing formation samples to be collected (generally as a 10 ft. sample) by scooping settled material. The 'mistry' uses his experience to select a suitable location for screen emplacement on the basis of the samples collected. However, the samples he inspects have fines washed out and may only contain the coarser fraction of the formation. Well screens ('filters') are typically set in a single length against the selected aquifer horizon. It is understood that these aquifers are fine to medium sands, although no sieve analyses have been seen by the writer. Fine sand is generally classed as grain sizes 0.1 to 0.25 mm and medium sand from 0.25 to 0.5 mm.

5. It is understood that typical wells are currently designed as follows :

(a) hole diameter : 75 mm to about 18 m
50 mm to total depth (if no gravel pack used)
75 mm to total depth (if gravel pack used)

(b) upper well casing :	60.4 mm OD (54 mm ID) PVC pipe to 15 m
2 m cylinder (integral with casing):	60.4 mm OD (54 mm ID) PVC pipe from 15 m to 17 m.
(c) lower well casing :	48.2 mm OD (42.8 mm ID) PVC pipe, typically 20m long.
screen :	also 48.2 mm OD/42.8 mm ID, 2 m long, 11% open area, 0.22 mm slotted PVC pipe (UNICEF use 3 m of 4% open area screen).
sand trap :	also 48.2 mm OD/42.8 mm ID, 4 m long (UNICEF use either 1 m length or no sand trap).

(d) typical well depth 45m (commonly in range 25 – 60 m).

(e) gravel pack (if used) 5–6 cu. ft. of 1.5 mm – 2 mm washed and sieved coarse sand.

6. Development of the well is carried out by backwashing with clean water followed by pumping with a handpump. The care with which development is carried out is unknown, but there are indications that this is, at least sometimes, unsatisfactory. The sand trap below the well screen, where fitted, is not cleaned back to orginal depth after development.

Discussion on Well Design and Construction

7. The fundamental basis of well design in alluvial formations is the proper selection of a suitable formation of adequate grain size as the aquifer horizon to be used for groundwater abstraction, together with very careful identification of the location of the horizon. Once this selection has been made, then decisions can be made on:

(a) Whether a gravel pack is necessary or not.

(b) What grading the gravel pack should be.

(c) What screen slot size is necessary following answers to question (a) and (b).

(d) What screen length (s) are necessary, both in order to keep groundwater entrance velocities below empirically determined maximum recommended levels, as well as to match the geometry of the aquifer (i.e. one thick sequence or 2 or more thin sequences).

However, the generally recommended practice of preparing a unique design for each well, based on sieve analyses etc., is clearly not possible in the case of large numbers of low-cost HTWs. So we need to develop a series of standard design guidelines which will ensure an adequate safety factor in the construction of tubewells in a wide range of hydrogeological environments.

8. Some generally accepted principles of well design are given as follows (although 'expert' opinions differ widely on some of the detail) :

— aquifer grain–size distribution forms the basis for decisions on well design. The effective grain size of the aquifer is taken as the size at which 10% of the formation is smaller (i.e. 90% is larger). The uniformity or 'homogeneity' of the aquifer is another important parameter, described by a factor called the 'uniformity coefficient'.

— if the effective grain size of the aquifer is less than 0.3 mm and the sand grains are relatively uniform in size, an artificial gravel pack is indicated. With coarser sands and less 'homogeneity', a natural gravel pack can be created from the formation itself by vigorous development.

— the artificial gravel pack should have a grading of about 5 to 8 times that of the formation and the well screen slot size should be chosen to retain 90% of the gravel pack.

- if a natural gravel pack is to be developed in a homegeneous aquifer, a slot size that will retain about 50% of the aquifer should be selected, so that development will remove fine material and result in increased near–well permeability.
- it is generally recommended that artificial gravel packs are at least 75 mm thick, although the writer believes that a 50 mm gravel pack annulus can be installed effectively with care.
- having selected screen slot size (which will define the open area for a particular well screen), screen length and diameter can be determined by calculation in order to keep entrance velocities through the screen below maximum recommended levels. In practice, screen diameter may have been fixed by well diameter. Maximum screen entrance velocities are commonly (but empirically) set at 3 cm/sec (or 0.1 ft/sec). However, the literature commonly recommends that effective open area of the screen be used in the calculation of entrance velocity and that this is half of the actual open area of the screen, due to blockage of slots by grains settling against the screen. Thus, for safety, it may be wise to adopt a safe maximum screen entrance velocity of 2 cm/sec, taking the full screen open area.

