WATER AND SANITATION
FOR HEALTH PROJECT

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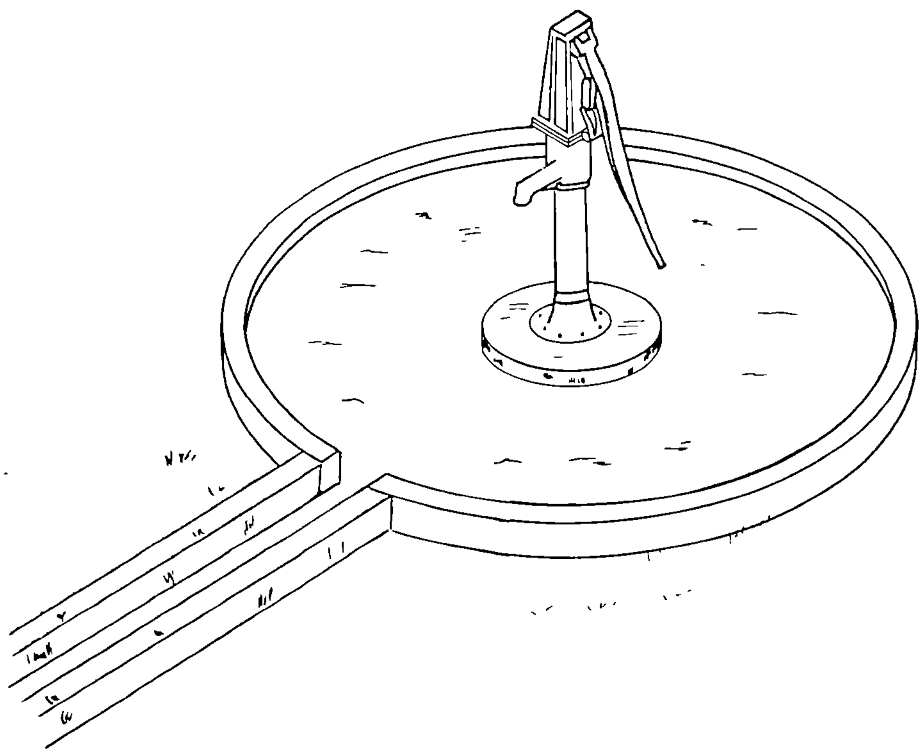
A WORKSHOP DESIGN FOR HANDPUMP INSTALLATION AND MAINTENANCE

A TRAINING GUIDE

WASH TECHNICAL REPORT NO. 26



Prepared for:
Office of Health
Bureau for Science and Technology
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A WORKSHOP DESIGN FOR HANDPUMP INSTALLATION AND MAINTENANCE

A TRAINING GUIDE

Prepared for the Office of Health, Bureau for Science and Technology
Agency for International Development
Under Order of Technical Direction No. 122

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INTRODUCTION

1. INTRODUCTION TO THE TRAINING GUIDE

1.1 Needs Addressed by the Training

The purpose of this training workshop is to provide participants with the skills and knowledge needed for assisting rural communities to organize, implement, and maintain handpump projects. Therefore, planning, constructing, and maintaining a handpump project is the central theme of this training. This guide is intended to be used by the trainer(s) who will conduct the workshop. It is not a guide for the participants, although it contains materials which will be handed out to them.

The workshop is intended for participants who work in rural community settings with local communities who want to improve their water supply (as such it is designed for individuals lacking the technical skills or knowledge needed to plan and construct handpump projects, or for those who desire to practice, review, and refine their present level of knowledge and skill). It is designed to provide sufficient understanding and skills to enable participants to implement successful village-based handpump projects.

This training workshop is appropriate for project promoters, field workers, rural development specialists, and others involved in the promotion of improved water supply. They may be ministry staff, extension workers, Peace Corps volunteers, or any individual responsible for and interested in working for improved community water supply through the installation of handpumps.

The workshop focuses on the activities of a handpump project that follow the well's construction and development. It makes use of an existing dug or drilled well and addresses both a shallow well pump and a deep well pump. Trainer notes and guidelines are given later in this Introduction and in the sessions on how to adapt the technical sessions to the different wells and pumps.

1.2 Overall Workshop Goals

During the workshop a balance is struck between the technical skills needed to prepare a well site for receiving a handpump and to install, maintain, and repair a handpump, and the community development skills needed to mobilize communities to assume responsibility for their water improvement project. In the workshop, participants will be involved in the planning and implementing of a handpump project in the local community. They will participate in all phases of this project. At the same time, they will be learning effective methods of involving communities in planning and implementing handpump projects.

At the end of this workshop, participants will be able to:

1. identify resources necessary for a village handpump project

2. conduct an assessment for project feasibility and determine next steps

3. identify and apply strategies for involving the community in all phases of the handpump project

4. survey, evaluate, and select sites for handpumps including an assessment of the quantity of water

5. facilitate the formation and functioning of a water committee or other appropriate village organization

6. develop a project cost estimate

7. develop and implement work plans and logistics necessary for project start-up with appropriate village organization

8. coordinate and monitor construction activities and the procurement and delivery of materials

9. prepare selected sites for receiving handpumps

10. install locally available shallow or deep well pumps

11. operate, maintain, troubleshoot, and repair handpumps

12. design a user education strategy

13. train village caretakers in appropriate maintenance and repair tasks

14. identify alternative strategies for solving most common non-technical problems which develop before, during, and after handpump installation

15. monitor and evaluate the effectiveness of the handpump project

16. develop an awareness of national and regional handpump program resources.

1.3 Trainers

This training guide has been designed to be used by trainers who have expertise in handpump technology and skills in training adults. For a group of 11 or more participants, a team of two trainers will be needed. At least one of the two must have experience in working with handpump installation and maintenance. A minimum level of experience would include the installation and maintenance of three handpumps on the most common types of wells (deep or shallow) in villages of the developing world under significantly different conditions (either in respect to type of pump or site).

At least one of the two trainers must have prior training experience. He or she should have participated, or have the opportunity to participate, in Training of Trainers Workshops and have conducted previous workshops using active learning techniques. This trainer must be skilled in facilitating groups, have experience in development work at the village level, and feel comfortable with technical material.

One trainer can handle a participant group of ten or fewer. This trainer, however, would need both the training and technical skills described above. All trainers who use this guide must be oriented toward practical training and pump installation, since much of the training will involve actual work with handpumps.

1.4 Approach to Training

This program is based on the belief that the knowledge and skills required by those implementing handpump projects involve both:

1. technical areas including site selection, apron construction, handpump installation, maintenance and repair and

2. community development skills including facilitating village mobilization and decision making, problem solving, user education, planning, and strategy development

The content of the program reflects both of these areas and is organized around the sequence of activities required to complete a handpump project. The activities and their sequence are described in the project cycle.

The training program design is based on the belief that people can best learn how to implement handpump projects from training experiences that include both classroom theory and discussion and "hands-on" application of this theory in an actual work setting. Trainees spend time both in workshop sessions learning about how to install a handpump and in the field at the project site where they actually perform the activities required to install the pump. In this way, the community and its handpump project become an integral part of the training.

Since this course requires participants to become involved in, and learn from, actually working on a project (with a good deal of access to the trainers throughout the course), the number of participants should be small. The maximum number of participants suggested is 20. More than 20 participants can limit the workshop's effectiveness. The training staff should include one or two trainers (depending on the size of the group), a workshop coordinator, a project or site supervisor, and an appropriate size labor force. The trainers conduct the training sessions; the workshop coordinator arranges for the procurement of materials and labor, for the transportation and housing of participants, and for other logistical support; the project supervisor oversees the project and supervises the village labor force; and the village work force prepares the site and supplements the participants' labor.

Villagers' participation in the training program as participants is welcomed and encouraged. This will increase village involvement in the handpump project, provide training for the villagers, and introduce ideas into the workshop that come from the users themselves. Key villagers to involve are the caretaker(s) and members of the water committee or other appropriate organization. The advantages of involving villagers in the actual sessions, however, must be weighed against the disadvantages of too large a participant group. There may be certain sessions or portions of sessions in which villagers can be easily included, however.

1.5 Organization of the Training Guide

This course is divided into 19 training sessions. Each session covers a specific topic. A training session may be as short as two hours or as long as eight hours. They generally require a half or full day, depending on the nature of the topic. The session lengths given for each session and in the "Workshop Schedule" do not include breaks or lunch.

1.5.1 Trainer Guidelines

A synopsis of each session's steps, procedures, time, handouts/materials, and required flipcharts is contained in chart form at the beginning of the session. Trainer guidelines are written for each training session. These are intended to provide the training staff with detailed instructions on how to deliver the session. Specifically these guidelines include:

- session objectives
- an overview of the session--what is contained in the session and why it is important
- detailed instructions for conducting the training activities included in the session (i.e. lecturettes for theory, group discussions, role plays, field activities, etc.)
- a time frame indicating how long each part of the session should take
- lists of materials needed for conducting the session
- prepared materials for distribution to participants

This guide is intended to help the training staff organize and deliver this training program. The guide assumes, however, that the training staff has the technical expertise as well as the training skills necessary for conducting participatory, interactive workshops.

1.5.2 Materials for Participants

The materials to be distributed to participants are located following the trainer guidelines for each training session in the guide and also for convenience have been regrouped at the end of the guide in the section titled "Participant Reference Packet (Handouts)." This will enable the trainers to remove all the handouts for duplicating purposes without disturbing the handouts inserted at the end of each session. The materials can be taken out of the guide and copied for distribution, then replaced in the training guide for the next time the course is given.

Participants should be provided with a notebook in which to keep their materials. The notebook should have at least five dividers, one labeled for each phase of the project cycle. The participants can put the appropriate materials, along with their own notes, in the proper section of the guide, and it will then serve as their guide for handpump projects.

The trainer can choose to distribute materials in one of two ways. One method is to distribute the handouts at the time they are covered in the training session, or the training staff can assemble all the handouts and put them into the notebooks prior to the workshop. Thus, on the first day, the notebooks already containing handouts for the entire course are distributed to the participants. Both methods work effectively, and the training staff should choose the preferred method.

1.6 Workshop Content and Methodology

1.6.1 Assumptions and beliefs

This training program and the methodologies it uses are based on the following assumptions and beliefs:

- A successful handpump project is one that is village based, managed effectively over time by the village itself with minimum dependence on outside expertise, and results in the use of clean water by the majority of the village population.

- Successful handpump projects require technical skill, skill in community work, and skill in project management.

- Necessary knowledge and skills can best be acquired through a balance of technical theory and practical "hands-on" application.

- Adults learn best when they are actively involved in the learning process--doing things, discussing, analyzing, experimenting--rather than passively listening to lectures or observing trainer-centered activities.

- Workshop participants learn from each other as well as from the trainers and therefore the learning process should include small groups of participants working together.

