GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: June 5, 1979

Project Title: Evaluation of Handpump Selection & Testing Methods

Project No: A-2386

Project Director: P. W. Potts

Sponsor: US Agency for International Development

Agreement Period: From 5/27/79 Until 6/20/79

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Defense Priority Rating:

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT TERMINATION

Date: 10/23/79

Project Title: Evaluation of Handpump Selection and Testing Methods

Project No: A-2386

Project Director: P. W. Potts

Sponsor: US Agency for International Development

Effective Termination Date: 6/20/79

Clearance of Accounting Charges: 6/20/79

Grant/Contract Closeout Actions Remaining:

- Final Invoice and Accounting Charges
- Final Fiscal Report
- Final Report of Inventions
- Govt. Property Inventory & Related Certificate
- Classified Material Certificate
- Other

TERMINATED

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Project Code (GTRI)
Other ___________________________

CA-4 (1/79)
WORKING MEETING ON HAND PUMP SELECTION AND TESTING
Harpenden, Hertfordshire, England
May 29-June 2, 1979

Prepared by
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Senior Research Scientist

for the
U.S. Agency for International Development
Washington, D. C.

Office of International Programs
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia 30332
WORKING MEETING ON HAND PUMP SELECTION 
AND TESTING

Introduction

Between the dates of May 29 and June 1, 1979, a three-and-one-half day 
meeting was held at the Glen Eagle Hotel in Harpenden, Hertfordshire, England, 
for the purpose of formally establishing a methodology and guidelines to be 
used in hand pump selection and testing. The Agency for International Devel-
opment sponsored a four-man team (Mr. Leo Surla, Mr. Robert Knight, Dr. Yaron 
Sternberg, and Mr. Phillip Potts) to attend the meeting through Georgia Tech's 
Indefinite Quantity Contract No. AID/SOD/PDC-c-0143.

The stated objectives for the meeting are as follows:
1. To assess the hand pump requirements of rural water supply programs.
2. To develop guidelines for the selection and development of hand pumps 
   for rural water programs.
3. To establish guidelines for field evaluation of hand pumps.
4. To establish a protocol for hand pump testing.
5. To design a mechanism for international cooperation and systematic 
   exchange of results of testing and evaluation projects.
6. To develop a proposal for a program of hand pump field trial projects 
   in selected countries.

It was decided early in the meeting that items 2, 3, 4 and 5 would receive 
priority attention. However, as it turned out, item 6 became a major topic of 
conversation, especially in informal conversations after the conclusion of each 
day's activities.

Participants at the meeting were as follows:

NATIONAL AGENCIES/ORGANIZATIONS

Bangladesh
Mr. K. D. Tewari

Ghana
Mr. T. B. F. Acquah
Mr. R. R. Bannerman

DPHE/UNICEF
Rural Water Supply Programme

Ghana Water & Sewerage Corporation
Ghana Upper Region (CIDA) Water Supply Project
India
Prof. S. Subba Rao
All India Institute of Hygiene and Public Health

Indonesia
Mr. Soebeno Hadiwijoyo
Ministry of Health Division of Hygiene and Sanitation

Malawi
Mr. L. H. Robertson
Ministry of Community Development

Philippines
Mr. C. M. Borromeo
Ministry of Human Settlements

Thailand
Mr. Verasak Kraivichien
Ministry of the Interior Office of Accelerated Rural Development

BILATERAL DEVELOPMENT AGENCIES
Mr. B. M. U. Bennell
ODM, U.K.
Mr. I. Ahman
ISDA, Sweden
Mr. C. Schippers
DTH, Netherlands
Mr. H. Koeppler
GTZ, West Germany

INTERNATIONAL ORGANIZATIONS
Dr. R. C. Ballance
WHO, Geneva
Mr. P. Bayer
UNICEF, Geneva
Mr. K. McLeod
UNICEF, New Delhi
Mr. J. Kalbermatten
World Bank, Washington
Mr. H. Tsutsui
FAO, Rome

RESEARCH, TESTING AND CONSULTING ORGANIZATIONS
Dr. J. Cuthbert
Consumers' Association, Harpenden Rise Testing Laboratory, U.K.
Mr. P. W. Potts
Engineering Experiment Station Office of International Programs Georgia Institute of Technology, U.S.A.
Mr. J. Collett
Intermediate Technology Development Group, U.K.
Dr. W. K. Kennedy
International Development Research Centre, Canada
Tuesday, May 29