9 Tlhe following observations can be made on present standard well designs :

(a) A brief look at literature[1] on the hydrogeology of Bangladesh suggests that HTWs penetrate the generally present upper clay and silt horizons into the top of the underlying thick sand aquifer. The top of this aquifer unit is composed primarily of very fine to fine sand, sometimes medium sand, with occasional clay and silt layers. It appears probable that HTWs are rarely deep enough to penetrate the medium to coarse grained sands which occur beneath the fine sand upper section and constitute the main aquifer unit.

(b) If we assume a formation selected by the 'mistry' which is a fine to medium, uniform sand of 0.1 to 0.3 mm grain size, then conventional design practice would indicate the use [illegible] artificial gravel pack. This gravel pack should have a grading betwen 0.5 and 2 mm,

and a thickness of at least 50 mm. A well screen with a slot size of about 0.6 mm is then indicated, with length and/or diameter selected to give an entrance velocity of less than 2 cm/sec.

(c) In practice, where a gravel pack is installed it is of a grain size of 1.5 – 2.5 mm and is inserted into an annulus ranging from 7 mm to 15 mm in width. A well screen with 0.22 mm slots is used and entrance velocities range from 3 cm/sec (MAWTS) to 5.6 cm/sec (UNICEF)

(d) If an artificial pack is not used, a 0.22 mm slot is set against a 0.1 to 0.3 mm formation, representing about the median grain size and not, therefore, an inappropriate choice (although natural packs are generally not recommended for such fine sands).

(e) Development techniques in use are likely to be of limited value, and in particular where a natural pack is to be developed. It should be remembered that development specifically aims to move sand into the well and thus it pre–empts subsequent movement of material during normal pumping operations. A sand trap is not always used, and, even when it is, it is not cleaned after development. There is some evidence that wells without sandtraps start their life with a partially blocked screen due to sand movement and thus screen infill during development.

General Proposals

10. It is clear from the above observations that current practices approach but do not meet generally accepted criteria for well design. There is evidence that some HTWS appear to give sand–free water and have a long life and others choke very quickly. This perhaps demonstrates that present designs are close enough to give some success but still inadequate to ensure success. This writer has no instant solutions, and presents as an annex outline terms of reference for a rapid evaluation of the problem and possible solutions. This evaluation would involve both desk study and field work and would require a hydrogeologist for about four to six weeks.

1/ MPO (1984) Second Interim Report, Volume III, GroundWater Availability.

11. However, some general proposals are presented here in order to assist short–term decision making :

(a) Great care should be taken to ensure setting the screen against a suitable formation. This could be facilitated in many ways, including :

- drilling deeper to operate medium and medium coarse sands.
- provide drillers with a packaged sample to indicate minimum formation grain size to be screened (taking account of the washed nature of the drilling samples).
- provide well screen in 1 m lengths to allow location of short lengths interspersed with blank pipe, in case suitable sand layers are thin.
- establish routines to ensure a minimum aquifer thickness for screen installation, taking account of safety margins above and below screen.

(b) If an artificial gravel pack is to be employed, a minimum annulus around the screen of 40–50 mm is required. However, it is the writer's opinion that, if possible, use of an artificial gravel pack should be avoided due to the logistical problems of gravel pack location, procurement, transport and correct installation.

(c) The use of a gravel pack can be avoided if care is taken to ensure that an adequate proportion of medium sand is present in the formation to be screened. In this case screen of slot size 0.22 mm will be appropriate, if correctly located and then vigorously developed.

(d) Sufficient open area of screen should be provided to ensure that entrance velocities remain below 2 cm/sec. even at the instantaneous high discharge that can be obtained with the handpump to be used. An increase in total open area can be obtained by any of the following (singly or combined) :

- increasing the 'pitch' of the slots to provide a higher pipe open area, although the writer would not recommend exceeding 15% open area as the benefits to be gained beyond this are likely to be limited.
- increasing the diameter of the screen, which could fairly easily be done, from 48 mm OD to 60 OD (i.e. by 25%).
- increasing the total length of the screen — although this would substantially increase costs, as the Robo screen is expensive.

(e) Summarising the entrance velocity issue, if the 2 m length of 48 mm OD, 11% open area screen is replaced by a 2 m length of 60 mm OD. 15% open area screen, an entrance velocity of just under 2 cm/sec can be achieved at a pumping rate of 1 litre/second. The safety margin that would be obtained by these reduced velocities would probably justify the marginal extra cost of this action.