1.6.2 Handpump Technology Used in Workshop

Because of the many different handpumps available to a water supply program the workshop technical sessions were designed with adaptability to many pump types and models in mind. The AID handpump was selected as the model for the technical sessions because it is a basic reciprocating, single-acting pump, similar to most handpumps in use today, and because it is available both as a deep well and as a shallow well pump. The Mark II handpump was selected because of its wide use by various donor agencies. For other pumps, the specific technical steps in some sessions may have to be changed, but the trainer procedures will remain the same. Adapting the content of the technical sessions is discussed further in section 1.7.6.

1.6.3 Handpump Training Project

The handpump training project has two purposes: 1) to provide a laboratory for learning which simulates actual situations participants will face in implementing handpump projects and 2) to install a handpump in a village and leave an improved, functioning water source for the community.

In order to accomplish the above purposes, the project and the workshop are interdependent:

- Participants actually work on the project.
- Project activities are planned so that they fit into the course schedule.
- Most workshop topics are scheduled to fit into the natural sequence of project completion (with the exception of the construction sessions which occur out of sequence to allow time for the cement apron to cure). Many sessions begin in the classroom, move to the field, and are completed back in the classroom.
- Training staff is responsible for conducting the training program and for completing the project.
- A labor force is available to prepare the well site and to supplement the participants' labor.

In order for the workshop and the project to proceed at the same pace, the following are important areas for thought and planning:

- the training team must work <u>together</u> to plan and deliver the course <u>and</u> the project
- the community should be involved in helping to create a training project
- the labor force should be considered a part of the training team, not hired hands to do the excess hard work
- time must be planned and managed carefully so that the course and the project can evolve together.

1.6.4 Common Workshop Methods

Since this course is designed on principals of adult learning and experiential methodologies, some of the common workshop components are:

lecturettes (short trainer presentations)
demonstrations
large group discussions
small group tasks
role plays
simulations

cases studies of problems
questionnaires
individual reading and reflecting

All methods are designed to put the learner in the active role--performing tasks, solving problems, working with others to plan activities, developing strategies, and trying things out. Participants act as both individuals and as members of a working group.

The trainer's role is to plan and carry out these participant-centered learning activities, to act as a catalyst, to facilitate discussions, and to provide the technical expertise needed for learning how to install a handpump.

1.7 Planning for Training Program

Conducting a 12-day training program, implementing an actual handpump project, and coordinating them effectively for maximum learning is no small task. Obviously, the planning and preparation for this event will have to be given a good deal of attention. Planning and preparation can be divided into eight categories:

- Selecting the appropriate village in which to have the training program
- Working with the village to obtain participation and assistance
- Adapting session sequences to participant job roles and functions
- Selecting a well site for the training project
- Adapting technical session content to local wells and pumps
- Preparing for construction activities
- Selecting and preparing workshop facilities
- Preparing staff to deliver the training program

1.7.1 Selecting the Village

The village in which to conduct the training program must be chosen carefully. The following are some points to consider in making this choice:

- Assessment for project feasibility, including characteristics of the well, water quality, well location, community interest and support, and community resources*
- Village interest
- Ease of access to the village

* The assessment instrument can be found in Session 6.

- The availability of wells*
- Availability of from two to four villages to conduct practice assessment of project feasibility
- Availability of workshop facilities close to wells
- Living facilities for participants
- Labor force able to work on handpump project

1.7.2 Adapting Session Sequence

The workshop curriculum has been designed for individuals who have direct or indirect responsibility for planning, implementing and monitoring village based handpump projects, including supervising, monitoring, or planning well site preparation and handpump installation. The technical sessions are not designed to make participants expert masons, construction workers, or water technicians. Rather, they provide enough of an understanding of the steps involved, through actual practice, to enable participants to provide quality control for the activities, to monitor the activities, and/or to plan for how and when the activities will take place.

The curriculum has been designed and written for all the sessions to be used as they are currently layed out in their numbered sequence. It is also flexible enough, however, to allow for using only some of the sessions, depending upon the role and function of the participant group.

Suggestions for choice and sequence of sessions for participants with four different kinds of job responsibilities follows:

1. <u>Participants with responsibility for</u>:

   - Preparing the well site
   - Installing the handpump

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* One well is needed for every ten participants. The workshop curriculum is based on a maximum number of 20 participants and therefore makes use of two wells for apron construction to give the participants sufficient practical experience. These wells should be close to each other to facilitate instructing participants at both sites. Where two wells of such close proximity are not available, a "dummy" well can be used. The dummy well can be a shallow lined pit to represent a dug well or a section of well casing set in the ground to represent a drilled well.

The following sequence of sessions is recommended:

Session 1: "Introduction to the Workshop"
Session 2: "Work Site and Pump Orientation"
Session 3: "Implementing Water Supply Programs with Handpumps"
Session 4: "Determining Well Recharge Rate"
Session 5: "Constructing the Apron"
Session 10: "Finishing the Site"
Session 11: "Installing the Handpump and Disinfecting the Well"
Session 19: "Workshop Evaluation"

2. Participants with responsibility for:

- Conducting an assessment for project feasibility
- Presenting various options to the community and facilitating decisions about whether and how to proceed
- Working with the community to set up a water committee and helping to determine its purpose and activities
- Training caretakers
- Overall planning for a handpump project
- Evaluating a handpump project

The following sequence of sessions is recommended:

Session 1: "Introduction to the Workshop"
Session 2: "Work Site and Handpump Orientation" (portions of)
Session 3: "Implementing Water Supply Programs with Handpumps"
Session 6: "Preparing for Conducting Assessment for Project Feasibility"
Session 7: "Analyzing Assessment Results"
Session 8: "Working with the Village Community"
Session 11: "Installing the Handpump and Disinfecting the Well" (well disinfection section)
Session 13: "Training the Caretakers"
Session 14: "Developing a Project Cost Estimate and Work Plan"
Session 16: "Linking up with Regional and National Resources"
Session 17: "Evaluating a Handpump Project"
Session 18: "Planning a Handpump Project"
Session 19: "Workshop Evaluation"

3. Participants with responsibility for:

- Maintenance and/or repair of handpumps

The following sequence of sessions is recommended:

Session 1: "Introduction to the Workshop"
Session 2: "Work Site and Handpump Orientation" (portions of)
Session 3: "Implementing Water Supply Programs with Handpumps"

Session 11: "Installing the Handpump and Disinfecting the Well" (well disinfection section)
Session 12: "Maintaining and Repairing the Handpump"
Session 13: "Training the Caretaker"
Session 19: "Workshop Evaluation"

4. <u>Participants with responsibilities for:</u>

- User/health education

The following sequence of sessions is recommended:

Session 1: "Introduction to the Workshop"
Session 2: "Work Site and Handpump Orientation" (portions of)
Session 3: "Implementing Water Supply Programs with Handpumps"
Session 8: "Working with the Village Community"
Session 15: "Developing and Implementing User Education Strategies"
Session 17: "Evaluating a Handpump Project"
Session 19: "Workshop Evaluation"

When using a selected number of sessions rather than the entire curriculum, minor modifications in session content will have to be made. For example, the following steps would have to be modified in Session 1: "Introduction to the Handpump Workshop":

- <u>Workshop goals</u>: Goals are based on delivery of all sessions (step 4). Change to reflect sessions chosen.

- <u>Workshop schedule</u>: The schedule displays all sessions (step 5). Change to reflect sessions chosen.

- <u>Points about workshop</u>: These points are made in reference to the entire curriculum (step 5). Change to reflect sessions chosen.

- <u>Trainer expectations</u>: Some expectations are based on delivery of all sessions (step 6). Change to reflect sessions chosen.

- <u>Self-assessment</u>: The inventory is based on the task analysis which includes all tasks (technical and non-technical) involved in planning and implementing a handpump project (step 7). Change to reflect sessions chosen.

It is important to review the current and anticipated future job roles and functions of the participants as well as the session objectives and overviews before making any decisions about which sessions to use.

There may be instances in which ministries and other organizations desire to broaden the knowledge and skills of a group of employees who currently have a limited area of responsibility. This may increase their understanding of how they fit into an overall handpump program, enable them to better integrate their activities with those who have differing areas of responsibilities, and/or increase their ability to carry out tasks. For example, an extension worker with responsibility for working with the community prior to handpump installation will be better able to explain the construction/ installation activities, and to help villagers plan and prepare for them, if he or she has actually been involved in apron construction and handpump installation.

It is also possible to use the handpump workshop curriculum with a group of participants who have different job functions as a way of promoting team building, coordination, and planning.

1.7.3 Selecting the Well(s)

The well(s) chosen must fit all criteria found in Handout 5-10: Assessment for Project Feasibility Instrument (Session 5). The well(s) must also be useful as a training site--namely, be not too far from the workshop site and be in as comfortable a setting as possible. If the well is an older well it must be rehabilitated or if a dug well, repaired to the point where Session 5: "Constructing the Apron" is applicable.

1.7.4 Adapting Technical Session Content to Local Wells and Pumps

The training manual was developed for use with both dug and drilled wells and shallow well and deep well pumps. It was designed around the shallow well and deep well versions of the AID handpump and the Mark II deep well handpump but can be easily modified to train participants in how to install, maintain, and repair any other shallow or deep well pump. Information which pertains to a certain design or construction method is separated from the session procedures, and is included in a section called "Trainer Reference Sheets." The trainer reference sheets provide the technical steps for apron construction or pump installation, team work plans, and special trainer guidelines for supervising the technical field activities. When apron designs, construction methods, or pumps are used that are different than those described in the session, the trainer reference sheets can be used as a model for developing material to suit the designs, methods, and pumps. Modification of the trainer reference sheets will not affect the procedures of the sessions, which should remain the same for dug or drilled wells and shallow or deep well pumps unless otherwise noted. Technical and time modifications required for different pumps and wells can be found in the table at the end of this section titled "Effects of Different Pumps and Wells on the Workshop Technical Sessions."

The sessions which use trainer reference sheets are Session 5: "Constructing the Apron," Session 10: "Finishing the Site," and Session 11: "Installing the Handpump and Disinfecting the Well."

To use the trainer reference sheets for a particular session, select the appropriate sections found at the end of the session (or develop sheets for the apron design construction method or pump you will be using) and insert them in the text after the page in which they are referenced.

Review the handouts and trainer reference sheets in advance and modify them as needed to suit your workshop needs.

1.7.5 Preparing for Construction Activities

Activities necessary before construction can begin must be planned and carried out. Among these are:

- determining the size and shape of the apron
- calculating material and tool quantities
- ordering or locating tools and materials
- arranging for participants to conduct an assessment for project feasibility (Session 7) in two to four nearby villages (depending upon the size of the participant group)
- arranging storage for tools and materials
- hiring project/site supervisor
- hiring and preparing a labor force
- arranging financing

1.7.6 Securing Workshop Facilities

The training facilities must be reserved prior to the workshop. There must be adequate meeting space for the entire 12 days. The room(s) should also be available for possible evening sessions. Since participants will meet as a total group, as well as in small work groups, ideally more than one meeting room should be available. The meeting rooms should not be too far from the training project well site or transportation will consume too much time.