The working meeting on hand pump selection and testing opened at 9:30 a.m. with Mr. E.H.A. Hofkes (WHO International Reference Centre for Community Water Supply) emphasizing the importance of the testing and selection of hand pumps. He indicated the magnitude of the task of "water for all" during the upcoming 1980-1990 decade of water. He further requested that the meeting's participants assist in arriving at suitable recommendations which could be translated to action worldwide. Mr. Hofkes also emphasized that it is worthwhile to invest a small amount of money, say one percent of the cost of the purchase of pumps, on testing and selection of the pump which will assist the decision makers in a judicious final selection. Unfortunately, according to Mr. Hofkes, there is at present no uniformity of testing procedures; thus, the meeting has the primary objective of working out a widely acceptable methodology and guidelines for testing and selection of hand pumps.

Mr. C. K. Stapleton (consultant) presented a paper entitled "Hand Pump Requirements of Rural Water Supply Programmes" in which he stressed the importance of the "bottom up" approach involving the participation of local villagers. (Appendix A contains the text of Mr. Stapleton's presentation.) He also stressed the importance of hygiene and sanitation, which should go hand-in-hand with water supply programs (health-water linkages). The presentation concluded
with an explanation of the basic criteria which govern the selection of pumps, such as:

- Source of supply
- Cost
- Number of users
- Method of installation
- Ease of maintenance
- Social attitudes
- Financing
- Standardization

During a discussion period following Mr. Stapleton's presentation, the question of water quality standards was brought up. Mr. Stapleton replied to this that standards must be local standards set by the country involved, to which most participants agreed. Mr. John Kalbermatten (World Bank) interjected at this point a rather emphatic contention that pending U.S. attempts to include continuous water disinfection linked with hand pumps was impractical and destined for failure.

In the afternoon session, Mr. John Kinghan (Consumer's Association, Harpenden, Hertfordshire, England) presented his draft report on "Guidelines for the Testing of Hand Pumps" (Appendix B). Mr. Kingham emphasized that laboratory testing would help to introduce standardization and choice of pumps, would delineate the problems in arranging the pump design, would eliminate pumps which are unsound, and would assist in the selection of pumps for particular programs. The SMART technique was then described in analyzing the results of laboratory testing. Following Mr. Kingham's presentation, a rather heated discussion was held concerning the correlating of costs with laboratory results; consensus of opinion was that cost effectiveness should be considered in the final analysis of laboratory testing, a matter not considered too important by Mr. Kingham.

Wednesday, May 30

Mr. Eugene McJunkin, consultant, began this day with his presentation (Appendix C) on "Guidelines for Field Evaluation of Hand Pumps." He explained the need for field evaluation, there being an explosion of evaluation programs throughout the world. He stressed the importance of coordinating field testing programs between countries and agencies. He went on to explain the
purpose of guidelines in terms of:

Field evaluation
Exchange of information
Decision making
Procurement

He emphasized the need for common criteria, checklists and format. He then went on to explain the methodology of field testing, selection of pumps, characteristics of pumps to be evaluated in terms of performance, reliability, ease of maintenance and cost. The importance of statistical analysis of data was also explained.

In the discussion that followed Mr. McJunkin's presentation, the importance of field testing was stressed for the selection of hand pumps and also to lead to development and improvement of the pump selected.

The participants of the meeting then heard details of various programs in different countries, including the following:

1. Mr. K. McLeod (UNICEF, New Delhi) explained the development of the India Mark II pump and the three-tier system of maintenance. He strongly recommended that a good pump is a prerequisite for the "bottom up" approach. This was endorsed by Mr. L. H. Robertson (Ministry of Community Development, Malawi), who reported that in Malawi, where the community participation is well developed, the actual hand pump program was being held up waiting for the testing and final standard design of a suitable shallow-well pump.

2. Mr. P. W. Potts (Georgia Tech, U.S.A.) explained the development of hand pumps in Nicaragua, Costa Rica, the Dominican Republic and Indonesia, recognizing the need for suitable guidelines for pump evaluation.

3. Mr. K. D. Tewari (UNICEF, Bangladesh) traced the history of development of the new Bangladesh pump No. 6 and explained the main features of the improved pumps well as the older No. 2 and No. 4 pumps.