(f) The sand trap–a blank length of casing pipe below the screen – provides a repository for sand entering the well and ensures that the screen itself is not blocked – at least until the sand trap is filled. On the one hand a 4 m sand trap provides a good safety margin; on the other hand such a long sand trap is expensive and it reduces the chances of a tubewell of given depth penetrating coarser sands that should eventually be reached in the 'fining–up' alluvial formation in Bangladesh. Tentative recommendations are as follows :

- sand trap diameter should increase from 40 mm OD to 60 mm OD, thus allowing a one third reduction in length and still giving the same storage volume. Thus a 2.5 m sand trap can be used.
- if vigorous development is used and the sand trap is cleaned after development the 2.5 m length should be retained.
- if vigorous development is used and the sand trap is cleaned to total depth after development, as this writer strongly recommends, the sand trap could be reduced to a length of 1 m.

(g) Improved development techniques may be the single most important way in which tubewell (and handpump) life can be improved. Current development methods appear to just be a routine to clear the muddy water that will dissipate as pumping removes the clays in the formation around the well screen. The writer understands that attempts to use a surge block have resulted in sand–locking of the block in the well and emphasises that this demonstrates both the effectiveness of this technique for bringing sand into the well (the purpose of development) and the need for care in the use of the technique. A possible routine, for confirmation through field evaluation and experimentation is as follows :

- after completion of well screen installation, install test handpump (ideally fitted with a large T bar enabling 2 men to operate the pump vigorously), initially pump slowly, gradually increasing the rate over 15 minutes when pumping should stop.
- trip the footvalve to allow backwashing, reset footvalve and pump again at a gradually increasing rate for 15 minutes.
- repeat the process of backwashing and pumping until the water is reasonably clear (or about 2 hours).
- clean the sand trap completely (either with a sandpump fabricated from a length of PVC pipe with a flap valve and plunger, or by the 'sludger' method with a small diameter pipe).
- insert a surge block (i.e. a solid wood or PVC block with rubber flaps at either end) on the end of the pump rod and surge immediately above the well screen, starting very slowly and carefully, gradually increasing the surge rate. After 15 minutes of surging the well should be plumbed and if the sand trap is filled it should be cleaned.
- surging should continue until no further sand is brought into the well and thus no further infill of the sand trap is recorded following vigorous surging.
- ideally an inspection system should be instigated whereby the well is pumped at a high discharge (say 1 litre/second). To purge a 50 m deep well (casing 54 mm ID) of water, 100 litres must be pumped, so for inspection it may be necessary to pump 150 litres (say 3 minutes pumping) into containers which should be inspected and show minimal settled solids. The actual inspection procedure and acceptable sand levels would need to be established through field trials.

Conclusions

12. In conclusion, the writer believes that efforts should be made to improve the design and construction of HTWs. However, the ideas presented in this note are food for thought only, as a more detailed review and careful field trials are essential. A proposal for a consultancy to undertake this review and field trial is attached as an annex to this note.

Proposal for Consultancy to evaluate hand tubewell (HTW) design and construction in Bangladesh and to develop and field test improvement to be adopted as standard practices within the national HTW construction programme.

It is recommended that a consultant be employed as follows :

A. **.Qualifications**
The consultant will be a professional hydrogeologist (geohydrologist) with postgraduate training and/or extensive experience in hydrogeology. Experience in the design and construction of wells for drinking water supplies in rural areas of developing countries is essential.

B. **Duration and Location**
The consultant will undertake the study over a period of six weeks and will be based in Dhaka, Bangladesh. However, considerable periods of time will be spent in the field observing and supervising well construction operation.