Materials needed for the workshop include flipcharts and flipchart stands (or blackboards), paper, pencils, magic markers, masking tape, a 3-hole punch, and a stapler. Although flipchart stands and paper may be difficult to obtain, their use is superior to blackboards since flipchart paper can be posted on the wall and left visible for later tasks or individual reflection. Blackboards usually allow for much less writing space and require erasing before the next materials can be written. Simple flipchart stands can be constructed out of locally available materials. They need not be the fancy, steel variety. Flipchart paper can be low-grade newsprint or butcher paper.

Room and board for trainees must be arranged. Ideally these facilities should be within walking distance of the workshop site so transportation will not be a problem.

1.7.7 Preparing the Staff to Conduct Training Program

For a training program of this complexity to be conducted effectively and run smoothly, the training staff must work together as a team. A vital part of teamwork is having time together before the workshop begins to plan and coordinate how the training activities will be delivered. These planning activities should take several days and involve points such as:

- a concerted effort to build the needed teamwork
- a mutual understanding of how the training program will be conducted
- decisions about which trainer will do what
- preparation for conducting workshop sessions
- advance preparation for participant field work (at the site and in the community)
- planning how workshop time and site progress will be coordinated

1.7.8 Workshop Check List and Time Table

The following table indicates the key steps and time frame for planning and implementing the Handpump Training Workshop.

Activity	Time to Be Completed Before Workshop
• Determine how the workshop will fit in with the on-going water program and how workshop activities (including training project well sites) will be followed up.	4 months
• Determine role, experience, learning needs, and probable number of participants and decide on session sequence.	4 months
• Identify/hire training staff (trainers, workshop coordinator and project/site supervisor)	2 months
• Identify and recruit participants.	2 months
• Determine types of wells and pumps to be included in workshop.	2 months
• Get up-to-date information on existing water programs in country and how they operate including maintenance systems and well and apron construction practices.	2 months
• Select an appropriate village or community for field work and choose well sites based on assessment for project feasibility instrument and workshop needs.	2 months
• Locate an adjacent training site facility and participant/staff lodging and arrange for meals.	2 months

Activity	Time to Be Completed Before Workshop
• Work with the village to obtain cooperation and appropriate participation.	1 month
• Review lists of materials, tools, and supplies in the manual and decide which items are appropriate or should be added to the list	1 month
• Arrange all necessary transportation (to training site and between training site and well sites).	1 month
• Gather necessary data on wells (for example, diameter and depth to water level) and calculate, identify, and obtain all needed construction materials and tools.	1 month
• Arrange for three to four nearby villages to participate in an assessment for project feasibility.	1 month
• Arrange for the storage of supplies.	1 month
• Identify and arrange for a local labor force.	1 month
• Prepare workshop materials including handouts relating to a specific apron or pump design.	1 month
• Trainers contact and work with village leaders and groups affected by the construction project.	2 weeks
• Schedule and sequence construction work with labor crew.	2 weeks
• Ready well(s) to point where apron construction is next step.	2 weeks
• Staff preparation for training.	2 weeks
• Begin training.	---

1.8 Materials and Supplies, Tools, and Labor Required to Implement Workshop

A suggested list of materials and supplies, tools, and labor and the sessions in which they are used, follows. These lists were based on actual field installation requirements of the AID shallow well and deep well handpumps and may have to be modified depending upon the type of pump used and the local availability of specific materials, supplies, and tools.

Material quantities are not given because they depend on the type and diameter of the well. Follow the steps given in Handout 14-1: Calculating Material Quantities found in Session 14, "Developing a Project Cost Estimate and Construction Work Plan," to determine the specific quantities for your workshop.

Unless otherwise noted, tool quantities are based on the number of tools needed for each team. Two exceptions are the tripod (one per well site) and the pipe threaders (one set for every two or three groups depending on availability).

The number of laborers required is for each well site. One skilled worker and two unskilled laborers per well site are needed in the sessions that use cement mixes (Sessions 5 and 10).

In the last column are the sessions in which the material, tool, or labor is required.

In order to keep track of the tools and supplies it will be necessary to establish a method of checking tools in and out of a storage room near the work site. To establish this system, it is first necessary to make an inventory list of all the tools and supplies. Second, a person must be assigned the task of disbursing the tools and supplies. The larger supplies (barrels, pumps) should be set out on the work site before the session in which they are used. Third, a list of which tools and supplies are needed for each session should be provided to the person disbursing them. He/she should check off the groups when they have received and returned tools and supplies.

MATERIALS AND SUPPLIES

Material or Supplies	Quantity*	Used in Sessions
cement		5, 10
sand		5, 10
gravel		
forms (wood, brick, etc)		5
reinforcing bars (dug wells only)		5
tying wire (dug wells only)		5
anchor bolts		5
string		5, 10, 11
concrete blocks (or drain tile, etc.)		10
drop pipe (deep well pumps only)		11
plunger rod (deep well pumps only)		11
pipe and rod connectors (deep well pumps only)		11
teflon tape		11, 13
suction pipe (shallow well pump)		11
PVC solvent (if PVC suction pipe used)		11
grease		11, 12, 13
disinfectant (chlorine)		11, 13
spare parts		11, 13

* Quantities will depend on the type of well and the size and shape of the apron and drain.

Small group supplies**	Quantity*	Used in Sessions
shallow well pump		11, 12, 13
deep well pump		11, 12, 13
barrel		11, 12, 13
nipple (drop pipe diameter)		11, 12, 13
short length of plunger rod		11, 12, 13
short suction pipe		11, 12, 13
platform to mount pump on barrel		11, 12, 13
teflon tape or pipe joint compound		11, 12, 13

* Quantities will depend on the type of well and the size and shape of the apron and drain.

**Certain small group activities are conducted using a pump on a barrel instead of on a well. This arrangement allows the participants to get sufficient practical experience in installation and repair without needing additional well sites. The supplies below are in addition to the materials and tools listed earlier and must be procured before the workshop begins.

TOOLS

Tools	Quantity	Used in Sessions
trowel	3**	5, 10
shovel	3**	5, 10
metal bucket	3**	5, 10, 11, 12, 13
plastic bucket	1	11, 13
screed	3**	5, 10
hammer	3**	5, 11, 14, 15
wire brush	1	5, 10, 12, 13
wood saw	3**	5, 10
square	3**	5, 10
pick/maddox	3**	5, 10
tape measure	1	5, 10, 11
clear plastic hose	1*	5
wire cutter	1*	5
hack saw	3**	5, 11
strap wrench	1	11, 12,
pipe wrench (8-10 cm grip-- deep well pump only)	1	11, 12, 13
pipe wrench (5-6 cm grip-- shallow well pump only)	1	11, 12, 13
adjustable wrench	2	11, 12, 13
pipe clamp (deep well pump only)	1*	11
pipe threader for plunger rod (deep well pump only)	1***	11
pipe threader for drop pipe (deep well pump only)	1***	11
pliers	1	5, 11, 12, 13
punch	1	11, 12, 13
tripod (deep well pump only)	1*	11
pulley or block and tackle (deep well pump only)	1*	11
heavy rope (deep well pump only)	1*	11
broom	1	11, 13
measuring cup	1	11, 13
rebar bender	1*	5

The quantities given are based on one small group. They should be multiplied by the number of groups to find the total quantity needed.

*Quantity is based on one work site. The quantities should be doubled for a second work site.

**The quantity is based on three small groups using the tools at one work site at the same time in the construction sessions.

***Because of the cost of these tools, it may be advisable to share one tool between two or three groups. This will cause some delay in the session's completion but will be tolerable if one tool is shared between a maximum of three groups.

LABOR

Labor	Quantity	Used in Sessions
skilled mason	1	5, 10
unskilled workers or helpers	2	5, 10

1.9 Task Analysis

On the following pages is the task analysis on which the design of the workshop is based. The sessions are intended to build skills and knowledge in carrying out the tasks listed. The task analysis is divided into the five phases of the project cycle: pre-planning and assessment, planning and design, construction, maintenance and repair, and evaluation.

Each task is rated in accordance to its importance, its difficulty, and the frequency with which it is done. The ratings are on a scale of one to three, with one high, two medium, and three low. For example, a task which is rated one in importance means it is very important and a task which is rated three is not critical but important enough to be taught during the workshop.

TASK	IMPORTANCE	DIFFICULTY	FREQUENCY
PRE-PLANNING AND ASSESSMENT			
1. Identify and be familiar with availability of national/regional resources for a handpump program, for example: - pumps - funds - political support - technical expertise - spare parts	1	3	3
2. Conduct a preliminary assessment of villages in area to determine most likely villages for initial projects. Criteria to include: - need - interest - leadership capabilities - technical difficulties	1	2	1
3. Meet with and explain to village leaders what your role is, what handpump/well improvement is, why it is needed in the village, how it will help the villagers.	1	1	3
4. Discuss and assess with village leaders: - past projects in village and reasons for success/failure - potential resources - potential role of women and men in project - current practices re: water - current problems with wells and pumps.	1	1	3
5. Conduct an assessment of existing wells and pumps in village including type, total depth, depth to water table, water quality (taste, bacteria if possible), reasons for non-use and use, past dry periods, number of users, etc.	1	3	3

1: HIGH
2: MEDIUM
3: LOW

T A S K	IMPORTANCE	DIFFICULTY	FREQUENCY
6. Develop a cost estimate for handpump program in village with varying options.	2	2	3
7. Be familiar with and have solutions for the most common problems a field worker encounters in implementing and maintaining a handpump program.	2	2	3
8. Help leaders determine how to form a water committee in keeping with village characteristics and interest.	1	1	3
9. Assess with leaders village resources including finances, labor for installation and maintenance, materials, tools, equipment.	1	1	3
10. Present recommendations and cost estimates to leaders on how to proceed with the handpump program.	1	2	3
11. Discuss and arrive at decision with village re: - commitment of village resources to program - determination of roles/responsibilities before, during, after installation - determination of community financing system and procedures - development of criteria and selection of caretakers and determination of compensation - rules and guidelines for use of pump.	1	1	3
12. Orient committee members to the concept of clean water for health using handpumps and plan strategies for introducing concept to different group in the village.	1	1	3

1: HIGH
2: MEDIUM
3: LOW

T A S K	IMPORTANCE	DIFFICULTY	FREQUENCY
PLANNING AND DESIGN			
13. Know how to competitively select and care for quality tools and train caretakers in the same.	1	1	3
14. Select site by analyzing information collected during the assessment for project feasibility.	1	3	2
15. Familiarize caretakers in reasons and criteria for well selection.	1	2	3
16. Assess the extent of repairs required to sanitarily protect the well and calculate costs.	2	2	2
17. Determine the apron size, shape, orientation (for drainage) and need/ size for soakage pit.	2	3	2
18. Calculate the required amounts and types of materials (sand, gravel, cement, rock, brick, re-bar, forms, etc.) and determine what will be procured locally and what must be imported.	2	1	2
19. Determine the amount and quality of labor and determine if it is available locally or if it must be hired from outside.	2	1	2
20. Discuss costs of materials, tools, and labor with water committee if substantially different than estimates or previous agreements.	1	3	2
21. Procure materials, tools and hire labor. Arrange such things as transport, payment, wages.	1	3	2