4. Dr. S. Subba Rao (All India Institute of Hygiene and Public Health) explained the shallow-well pump development research project being undertaken in India with the assistance of WHO and UNICEF, which is awaiting a field testing phase.
This morning's session heard prepared suggestions from participants to improve draft reports earlier given by Mr. McJunkin and Mr. Kingham. It was agreed, in general, that there was need for concentration of specific guidelines as to what to measure, what to look for in surveys, and what to record from the measurements and surveys in the three fields of technical considerations, economic considerations, and monitoring and field observation.

In the afternoon session, it was agreed that consolidated laboratory and field testing procedures should be pre-tested in a formal testing program before being widely circulated. The chairman of the meeting (Dr. R. C. Ballance, WHO/Geneva) requested countries to offer facilities for this, and participants from the Philippines, India, Indonesia and Bangladesh expressed their willingness to cooperate. At this point, Mr. J. Kalbermatten (World Bank) discussed a World Bank proposal on "Rural Water Supply Hand Pumps -- Laboratory and Field Testing Development of Selection Guidelines," which is shown in Appendix D of this report. (Mr. Kalbermatten stressed that the investment of a small amount of money at this stage to facilitate the right selection of pumps and programs would bring a maximum benefit.) Because of suggestions by Dr. Ballance, Mr. C. M. Barromeo (Ministry of Human Settlements, Philippines) volunteered to draft a joint resolution supporting the World Bank proposal. The resolution reads as follows:

Whereas, this Conference recognizes the urgency of attaining the goals of the International Drinking Water and Sanitation Decade;

Whereas, a significant proportion of country level programs during the Water Decade will centre on the wide application of handpumps in developing countries;

Whereas, a serious problem exists in the area of handpump technology, design and application;

Whereas, the development of handpump technology will require a set of standard guidelines establishing the protocol and methodology for handpump testing, evaluation and development;

Whereas, international cooperation and correspondence in the area of handpump technology will be of universal benefit to all countries of the world;

Whereas, a coordinating mechanism will be required to administer international efforts in handpump technology;

It is resolved, as this Conference does hereby resolve to:

1. Notify the United Nations Development Program by way of a copy of this Resolution, of this Conference's strong recommendation to approve Global Project Proposal entitled

-6-
Rural Water Supply: Hand Pumps
- Laboratory and Field Testing -
- Development and Selection Guidelines -

As submitted in June 1979, a copy of which is attached as Annex "A" to this Resolution.

2. undertake cooperative action in the field of handpump technology through a continuing exchange of information among the participants of this conference and to include other interested agencies and individuals.

3. request the International Reference Centre/Community Water Supply to undertake the administration and coordination functions required by the resolved undertakings as described in the preceding paragraphs above.

Done on this 1st day of June, Nineteen Hundred and Seventy-Nine, in Harpenden, Hertfordshire, United Kingdom.

Friday, June 1

This day's session, lasting until eleven o'clock (A.M.), centered around accomplishments of the week's activities. The chairman, Dr. Ballance, concentrated on the following before the meeting:

- Wells and boreholes fitted with hand pumps will play an extremely important role in bringing safe drinking water to the rural areas of developing countries. They often are the most suitable means of providing a water supply, and in many cases the cheapest.

- The technical and economic feasibility of hand pump water supplies is not in doubt, but there certainly is much scope for improvements in the design and manufacture of hand pumps, for adaption of existing hand pump models, and development of new pumps; so as to improve reliability, efficiency and users' acceptance.

- Field performance evaluation, field trials and testing are valuable tools in selecting and improving hand pumps. This implies that activities in testing and trials of hand pumps should identify design and materials weaknesses which may be candidates for research and development projects aimed at achieving increased durability, lower costs, and/or improved design, ease of maintenance and installation.

- Comparison and evaluation of hand pumps on an international basis will require common criteria, definitions and methodologies. More uniformity in the collection and recording of hand pump performance data is required.
Therefore, a protocol for field test evaluation of hand pumps should be established.