C. **Terms of Reference**
The consultant will carry out the following tasks :

1. Literature search on relevant aspects of hydrogeology of the Ganges Basin.
2. extrapolation from experience gained in the deep tubewell construction programme.
3. field inspection of existing HTW design and construction, including, but not limited to :
   - hole verticality.
   - identification and accurate location of screenable aquifer (this may require down–hole geophysical logging and grain size analysis).
   - evaluation of well screen setting accuracy, and gravel pack emplacement.
   - evaluation of well development techniques, including sand content of pumped discharge of operating wells and HTW sand infil
4. data search to :
   identify scale of problem of HTW failure through sand choking or other causes.
   - identify scale of problem of handpump breakdowns caused by poor HTW design (e.g. sand–pumping, non–verticality).
5. field testing of improved HTW design and construction practices to include, but not be limited to :
   - drilling depths and diameters, screenable aquifer identification and accurate location.
   - casing and screen dimensions and screen slot sizes; pipe installation practices.
   - development techniques (including techniques for rehabilitating choked HTWs).
   - HTW acceptance routines.
6. preparation of report setting out recommendations which will :
   (a) Maximise HTW life and reduce handpump wear through prevention of sand pumping.
   (b) Establish standard HTW designs that will best suit the range of hydrogeological conditions to be encountered in the country.
   (c) Establish standard HTW construction and development routines within the capacity of small scale artisan drillers ('mistries') to implement with minimal additional training and equipment.
   (d) Establish simple HTW acceptance tests that will encourage a continued high standard of HTW construction and development practices through the rejection of poorly–constructed HTWs.

APPENDIX VI

PROPOSED TARA TUBEWELL DEVELOPMENT ROUTINE

by :
W. K. Journey
World Bank Handpump Project
Dhaka, Bangladesh.

PROPOSED TARA TUBEWELL DEVELOPMENT ROUTINE

by :
W. K. (Tim) Journey
World Bank Handpump Project, Dhaka..

INTRODUCTION

David Grey has proposed in his paper "Note on Hand Tubewell Design and Construction" a series of steps to develop the wells effectively. The first step proposed is slow pumping, gradually increasing to a more rapid rate, for fifteen minutes, after which the footvalve is "tripped"backwashing the well mildly by gravity, followed by resetting the footvalve and pumping as in step one. This cycle is repeated until the discharge is reasonably clear. Then the well is cleaned with a sand pump or by the sludger technique. Finally the well is surged with surge block and desanded in cycles until no more sand enters the well.

I agree that the steps proposed would result in a stabilised aquifer if carried out concientiously by the contractor, but propose a slightly different series and order of steps which would result in the desired results, perhaps more effectively and with fewer steps :

(a) After the screen is located next to the selected horizon, backwashing should be done by pumping clear water in the reverse direction, i.e. down the well;

(b) After backwashing, the well should be surged with a surge plunger;

(c) After surging, the well should be desanded with a sand pump;

(d) Surging and desanding should be repeated until insignificant amounts of sand can be drawn into the well.

DISCUSSION

1. BACKWASHING

The purpose of backwashing is to remove the majority of drilling fluid residues and fines from the area adjacent to the screen and move them upward through the annulus. Ideally, backwash pressure and volume would be high, but this is not feasible with manual equipment. Maximum pressure can be created by a special piston with the valve on the bottom, introduced into the upper well casing on a 2 m or 2.5 m 3/4"nominal diameter GI pump rod with a wide T-bar handle to enable two men to operate it. Clear water is introduced into the well continuously and pumped down the well (footvalve removed) This backwashes the well under substantially more pressure than by gravity. A muddy return flow from the well annulus should result. When the return flow begins to clear and begins to diminish in volume or is lost entirely, it may be assumed that most of the drilling fluid residue has been flushed out of the aquifer zone, if not the entire well. The reduction or loss of return flow means that the aquifer materials has collapsed around the screen and the aquifer is absorbing the backwash flow. This step has the advantage of displacing the clay and some fines without having to draw them into the well. which should speed up the process of development.

2. SURGING

The same piston used for backwashing is blocked by substituting a steel plate for the valve on the bottom of the piston. The two operators prime the well and top it off with clear water when the surge plunger is introduced. Then they surge with long slow strokes initially, increasing the rate gradually for about 15 minutes, or until high resistance to the downstroke is noticed.

3. DESANDING

Surging is pointless in the absence of a simple, compact and inexpensive desanding tool. A standard device for this purpose is a type of bailer known as a "sand pump". The wire attached to the piston inside the sand pump is pulled up violently to draw in a slurry of sand and water. After each stroke it must be lifted (it will settle to a lower position) to allow sand in the annulus between itself and the sand trap to settle. If this is not done, a sand lock will result. When the sand pump is full, the piston will not return to a lower position. It is then removed to the surface and evacuated, and the process is repeated until the sand trap is cleared. A full sand trap 2 m long of one inch nominal diameter pipe will contain 1.2 liters, while the sand trap will contain 1.5 liters/m. Therefore four meters of sand trap can be cleared by five cycles with the sand pump.