1: HIGH
2: MEDIUM
3: LOW

TASK	IMPORTANCE	DIFFICULTY	FREQUENCY
CONSTRUCTION			
22. Construct apron following 11 major steps.	1	2	3
23. Construct soakage pit if no existing drainage trench is nearby.	1	2	2
24. For drainage, clear and grade an area around the apron. Cover this area with packed gravel.	1	3	2
25. Identify and locate necessary materials and tools.	1	3	3
26. Describe and perform pump installation tasks.	1	3	2
27. Describe and perform steps with caretaker and water committee for installing and repairing a handpump above ground.	2	2	2
28. Explain to water committee/users what well disinfection involves and why it helps water supply.	1	2	2
29. Identify and perform steps for disinfecting well.	1	2	2
MAINTENANCE AND REPAIR			
30. Perform and instruct caretaker in pump lubrication and site maintenance.	1	2	2
31. Develop with caretaker a maintenance schedule.	1	3	2
32. Identify and solve technical problems which may arise with shallow or deep well pump such as poor flow rate and leakage and train caretakers to do same.	1	1	2

1: HIGH
2: MEDIUM
3: LOW

TASK	IMPORTANCE	DIFFICULTY	FREQUENCY
33. Set up procedures for acquiring outside technical assistance, material and spare parts and train caretakers in knowing when and how to use these resources.	1	2	3
34. Understand community problems that affect the use of the pump and success of the program. Develop strategies with the water committee for overcoming problems and for enforcing rules/guidelines for use of pump.	1	1	3
35. Know and demonstrate how to troubleshoot by identifying possible causes of various symptoms of pump problems.	1	1	2
36. Apply principles of water contamination and protection in a variety of situations and develop appropriate user education sessions demonstrating clean water handling and storage techniques.	1	1	2
EVALUATION			
37. After completion of initial project, analyze what worked, what didn't, and why and identify changes in strategy for next venture.	1	1	3
38. Encourage the village to celebrate and feel proud of its handpump program.	2	3	3

1: HIGH
2: MEDIUM
3: LOW

WORKSHOP SCHEDULE

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
a.m.	Session 1 Introduction to the Handpump Workshop	Session 3 Implementing Water Supply Programs with Handpumps: an Overview	Session 5 Constructing the Apron	Session 5, pt. 2 Constructing the Apron	Session 6, pt. 2 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7, pt. 2 Conducting the Assessment and Analyzing Assessment Results Session 8 Working with the Village Community	O F F
p.m.	Session 2 Work Site and Handpump Orientation	Session 4 Determining Well Recharge Rate		Session 6 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7 Conducting the Assessment and Analyzing Assessment Results	Session 9 Mid-Point Evaluation	

	DAY 8	DAY 9	DAY 10	DAY 11	DAY 12
a.m.	Session 10 Finishing the Site	Session 11, Pt. 2 Installing the Handpump and Disinfecting the Well	Session 13 Training the Caretakers	Session 15 Developing and Implementing User Education Strategies	Session 17 Evaluating the Handpump Project Session 18 Planning a Handpump Project
p.m.	Session 11 Installing the Handpump and Disinfecting the Well	Session 12 Maintaining and Repairing the Pump	Session 14 Developing a Project Cost Estimate and Construction Work Plan	Session 16 Linking Up to Regional and National Efforts	Session 19 Workshop Evaluation

EFFECTS OF DIFFERENT PUMPS AND WELLS ON WORKSHOP TECHNICAL SESSIONS

STANDARD FOR THE WORKSHOP DESIGN an AID shallow well or deep well pump installed on a dug well or a drilled well. Changes from the standard will not affect the session procedures, only the session lengths, handouts and Trainer Reference Sheets as noted below.

Effects on Sessions	SESSION 2 Work Site and Handpump Orientation	SESSION 4 Determining Well Recharge Rate	SESSION 5 Constructing the Apron	SESSION 10 Finishing the Site	SESSION 11 Installing the Pump and Disinfecting the Well	SESSION 12 Maintaining and Repairing the the Pump	SESSION 14 Developing a Project Cost Estimate and Construction Work Plan
Dug wells only	None	Use procedures for dug well	Use Trainer Reference Sheets and handouts for dug well. Session time: 10 hrs 20 min.	Use Trainer Reference Sheets for dug well. Session time: 3 hrs 5 min.	None	None	None
Drilled wells only	None	Use procedures for drilled well	Use Trainer Reference Sheets and handouts for drilled wells. Session Time: 7 hrs 20 min	Use Trainer Reference Sheets for drilled wells. Session time: 2 hrs 35 min	None	None	Omit re-bar material requirements from handouts
Use of Non-AID pumps (trainer reference sheets for Mark II pump are provided)	Description of pump operation may vary with the pump; may need to revise handout	None	Anchor bolt and pedestal dimensions may be different to suit pump; handouts may need revision	None	Installation procedures & tools may vary with pump; handouts may need revision	Procedures and tools may vary with pump; handouts may need revision	Material, tool, labor requirements in handouts may vary with the pump
Use of both a shallow well pump and a deep well pump	Repeat steps 5-7. Add approx. 40 min	None	None	None	Repeat steps 5-8. Session time with both pumps is 9 hrs	Repeat step 3. Add approx. 45 min. to session time	None
Use of more than 1 brand of deep well or shallow well pump	Repeat steps 5-7. Add approx. 40 min per each additional pump	None	None	None	Repeat steps 5-8. Add approx. 1 hr 15 min. per each additional shallow well pump. Add approx. 2 hrs 15 min per each additional deep well pump	Repeat step 3. Add approx. 45 min per each additional pump	Include brand specific material & tool requirements (see also use of non-AID pumps) in handouts

2. WORKSHOP TRAINING SESSIONS

SESSION 1

SYNOPSIS OF SESSION 1: Introduction to Handpump Workshop

Total Time: 2 Hours 55 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	15 Min.		Session Objectives
Welcome from Sponsoring Agency	Sponsor Presentation	15 Min.		
Getting Acquainted	Three rounds of interactions of pairs	60 Min.		Instructions
Workshop Goals and Participant Expectations	Trainer Presentation	20 Min.	Flipcharts on expectations prepared by participants Handout 1-1: Workshop Goals	Workshop Goals
Schedule and Methodology	Trainer Presentation	15 Min.	Handout 1-2: Workshop Schedule	Workshop Schedule
Workshop Procedures	Trainer Presentation and Discussion	15 Min.		Trainer Expectations
Self Assessment	Individual work and discussion in pairs	30 Min.	Handout 1-3: Self Assessment Inventory	
Closure	Trainer Presentation	5 Min.		

Session 1: Introduction to the Handpump Workshop

Total Time: 2 hours 55 min.

OBJECTIVES

By the end of this session, participants will have:

1. become acquainted with one another and the training staff
2. identified and clarified expectations for the workshop
3. assessed their skill level in planning and implementing handpump projects

OVERVIEW

This is the first training session of the workshop. It introduces the participants to what they are going to do and sets the atmosphere for learning and working together. It highlights the goals and approaches of the workshop.

The session shows the participants that their ideas and experiences are as important as those of the trainers. It should be clear that a successful workshop is one where all participants share knowledge, skills, ideas and experiences.

PROCEDURE

1. Introduction — Time: 15 min.

Briefly introduce yourself and the other members of the training staff. In the same brief fashion ask the participants to introduce themselves. Then, explain what this session will cover. Refer to the session objectives, and indicate that it will take about 2-1/2 hours to complete.

2. Welcome from Sponsoring Agency — Time: 15 min.

If possible, have an official from the water agency sponsoring the workshop welcome the participants, give a brief overview of the work and plans of the agency, and tell why the workshop is important. If no official is available, you should give some background information about the sponsoring agency and its decision to sponsor the workshop.

3. Getting Acquainted — Time: 60 min.

A) Explain that a goal of the session is to get to know one another and that the following activity is intended to help achieve that goal. Ask the participants to do the following tasks. Put them on the flipchart or blackboard and display it since this activity may be new to some of the participants and they might not understand it. This activity should take 30 minutes:

- Get up from your chairs.

- Choose one other person, talk with him/her, and find out:
  a) who he/she is
  b) where he/she is from

- Be prepared to offer the same information about yourself.

- There will be three rounds of meetings. For each meeting I will ask you to discuss a different topic with your partner.

- I will tell you when to switch partners.

- The topic for Round 1 is:

  "What I would like to be doing in my work"

B) Allow approximately 10 minutes per round. Tell partners when to switch. The topics for Round 2 and 3 respectively are:

"My most rewarding experience working with a village community"

"What I hope to learn or do during this workshop"

C) At the end of Round 3, ask three pairs to form a group of six. Give the groups the following task to perform in 30 minutes.

- Discuss what each member of <u>your</u> group hopes to learn or do during this workshop, i.e., <u>your</u> expectations for the workshop.

- Choose one person to write <u>your</u> group's expectations on flipchart paper. Make sure all expectations of every group member are included, but if some members have the same expectations only write them once.

4. <u>Workshop Goals and Participant Expectations</u> Time: 20 min.

Each participant will have his/her own expectations of what the workshop will be like, what will be learned from it, and, in general, what is expected.

The lists of participants' expectations give the training staff an opportunity to learn what the participants want. This exercise will then clarify which expectations can and cannot be satisfied by this particular workshop.

A) Post the lists of expectations in the front of the room and go over each list to clarify the items.

B) Tell the participants that we will look at the workshop goals and see how close they come to matching what they said they wanted to learn. Pass out <u>Handout 1-1: Workshop Goals</u>.

C) Go over the goals with the group and make sure they are clear and understood. If the group comments on the goals, or wishes further clarification, discuss the issues raised. Note: Have the workshop goals written on a blackboard or flipchart.

D) Compare the goals with the lists of participants' expectations by looking at each item on the participants' lists and identifying the goals that cover the item. You can use the participants' lists to explain what the workshop goals mean.

E) Note any items on the participants' lists that will not be covered in the workshop. Make it clear that they will not be covered. Most of the participants will understand and be cooperative if they know what to expect.

5. Schedule and Methodology Time: 15 minutes

A) Pass out Handout 1-2: Workshop Schedule. It is a good idea to have this schedule drawn on flipchart paper and posted on the wall for use throughout the course. Then the presentation should be made from this large diagram of the schedule.

B) Go over the schedule and explain how the training activities are arranged to meet the workshop goals.

C) Explain the kinds of activities that will take place each day. Make sure it is clear that the participants are at a workshop--not a traditional course. They are going to learn by doing. The methodologies used will be field experience, group and individual problem solving, discussions, role playing, demonstrations, and skill building practice.

D) Make the following points:

- We expect to leave ____________________ (name of village where training site is located) a functioning handpump by the end of our training session.

- As you can see by the workshop goals, there are two primary areas of training--one that deals with technical skills (how to construct an apron and install a handpump, for example) and one which encourages community development skills, such as helping village leaders make informed decisions about handpump projects and developing ways to involve villagers throughout the life of the project).

- We will use the steps in the project cycle to organize this workshop. In other words, we will cover all the steps an extension worker would need from initial planning and assessment through evaluation. You will have an opportunity to actually plan and implement a handpump project.