- The need for a widely accepted methodology for hand pump evaluation and testing had been the subject of an international collaborative effort. In November 1978, a Workshop on Hand Pump Evaluation and Testing was held in Voorburg (The Hague), the Netherlands. The present meeting is intended to take the matter further. Hand pump testing requires careful design of the test procedure to make the results as reliable as possible. Problems encountered in designing a suitable test program for hand pumps include:

1. Hand pumps vary widely in design, cost, reliability and performance;

2. The physical, sociological and cultural environment in which the pumps are installed can be very different;

3. The interchangeability of components on some pumps makes it difficult to decide which combination to test.

The successful testing of hand pumps requires:

1. Knowledge of prevailing customs and cultural and sociological backgrounds of hand pump users;

2. Experience in (comparative) testing;

3. Scientific and technical skills in the practical testing of pumps.

4. It is highly desirable that the methods used in field trials and surveys of existing pump models be coordinated between countries and regions. In this way results could be "pooled," thereby giving opportunity to treat them as one large experiment and providing valuable information about the effects of geographical, sociological, infrastructure-dependent variables. This coordination and cooperative use of common methodology is not easy; some of the detailed techniques which might be needed include the use of common pro-forma observation records and free exchange of original data rather than of conclusions alone.

- It is desirable that field trials and surveys be designed to give as much information as possible about all attributes of pumps so that laboratory results and field test results can be compared as directly as possible. There are parameters which are more easily measured in laboratory conditions than in the field, but every effort should be made to obtain at least some measures of
these parameters. If resources permit, field trials and laboratory tests on the same models would be desirable.

- It is recognized that much valuable work on the testing and field trials of hand pumps has been carried out in the past few years. Unfortunately, in the absence of uniform procedures and methodologies, it is usually impossible to make valid comparisons of the results of these tests and trials. For these reasons, it is believed that a guidance document would be a valuable contribution.

- Whatever else may be needed, coordination of efforts is a "must." Design, technical testing, field trials, surveys, analysis and implementation of maintenance and manufacture probably amount to too large a package for any/most countries/agencies to cover completely. Much work has been done, and much is being done.

- All too often coordination between different research programs seems to be difficult; coordination is necessary, because commonality of aims, methods, and reporting facilitate the transfer of conclusions from one program to another, across the world.

- It is important to develop a universally useful laboratory and field testing guideline so that those agencies and institutions interested in the development and testing of hand pumps may follow the same procedures and methodologies. This guideline should be field tested on a meaningful scale prior to its finalization.

In general, the working meeting on hand pump selection and testing was successful in meeting its objectives. Rather than offer a consensus of opinion from Mr. Surla, Mr. Knight, Dr. Sternberg and Mr. Potts, the following perspectives are individually stated:

**Mr. Leo Surla**

The conference was a working meeting that had the objective of reviewing and commenting on two papers:

- Guidelines on Laboratory Testing
- Guidelines on Field Testing

Participation was excellent and the conference contributed substantially to the guidelines through comments on laboratory design and issues, questions,
data and methodology on pump design, economic considerations and social
considerations. The participants represented multilateral institutions,
bilateral development organizations, country development programs and academic,
private and nonprofit consultants. The location, approximately 30 miles from
London, encouraged a group atmosphere and discussions were held far past the
seminar's daily closing times. The following were highlights of interest:

- The "bottom up" approach on local participation concept was stressed.
- Existing and current field evaluations may constitute a baseline of
  information.
- Local manufacture of hand pumps versus imported pumps was an impor-
  tant issue.
- Different countries have different strategies for developing water
  supplies and different methodologies are used for field testing. For
  example, India is developing a single pump, while Ghana has been test-
  ing several different pumps.
- The selected pump will affect the required maintenance organization.

The lab testing conducted by the Consumers' Association revealed the
following:

- Testing of 12 pumps has the primary objective of selection as opposed
  to new design or improvement of existing pumps.
- The laboratory cannot take the place of field testing.
- The laboratory test stresses durability.
- No cost analysis will be conducted.
- The laboratory situation does not simulate the maintenance situation
  of the field or the real costs of maintenance.
- Its sample size of one pump model tested may affect conclusions.

The interest of the conference was mainly on field testing and laboratory
testing was seen as a possible means for elimination of pumps rather than the
selection of a pump. Guidelines for both laboratory and field testing were
seen as relevant for cross-country hand pump analysis. The World Bank is suf-
ciently interested in this area to submit a proposal to UNDP.
Little has apparently been done in the area of guidelines for "field testing methodology." Design of field tests has limited objectives and socio-economic considerations tend to be given short shrift. An analysis of existing laboratory and field test methodologies might contribute to guidelines development.