- We believe that community participation in planning, implementing, and maintaining a handpump project is vital. We hope that the way we work with the villagers, who agreed to allow us to use their village as a site to conduct this training program, will reflect this approach.

- At this point, give participants a brief overview of what "advance work" has been done with the village and what the role of the villagers will be in the training program. For example, if caretakers have been selected, how and when they will join the training program; if village men are members of the labor force, at what points they will be involved; if a water committee has been established, how it was organized.

- Community participation is one of the key elements for a successful project. We define a successful project as one which can be managed over time by the village with a minimum of back-up support, and one that results in the use of clean water and the practice of proper hygiene and sanitation by the majority of the village population.

- Finally, one does not have to know how to construct an apron or install a handpump to participate in this workshop. Some participants may know more than others about these tasks. Everyone, however, will have ideas to contribute. Participants will learn from each other as well as from the trainers.

E) Answer any questions that have arisen.

6. <u>Workshop Procedure</u> Time: 15 min.

Since the group will be working together for two weeks, to avoid future misunderstandings it is important to discuss how everyone will work together.

A) Prepare a list of training staff expectations (see Trainer Note 1).

B) Ask the group for their expectations of the trainers and of each other.

C) Add these to the trainer's list and discuss. By the end of this segment, everyone should understand how they will work together and what is expected of them.

7. <u>Self Assessment</u> Time: 30 min.

Distribute <u>Handout 1-3: Self-Assessment Inventory</u>. Explain that it was based on an analysis of all major tasks involved in the design and implementation of a handpump project. The task analysis was used to design this training course and develop the goals and schedule. To enable participants to assess their own skills, they will fill out the self-assessment inventory at the beginning and at the end of the workshop. Tell them they will be able to keep this aid.

Ask participants to take 15 minutes to fill out the self-assessment inventory. Answer questions about the inventory. When completed, have them form pairs and take another 15 minutes to discuss the following:

- their personal strengths and weaknesses
- areas they hope to improve during the workshop

8. Closure — Time: 5 min.

Go back to the session goals. Ask if everyone understands what the workshop will cover and how it will be done.

MATERIALS

1. Handout 1-1: Workshop Goals
2. Handout 1-2: Workshop Schedule
3. Handout 1-3: Self Assessment Inventory
4. Flipchart paper
5. Marker pens
6. Tape
7. Notebooks
8. Prepared flipcharts for:
   - session objectives
   - getting acquainted task instructions
   - workshop goals
   - workshop schedule
   - trainer expectations.

TRAINER NOTES

1. The following is a sample list of trainer expectations:

As trainers we expect:

- Prompt attendance at all sessions. We will make every effort to begin and end sessions on time.
- Everyone to freely participate and share skills, information, and experience.
- Participants to maintain an "open mind" about the learning approach used in this workshop and try out the workshop activities.

- Participants to take responsibility for:

  - care and proper use of tools and equipment
  - safety at well site
  - helping others learn

- Participants to get their hands dirty and to involve themselves in physical labor.

- Participants to learn new skills and do tasks they may never have done before.

- Participants to be free to let trainers know what they think of the workshop.

- Participants and trainers together to make every effort to leave behind a working handpump project.

WORKSHOP GOALS

1. Identify resources necessary for a village handpump project
2. Conduct an assessment for project feasibility and determine next steps
3. Identify and apply strategies for involving the community in all phases of the handpump project
4. Survey, evaluate, and select sites for handpumps (including an assessment of the quantity and quality of water)
5. Facilitate the formation and functioning of a water committee or other appropriate village organization
6. Develop a project cost estimate
7. Develop and implement, with appropriate village organization, work plans and logistics necessary for project start-up
8. Coordinate and monitor construction activities and the procurement and delivery of materials
9. Prepare selected sites for receiving handpumps
10. Install locally available shallow or deep well pumps
11. Operate, maintain, troubleshoot, and repair handpumps
12. Design a user education strategy
13. Train village caretakers in appropriate maintenance and repair tasks
14. Identify alternative strategies for solving most common non-technical problems which develop before, during, and after handpump installation
15. Monitor and evaluate the effectiveness of the handpump project
16. Develop an awareness of national and regional handpump program resources

WORKSHOP SCHEDULE

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
a.m.	Session 1 Introduction to the Handpump Workshop	Session 3 Implementing Water Supply Programs with Handpumps: an Overview	Session 5 Constructing the Apron	Session 5, pt. 2 Constructing the Apron	Session 6, pt. 2 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7, pt. 2 Conducting the Assessment and Analyzing Assessment Results Session 8 Working with the Village Community	O F F
p.m.	Session 2 Work Site and Handpump Orientation	Session 4 Determining Well Recharge Rate		Session 6 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7 Conducting the Assessment and Analyzing Assessment Results	Session 9 Mid-Point Evaluation	

	DAY 8	DAY 9	DAY 10	DAY 11	DAY 12
a.m.	Session 10 Finishing the Site	Session 11, Pt. 2 Installing the Handpump and Disinfecting the Well	Session 13 Training the Caretakers	Session 15 Developing and Implementing User Education Strategies	Session 17 Evaluating the Handpump Project Session 18 Planning a Handpump Project
p.m.	Session 11 Installing the Handpump and Disinfecting the Well	Session 12 Maintaining and Repairing the Pump	Session 14 Developing a Project Cost Estimate and Construction Work Plan	Session 16 Linking Up to Regional and National Efforts	Session 19 Workshop Evaluation

SELF-ASSESSMENT INVENTORY

Rank yourself in terms of how well you feel you now do each of the tasks below. This is for your use to help you in your learning. Please be accurate and honest with your answers.

PRE-PLANNING AND ASSESSMENT

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
1. Identify and be familiar with availability of national/regional resources for a handpump program, for example: - pumps - funds - political support - technical expertise - spare parts	4	3	2	1
2. Conduct a preliminary assessment of villages in area to determine most likely villages for initial projects. Criteria to include: - need - interest - leadership capabilities - technical difficulties	4	3	2	1
3. Meet with and explain to village leaders what your role is, what handpump/well improvement is, why it is needed in the village, how it will help the villagers.	4	3	2	1
4. Discuss and assess with village leaders: - past projects in village and reasons for success/failure - potential resources to initiate - potential role of women and men in project - current practices re: water - current problems with wells and pumps.	4	3	2	1
5. Conduct an assessment of existing wells and pumps in village including type, total depth, depth to water table, water quality (taste, bacteria if possible), reasons for non-use and use, past dry periods, number of users, etc.	4	3	2	1

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
6. Develop a cost estimate for handpump program in village with varying options.	4	3	2	1
7. Be familiar with and have solutions for the most common problems a field worker encounters in implementing and maintaining a handpump program.	4	3	2	1
8. Help leaders determine how to form a water committee in keeping with village characteristics and interest.	4	3	2	1
9. Assess with leaders village resources including finances, labor for installation and maintenance, materials, tools, equipment.	4	3	2	1
10. Present recommendations and cost estimates to leaders on how to proceed with the handpump program.	4	3	2	1
11. Discuss and arrive at decision with village re: - commitment of village resources to program - determination of roles/responsibilities before, during, after installation - determination of community financing system and procedures - development of criteria and selection of caretakers and determination of compensation - rules and guidelines for use of pump.	4	3	2	1
12. Orient committee members to the concept of clean water for health using handpumps and plan strategies for introducing concept to different group in the village.	4	3	2	1

PLANNING AND DESIGN

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
13. Know how to competitively select and care for quality tools and train caretakers in the same.	4	3	2	1
14. Select site by analyzing information collected during the assessment for project feasibility.	4	3	2	1
15. Familiarize caretakers in reasons and criteria for well selection.	4	3	2	1
16. Assess the extent of repairs required to sanitarily protect the well and calculate costs.	4	3	2	1
17. Determine the apron size, shape, orientation (for drainage) and need/ size for soakage pit.	4	3	2	1
18. Calculate the required amounts and types of materials (sand, gravel, cement, rock, brick, re-bar, forms, etc.) and determine what will be procured locally and what must be imported.	4	3	2	1
19. Determine the amount and quality of labor and determine if it is available locally or if it must be hired from outside.	4	3	2	1
20. Discuss costs of materials, tools, and labor with water committee if substantially different than estimates or previous agreements.	4	3	2	1
21. Procure materials, tools and hire labor. Arrange such things as transport, payment, wages.	4	3	2	1

CONSTRUCTION

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
22. Construct apron following 11 major steps.	4	3	2	1
23. Construct soakage pit if no existing drainage trench is nearby.	4	3	2	1
24. For drainage, clear and grade an area around the apron. Cover this area with packed gravel.	4	3	2	1
25. Identify and locate necessary materials and tools.	4	3	2	1
26. Describe and perform pump installation tasks.	4	3	2	1
27. Describe and perform steps with caretaker and water committee for installing and repairing a handpump above ground.	4	3	2	1
28. Explain to water committee/users what well disinfection involves and why it helps water supply.	4	3	2	1
29. Identify and perform steps for disinfecting well.	4	3	2	1

MAINTENANCE AND REPAIR

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
30. Perform and instruct caretaker in pump lubrication and site maintenance.	4	3	2	1
31. Develop with caretaker a maintenance schedule.	4	3	2	1

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
32. Identify and solve technical problems which may arise with shallow or deep well pump such as poor flow rate and leakage and train caretakers to do same.	4	3	2	1
33. Set up procedures for acquiring outside technical assistance, material and spare parts and train caretakers in knowing when and how to use these resources.	4	3	2	1
34. Understand community problems that affect the use of the pump and success of the program. Develop strategies with the water committee for overcoming problems and for enforcing rules/guidelines for use of pump.	4	3	2	1
35. Know and demonstrate how to troubleshoot by identifying possible causes of various symptoms of pump problems.	4	3	2	1
36. Apply principles of water contamination and protection in a variety of situations and develop appropriate user education sessions demonstrating clean water handling and storage techniques.	4	3	2	1

<u>EVALUATION</u>

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
37. After completion of initial project, analyze what worked, what didn't, and why and identify changes in strategy for next venture.	4	3	2	1
38. Encourage the village to celebrate and feel proud of its handpump program.	4	3	2	1

SESSION 2

SYNOPSIS OF SESSION 2: <u>Worksite and Handpump Orientation</u>

Total Time: 2 Hours 25 Min. (If only 1 pump type is used)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Lecturette/Discussion: Orientation to the Construction Sessions	Lecturette and Discussion	30 Min.	Handout 2-1: Construction Line Chart	Construction Line Chart
Lecturette: Design Considerations in Apron Construction	Lecturette	10 Min.	Standard Design for Apron (to be provided by the local water supply program)	
Observing the Work Site	Trip to worksite to observe and discuss well site and surroundings	45 Min.		
Lecturette/Demonstration Becoming Familiar with the Pump	Description of parts of pump and demonstration of how pump operates	15 Min. Per Pump Type	Handout 2-2: Operation of Pumps (Shallow or Deep Well) Cut away model of pump or illustration shown in Handout 2-2 (shallow or deep well) One complete and assembled pump of each type used in workshop	Illustration Shown in Handout 2-2 (Shallow or Deep Well)
Practice: Becoming Familiar with the Pump	Groups of 3 disassemble a pump	20 Min. Per Pump	One pump of each type for every 3 participants	
Discussing the Practice Activity	Questions and Answers	15 Min.		
Closure	Trainer Presentation	5 Min.		

Session 2: Work Site and Handpump Orientation

Total Time: 2 hours 25 min.
(if only one pump type is being used in workshop)

OBJECTIVES

By the end of this session, the participants will have:

1. observed and commented on the training project work site, well and village
2. become familiar with the construction steps that will be undertaken in the workshop
3. taken apart and reassembled the components of the pumps used in the workshop

OVERVIEW

This session is the introduction to the construction sessions and contains an overview of the major construction steps and an orientation to the work site and the pumps that will be used in the workshop. Actual construction begins in Session 5: "Constructing the Apron" and is continued in Session 10: "Finishing the Site", and Session 11: "Installing the Handpump and Disinfecting the Well."

The practice session on the major pump components uses prototype pumps which the participants disassemble. Before the session, the pumps need to be procured, brought to the workshop site and their major connections loosened so the participants can disassemble them without tools.

PROCEDURE

1. Introduction — Time: 5 min.

Present the session objectives and major activities.

2. Lecturette/Discussion: Orientation to the Construction Sessions

Time: 30 min.

A) Post the "Construction Line Chart" on flipchart paper or a chalkboard. Explain the construction sequence that will be done during the workshop. Show the participants where the construction sessions are in the workshop schedule.

B) Remind the participants that the project being undertaken as part of this workshop is an actual handpump project in this village. Ask the following questions:

- At what points over the next two weeks will we need/want the involvement of the village?

- What impact could our working at the well sites have on the villagers?

- What additional information do we want to get from the villagers either informally or formally? What is the best way of getting it?

C) Make the following points:

- Practicing good safety habits at the work site is essential. Injuries and accidents can occur during construction work but only if caution and good common sense are missing. We must not only be concerned about ourselves, but also about villagers who are moving about the work site area.

- The correct use and care of tools is another practice we hope to emphasize over the next two weeks. At several points during the workshop we will discuss the use of tools and will ask you to use them correctly, keep them clean, and take responsibility for assisting us in dispersing and collecting them after use.

- How we will work:

  a) Construction teams
    - Participants will work in two teams - one at each well site.
    - Each team is responsible for the successful construction of the apron and installation of the pump.
    - Participants with construction skills will be evenly divided between the teams.
    - Teams will remain the same throughout the construction sessions.

  b) Work sites
    - Construction session activities will take place at the well site and in the classroom. There will be much movement and a need to move to and from the work site and classroom quickly.

  c) Construction session procedures
    - lecturette
    - preparation for field work
    - field work
    - discussion

  d) Pass out <u>Handout 2-1: Construction Line Chart</u>.

3. Lecturette: Design Considerations in Apron Construction — Time: 10 min.

Prepare a lecturette from the following text:

Most water programs have established design criteria for both well location and the shape of the apron. Location criteria include such items as minimum distances from sources of contamination such as latrines, septic fields, open wells, agriculture fields using fertilizers and pesticides, rivers, fish ponds, and canals. This water program suggests (or requires) minimum distances of ________ from the source of contamination. Another location criteria is that the well should be located above known flood levels. A third location criteria is accessibility for construction and for use. This may include being located on public land. Other location criteria considered by this program include _____. Let's look for these criteria on our visit to the site.

A standard apron design is usually provided by the water program. The essentials of the standard design usually include the apron size, length of drain, pump pedestal (if not mounted directly on the apron), the slope of the apron and drain, the concrete mixture and the type and quantity of reinforcing material required. The standard design(s) used by this water program include the following ... (pass out standard designs).

Even with a standard design, however, there are considerations that affect the actual design constructed in the field. These include:

- specific desires of the users
- nearby objects: trees, structures for clothes washing, walls
- building up or excavating the well site due to drainage, accessibility or other considerations
- where the runoff water is channeled (ditch or garden, etc.)

When we go to the site, look for these items. Your observations may affect the design of the apron we construct in this workshop.

4. Observing the Work Site — Time: 45 min.

Take the participants to the work site. Introduce them to the labor force and villagers in the area. Ask the villagers to explain to the participants why they are working on this project, what projects they have already completed, and any other information about the village to provide a background.

Ask the participants to look at the well site and its surroundings. Say to them "Tell me anything that you notice about this well and its location. Why do you suppose that is?" The participants might note the well diameter and depth, proximity to houses, possible number of users and the missing headwalls if it is a dug well (knocked down by workmen to prepare for laying the apron slab).

Then ask "What had to take place over the past several weeks and months so that we are able to begin construction?" Answers should be along the line of locating a well, ordering materials, and deciding on financing with the village leaders.

5. <u>Lecturette/Demonstration: Becoming Familiar with the Pump</u>

Time: 15 min. per pump type

A) It is probably most convenient to hold this activity and the following practice wherever the practice steps of sessions using barrels will be held (Session 11: "Installing the Handpump and Disinfecting the Well" and Session 12: "Maintaining and Repairing the Pump"). Set one complete and assembled pump of each type used in the workshop in front of the participants. Use these pumps when describing their parts and how each one operates. Also, have a set of internal working parts to demonstrate how the water is moved (in the case of reciprocating pumps, a piston assembly and foot valve will be needed).

B) Describe to the participants the parts of the pump. This can be done by the trainer or a participant. Use the Handout 2-2: Operation of Pumps as a guide. Demonstrate how the internal working parts of the pump move the water. Use the actual internal parts (e.g. actual piston and foot valve) to illustrate this step.

If a cut-away model of the pump is available, use it or the illustration showing the operation of the pump in Handout 2-2 (draw on flipchart paper or a chalkboard). Make the following key points about the operating steps for a reciprocating piston pump (if appropriate):

- operated by moving handle
- handle connected to piston
- piston moves up, foot valve opens and water enters cylinder
- piston moves down, poppet valve in piston opens and water passes through piston
- on next upward movement of piston, water is pushed up from cylinder into drop pipe
- water moved up to surface by repetition of piston movement

C) If the participants will be exposed to both shallow well and deep well pumps, remind them that a shallow well pump can raise water from a water level up to about eight meters below the plunger assembly and a deep well pump can raise water from the depth of the cylinder plus up to about eight meters below the cylinder. The same "suction" principle works for both pumps.

D) Present the similarities and differences between the pumps used in the course. Some similarities and differences between the AID shallow well and deep well pumps are presented below.

Similarities	Differences
upper structures (above ground) the same, so lubrication is done in same way	deep well cylinder below water and, therefore, does not need to be primed
both have same cups, valves, piston	deep well pump more difficult to install and below ground components weigh more
both need to have same connections tightened before installation	deep well pump has plunger rod in drop pipe

E) At the end of the lecturette/demonstration, pass out the appropriate section of Handout 2-2: Operation of Pumps. Tell participants they will now have the first of many opportunities to practice their problem-solving skills. Developing good problem solving skills will be a theme throughout the workshop. The problem they will be asked to solve now is to take apart and reassemble the major components of the pumps used in the workshop.

6. Practice: Becoming Familiar with the Pump   Time: 20 min. per pump type

A) Set up this activity by putting out one pump of each type for every three participants. Loosen the connections on the pumps so the participants will be able to disassemble them without tools (see Trainer Note).

B) Have the participants break into groups of three, one group for each pump (or set of different pump types).

C) Give the participants the following instructions:

- In your groups, disassemble the pumps so that you can see the main assemblies of the pump (piston, foot valve, etc.) Do not disassemble the main assemblies.
- Let those who have the least pump and/or mechanical experience be responsible for disassembly and reassembly.
- Help each other learn.
- Give everyone a chance to observe the various parts of the pumps.
- Familiarize yourself with every pump used in this workshop.
- Reassemble the pumps when you are done looking at them.

D) During the practice the trainer should move between the groups. The role of the trainer is to:

- act as a resource person if there are problems or questions that arise during disassembly or reassembly

- observe the work being done closely to spot problem areas or lack of understanding

- pose questions to participants instead of solving their problems for them. Ask questions such as "If the piston valve is closed during this stroke, what position would the foot valve have to be in for water to be pumped?" or "What would happen if this part were missing (or broken)?"

7. Discussing the Practice Activity Time: 15 min.

Ask participants if there are any questions regarding the operation of the pumps.

8. Closure Time: 5 min.

Review the session objectives to see that they were met.

MATERIALS

1. Handout 2-1: Construction Line Chart

2. Handout 2-2: Deep Well: Operation of Deep Well Pumps

3. Handout 2-2: Shallow Well: Operation of Shallow Well Pumps

4. One complete and assembled pump of each type used in workshop for every three participants

5. Flipchart paper

6. Marker pens

7. Tape

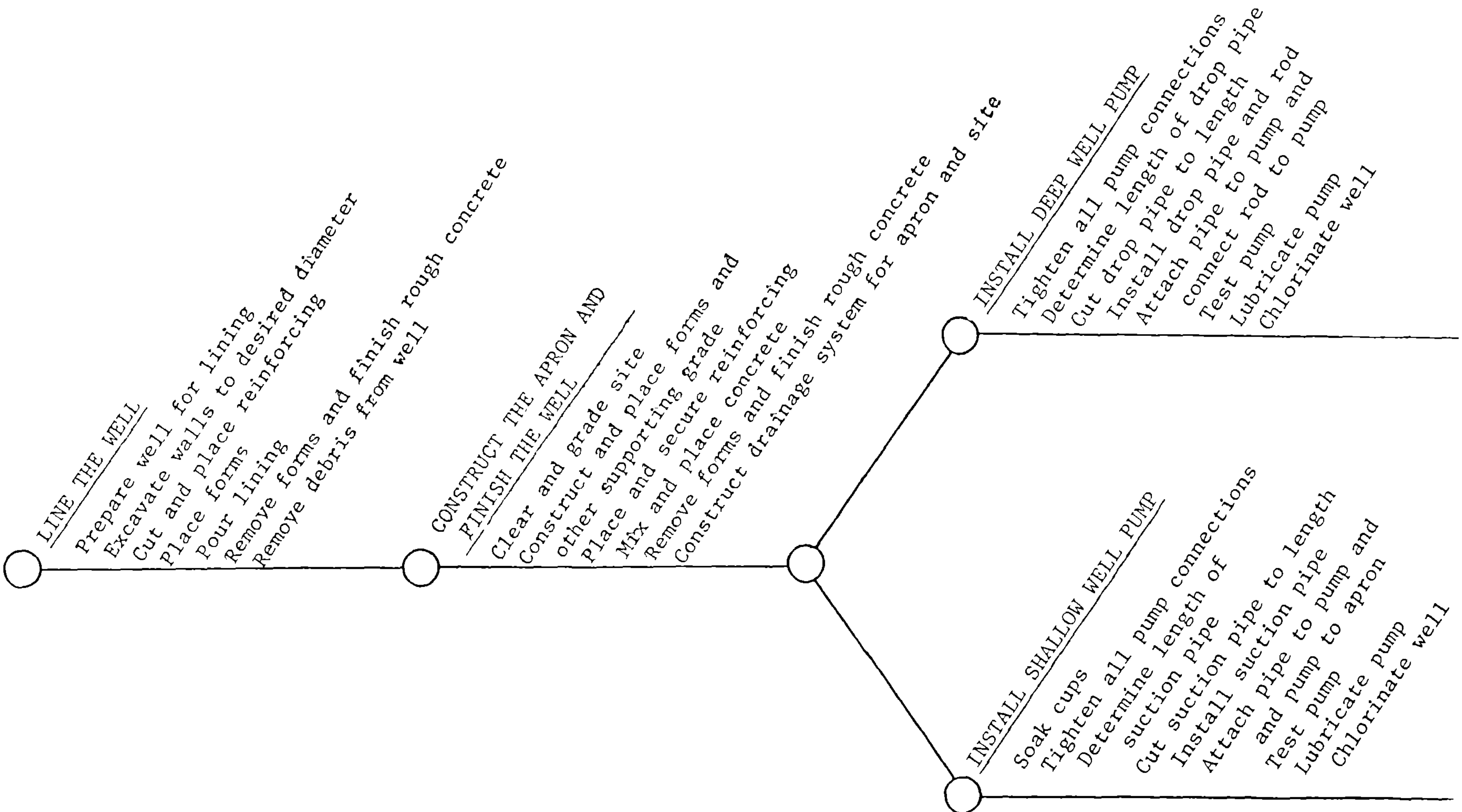
8. Prepared flipcharts for:
   - session objectives
   - construction line chart
   - operation of pumps