Mr. Robert Knight

The conference achieved a fair measure of success, although there seemed to be some ambiguity with respect to testing. Some members of the group agreed that laboratory testing should be complete before any pump should reach the field, while others thought that there is cause for further laboratory testing after a pump has been in service. This I failed to understand.

It was also suggested that a pump, such as the AID/Battelle pump, which has been tested extensively both in the laboratory and in the field should undergo a further series of laboratory tests when locally manufactured in a new country. While I agree that the testing of component parts for quality and strength would be wise, further laboratory testing of the pump, or to coin a phrase, "reinventing the wheel," makes little sense.

The untapping of available information was apparent to me during the meeting. There was a wealth of experience and knowledge sitting around the conference table. Some of the delegates had spent many years in the field and had much to offer. Unfortunately, the exchange of ideas was not flowing as it might have been.

Having the conference in Harpenden gave us an opportunity to visit Harpenden Rise laboratory. There we saw some interesting tests in progress, including its hand pump project. The hand pump test, although adequate as far as giving the pumps a rugged workout was concerned, seemed to fall short of simulating field conditions, which should be strived for in a laboratory test. A simulated head valve was an excellent idea, but the rest of the testing setup showed a lack of imagination.

At the risk of being political, it is felt that this proximity may not have been altogether prudent, as one sometimes sensed that the conference might easily have become a display window for the Consumers' Association. Lastly, a little opposition was noticed toward local manufacture of pumps, although no reasonable argument supported this school of thought.
Dr. Yaron Sternberg

The basic objective of the meeting was to develop guidelines for laboratory and field testing of hand pumps. The mechanisms used for the development of such guidelines were two documents -- one on laboratory testing prepared by the Consumers' Association and a field testing guide prepared by Eugene McJunkin. It was expected that the participants would review these documents, discuss their contents in detail, and offer constructive criticism which would lead to a final document on laboratory and field testing of hand pumps.

Of the some thirty participants, only about a dozen had any working experience in laboratory or field testing of hand pumps. The rest of the participants were LDC government officials working in the area of rural water supply and representatives of international organizations. Thus, the makeup of the group had a direct effect on the content and scope of the deliberations that took place during the four-day conference.

Presentation of the two documents by their respective authors, some general discussion and a short trip to the Consumers' Association's laboratory took about two days, leaving only about one day for specific and detailed discussion on testing. Consequently, field testing technology and methodology, i.e., the "what," "why" and "how" of testing, were severely limited. With regard to laboratory testing guidelines, the Consumers' Association presented its methodology, which the majority of the participants accepted without questioning the rationale behind some of the measurements taken and/or their frequency of recording. The general feeling of many of the participants was that since the Consumers' Association is a well respected consumer testing organization, its techniques and methodology employed for the testing of hand pumps are probably the correct ones. Furthermore, this feeling was enhanced by the fact that the International Reference Centre and the World Bank gave their respective appraisals of the tests conducted by the Consumers' Association. Personally, it is felt that the laboratory testing of hand pumps done by the Consumers' Association is of good quality, although there are some reservations concerning the methodology used. It is also believed that there was not sufficient emphasis that laboratory tests are to be used simply as a "first cut" guide, i.e., those pumps that failed laboratory tests should not be placed in the field, while those pumps that withstand the performance and
durability tests may not exhibit the same characteristics under actual field conditions.

The field testing guidelines were compiled into a good workable document, but, unfortunately, it is very general and somewhat sketchy in its discussion on pump performance tests and measurements. It is felt that this section will be strengthened in the final document.

The Consumers' Association has prepared an "unofficial" draft document on what it views as the proper methodology for field testing. Only about one hour was allocated for the discussion of this extremely important issue. The discussion was conducted by a subgroup (about eight participants), and it was obvious that the issues raised could not be resolved in the short time allotted. The suggested methodology also reflected the lack of actual field experience of the Consumers' Association staff responsible for this document. It is felt that the issues raised on "what," "why" and "how" of field testing require more careful thought and input from people with practical experience. A conference limited to just the above subject may be the proper mechanism for the development of a document on this subject.