TRAINER NOTE

This activity focuses on familiarizing the participants with the parts of the pump and their functions. How to repair or reassemble the pump is covered in Session 12: "Maintaining and Repairing the Pump." Do not spend time on pump repair at this time.

Handout 2-1

CONSTRUCTION LINE CHART



Operation of Deep Well Pumps

The cylinders of deep well pumps are usually located below the water level to prevent loss of priming. Water is lifted to the surface by the reciprocating action of the plunger assembly. The operation of a deep well pump is as follows:

1. On the first upstroke, the water in the cylinder is raised and more water enters the cylinder through the foot valve as in Figure 1A below. Note that the cylinder is submerged.

2. Upon completion of the upstroke, the foot valve closes by gravity, trapping the water that has just entered the cylinder, as shown in B.

3. On the downstroke, the plunger valve opens, allowing water to pass as shown at C.

4. When the plunger assembly reaches the bottom of the cylinder and stops, the plunger valve closes, trapping the water above the plunger assembly as shown at D.

5. On the next upstroke, more water is lifted up the drop pipe and more is introduced into the cylinder. On each stroke the process is repeated until water comes out of the pump spout. Note: If the foot valve is holding water well, the drop pipe should usually remain full of water. Water should then be delivered within a few strokes if not on the first.

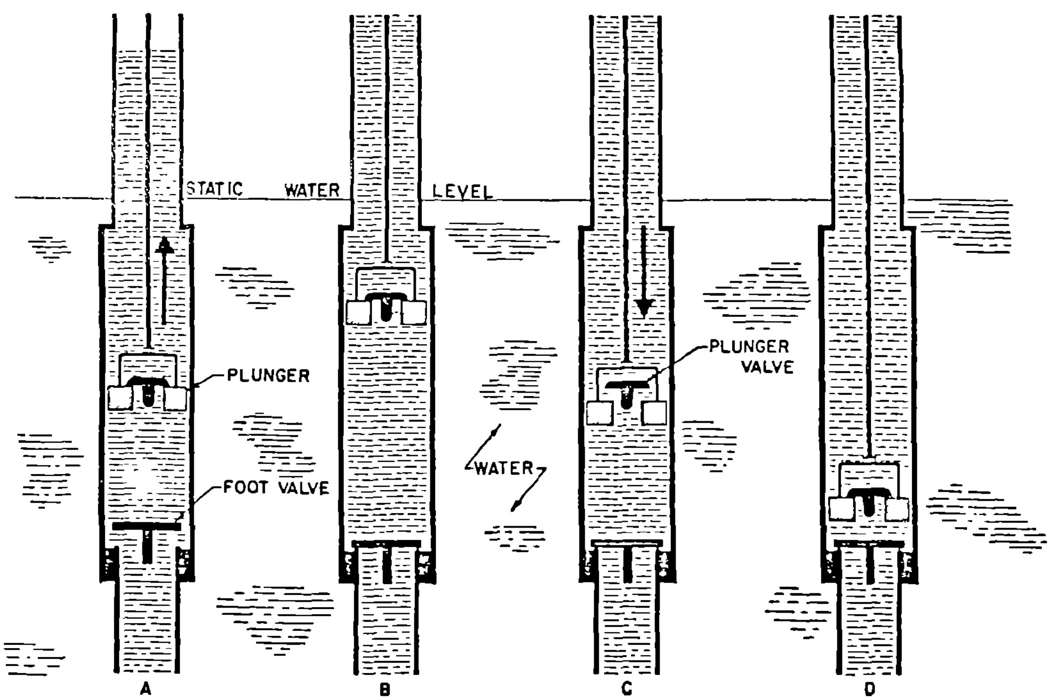


Figure 1. Deep Well Pump Operation.

Adapted from Pashkevich and Gass

Sometimes it may be necessary to attach a length of suction pipe to the bottom of deep well pump cylinders. Some examples (Figure 2) would be in the case of a lowered water table since the time of original installation due to overpumping of the source (irrigation, industry, etc.), drought or geological disturbances and the use of undersized casing when drilling through difficult subsurface strata (small boulders, etc.). However, the water table during pumping cannot be more than about 8 meters below the cylinder for water to be pumped with this arrangement.

The deep well pump is shown in Figure 3.

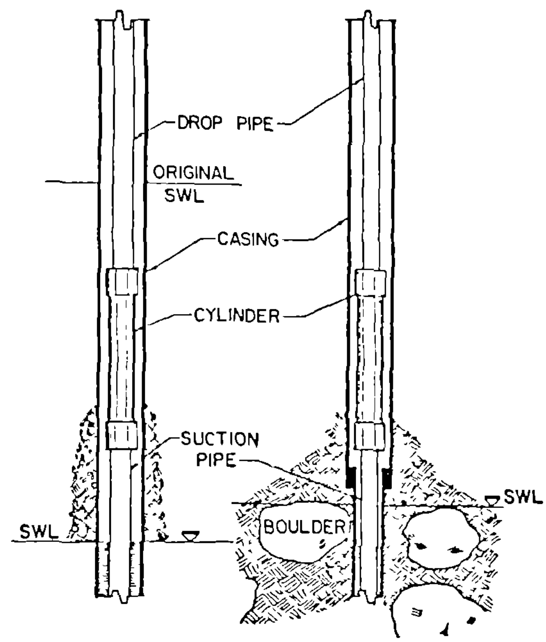


Figure 2. Optional Installation for Pump Cylinder.

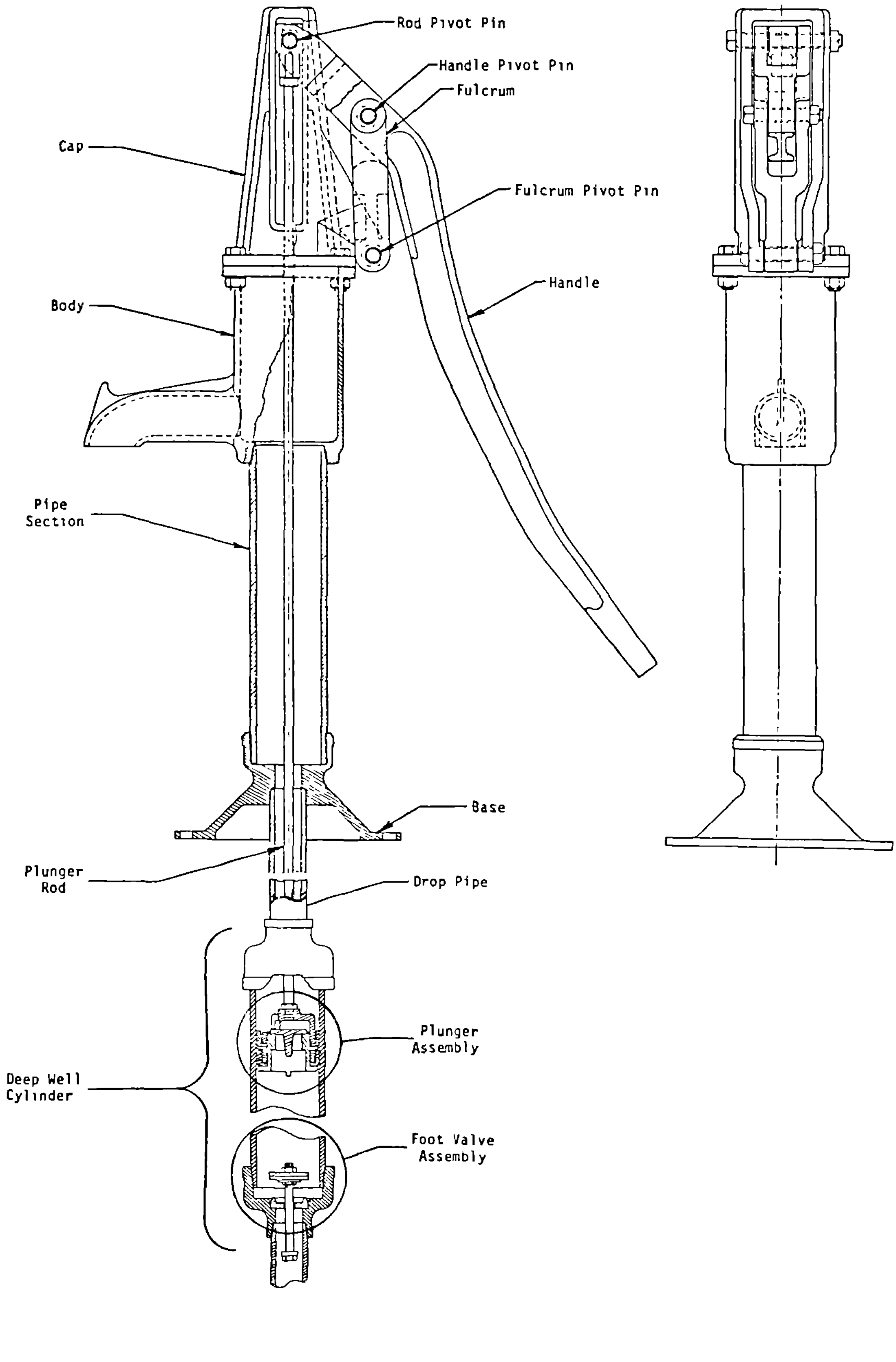


Figure 3. Deep Well Pump.