Early in the conference only a few of the participants were aware of the fact that the World Bank had submitted a Consumers' Association proposal to UNDP for the purpose of conducting laboratory and field tests of hand pumps. In the final hours of the conference, it was suggested that an endorsement of this proposal by the conference participants might enhance the likelihood of it being funded. A resolution to this effect was drafted and adopted by the conference; however, some of the participants felt that although an endorsement for a field testing project in which the formulated guidelines would be tested is an obvious conclusion to a meeting on hand pumps, the implications of such a resolution are unknown. (Some participants felt that a resolution leading to a project in which the Consumers' Association has a vested interest was inappropriate because such action may be misconstrued as an endorsement of a consultant by the conference.)

Mr. Phillip Potts

It is felt that the working meeting on hand pumps selection and testing was worthwhile in a first attempt to formally suggest a methodology for parties interested in developing a laboratory and/or field testing program
with hand pumps. However, it is also felt that the experiences of many participants was neglected because of special interests directed by the Consumers' Association, the International Reference Centre, and the World Bank in getting funding from the World Bank through UNDP for a future large-scale laboratory and field testing program. The proposed program would involve the Consumers' Association and the International Reference Centre; however, there was a noticeable amount of secrecy surrounding the proposal and there was no public mention during the working meeting that the Consumers' Association would be involved. This type of activity is out of order and inappropriate for a large-scale meeting that has been designed with an overall major purpose to establish laboratory and field testing methodologies and guidelines (not to secure contractual funding for a consulting organization). While the Consumers' Association has quite a bit of experience in testing of consumer products (lawn mowers, washing and drying machines, small electrical appliances, etc.), its background with hand pumps and other water-related programs has been restricted to the laboratory testing of only six hand pumps thus far; it also has had no international development programs, and it has had no field testing experience with hand pumps (locally manufactured or imported). These thoughts are not solely of the author, but were expressed by other participants, especially from UNICEF, at the meeting on hand pump selection and training.

The laboratory and field testing guidelines drafted by the Consumers' Association and Mr. Eugene McJunkin should be of value to planning future testing programs. However, the guidelines, as presented at the meeting, were much too general and needed specifics on quantifying data so that results will not be entirely subjective. Repeated attempts to introduce substantial discussions concerning more quantifiable testing data failed, but it is hopeful that the final version of the laboratory and field testing guidelines will be more appropriately thought out.

The proposal submitted to the World Bank by the Consumers' Association and the International Reference Centre (Appendix D) is not a bad proposal even though there are several areas of concern. The first concern is that, as already stated, the Consumers' Association has no history of field experience in the testing of hand pumps and only limited experience in laboratory testing of the same product. The second concern involves the complete absence of provision for investigation into the economics of various hand pump options
or the overall cost-effectiveness of these options. In other words, and this was verified by the Consumers' Association, durability, as determined by both laboratory and field testing, is the major concern no matter how expensive or inexpensive the hand pump is. The third concern is that the proposal includes the purchase of 3,000 hand pumps at an average unit cost of $250 and no line item for shipment costs of these 3,000 pumps. Most pumps being considered by the Consumers' Association far exceed a cost of $250; in fact, they are closer to a unit cost of $750-$1000. It is realistically conceivable that the 3,000 pumps, with transportation, could cost as much as $3 million, a figure that is twice the amount of the total proposed budget of $1.5 million. There are other concerns; however, not enough details are known as to whether or not a logical strategy has been thought out that would alleviate these concerns.

In conclusion, the Surla, Knight, Potts and Sternberg team contributed freely and positively to the working meeting, and it is felt that this contribution kept the proceedings on a relatively straight path. An even more positive contribution was probably made during off-duty hours, when participants gathered in the hotel dining room or the lounge to openly discuss hand pump problems of mutual interest, i.e., interaction of various hand pump components on each other, maintenance procedures, well preparation, manufacturing problems in developing countries, etc.
Appendix A
WORKSHOP ON HAND PUMP SELECTION AND TESTING
Appendix B

GUIDELINES FOR THE TESTING OF HANDPUMPS
Appendix C
GUIDELINES FOR FIELD EVALUATION OF HANDPUMPS
Appendix D

RURAL WATER SUPPLY HAND PUMPS
- LABORATORY AND FIELD TESTING -
- DEVELOPMENT OF SELECTION GUIDELINES -
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