Operation of Shallow Well Pumps

Figure 1 shows the components of a shallow-set pump. The body of the pump contains a valved plunger assembly which moves up and down during operation. The principle of its operation may be followed by examination of Figure 2.

Its operation is as follows:

1. With the pump primed, as shown at A, the plunger is raised. As air cannot pass the plunger owing to the water seal, a partial vacuum is created in the cylinder thereby reducing the air pressure on the surface of the water in the suction pipe. The atmospheric pressure on the water in the well is now greater than the air pressure on the water in the pipe, thereby forcing the air and water in the pipe upward. The space in the cylinder below the plunger fills with air from the pipe.

2. At the top of the cylinder the plunger stops, and the foot valve closes by its own weight, thus trapping air in the cylinder.

3. On the next downstroke the entrapped air is compressed between the plunger and the bottom of the cylinder. When the pressure becomes greater than the atmospheric pressure above the plunger plus the weight of the valve and of the priming water, the air will lift the plunger valve and escape through the priming water as shown at B.

4. On the next upstroke more air will be drawn out of the pipe and the water will rise higher, eventually flowing into the cylinder under the plunger as shown at C.

5. With the cylinder and pipe full of water as at C, the foot valve closes by gravity, trapping water in the cylinder.

6. On the next downstroke the plunger and valve pass through the water as shown at D.

7. When the plunger reaches the bottom of the cylinder and stops, the plunger valve closes, thus trapping the water above the plunger as shown at E.

8. On the next upstroke the water above the plunger is lifted out of the pump as shown at F. At the same time more water is forced into the cylinder through the foot valve.

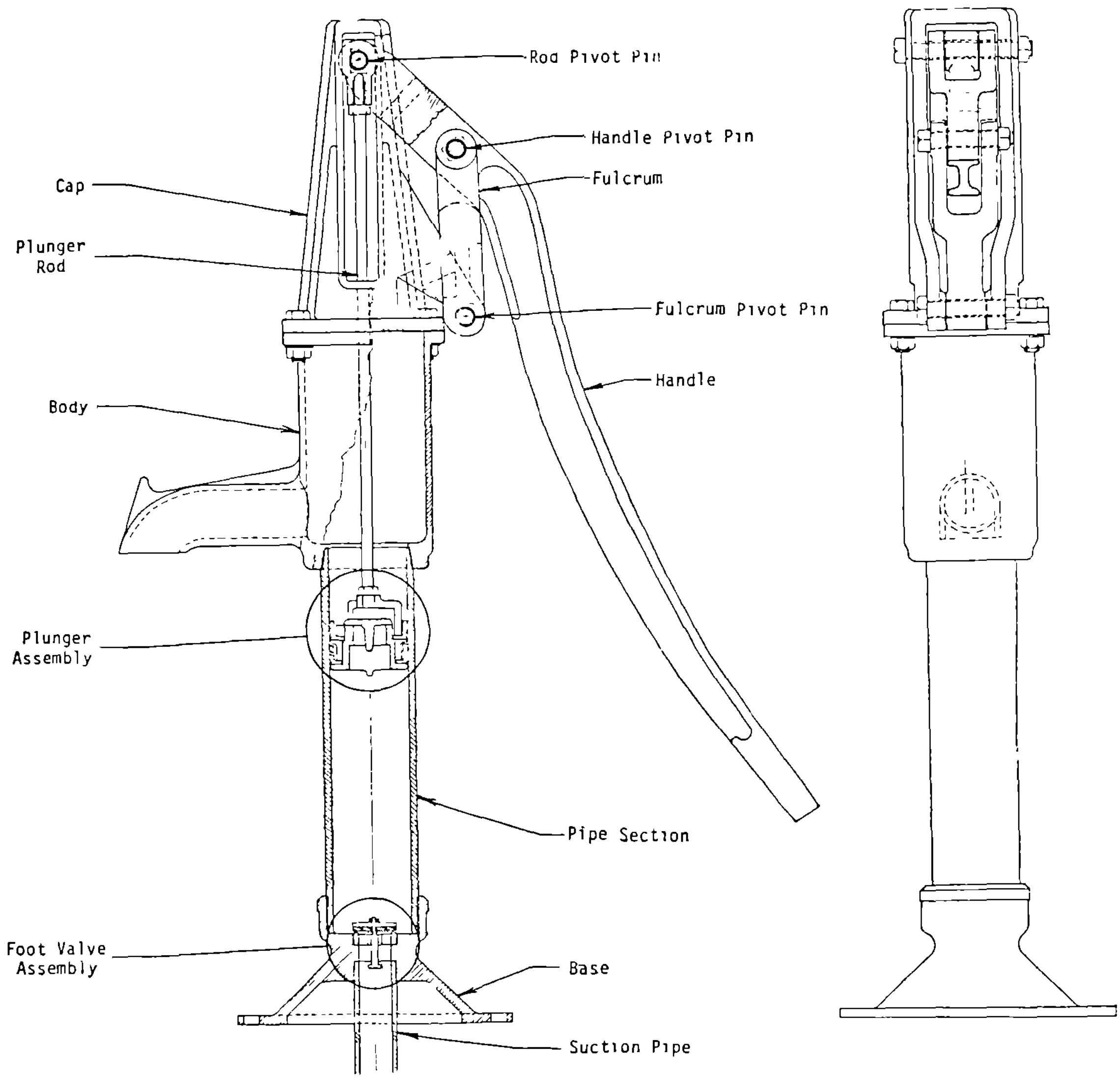


Figure 1 . Shallow Well Pump

9. On each successive downstroke step D is repeated, and on each successive upstroke step F is repeated. Thus the pump delivers water on each upstroke.

Shallow set pumps do not "pull" or "draw" water from the source. Rather the pump reduces the atmospheric pressure on the water in the suction pipe. The atmospheric pressure on the water outside of the suction pipe pushes the water up and into the pump. Because of vacuum leaks around the plunger cups and through the plunger valve, the use of shallow-well pumps is limited to conditions where the water table during pumping is within 8 meters of the cylinder even though "standard atmospheric pressure" is about 10.3 meters (34 feet).

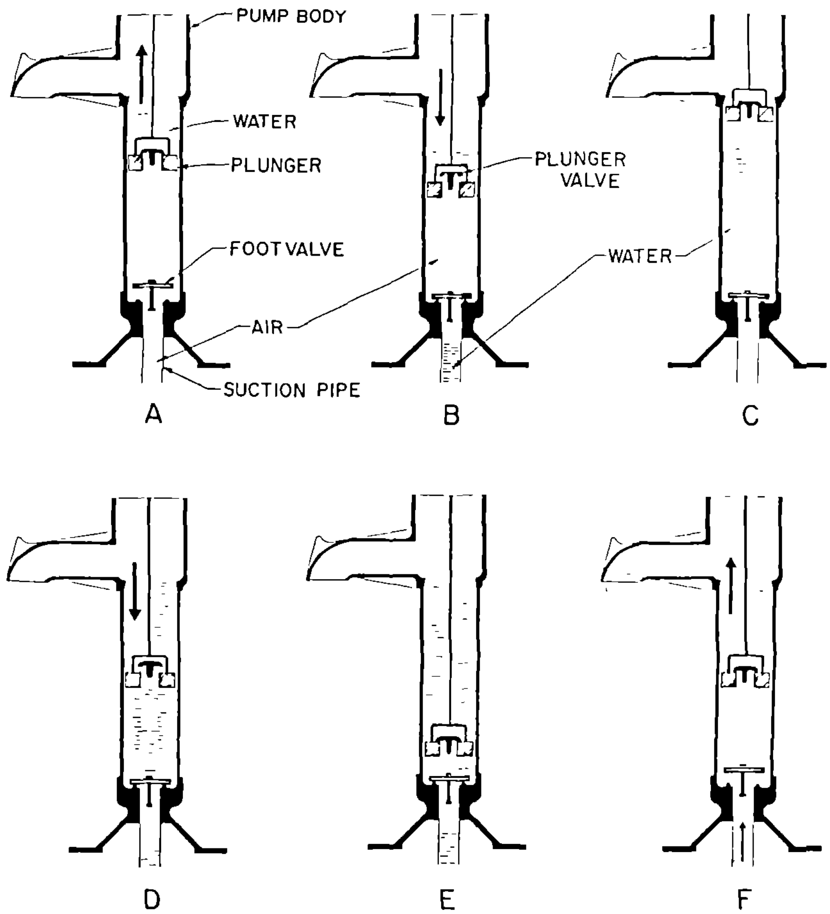


Figure 2 . Shallow Well Pump Operation

SESSION 3

SYNOPSIS OF SESSION 3: Implementing Water Supply Programs with Handpumps: An Overview

Total Time: 3 Hours
10 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Lecturette: Handpump Technology and the Development of Water Resources	Lecturette	15 Min.		
Discussion: Benefits of Handpump Projects	Discussion	45 Min.		Questions to Stimulate Discussion
Full Group Task: Water Diseases	Individuals read handout on water-related diseases	45 Min.	Handout 3-1: Water for the World: Means of Disease Transmission	Instructions for Small Group Task
Discussion: How a Handpump can Interrupt Disease Transmission	Discussion	15 Min.		
Lecturette: The Project Cycle	Lecturette	20 Min.	Handout 3-2: The Project Cycle	Project Cycle
Discussion: The Project Cycle	Discussion	20 Min.		
Generalization/ Application	Pairs share insight from session	20 Min.		
Closure	Trainer Presentation	5 Min.		

Session 3: Implementing Water Supply Programs with Handpumps: An Overview

Total Time: 3 hours 10 min.

OBJECTIVES

By the end of the session, participants will be able to:

1. present their views on the benefits of handpump projects

2. discuss causes for the transmission of diseases from water found locally

3. discuss how handpump projects can interrupt the transmission cycle of waterborne, water-washed, water-related and water-contacted diseases

4. describe a successful handpump project

5. identify the five stages of a handpump project cycle and describe activities included in each stage

OVERVIEW

This session expands on the topics introduced in Session 1. Participants discuss the benefits of handpump projects and who sees these as benefits. Health benefits are further explored by the presentation of disease transmission chains and a discussion of how handpump projects can interrupt these chains. Participants next describe what a successful handpump project looks like and identify their roles and the resources available to them. Finally, the project cycle which provides the framework for the training program is introduced.

Community participation is one of the most important factors in determining the success or failure of a handpump program and, therefore, is a theme throughout this workshop. Social and cultural attitudes toward water supply and sanitation technologies will weigh heavily in determining whether the new facilities are used or simply sit idle. To ensure that facilities are used, it is essential that community members be involved in the planning and execution of all projects.

Community participation consists of more than contributions by community members of time, money, and labor in building a facility. Community participation must allow local people to be involved in decision-making to be successful. This kind of involvement will be a valuable asset to the project designers as well as to the community. Local people have much useful information and wisdom to contribute to project development. Community participation also affords an opportunity for community education, which may be essential if villagers are to have the information and understanding they need to make intelligent decisions and to effectively use the facilities when they are completed.

PROCEDURE

1. Introduction — Time: 5 min.

A) Tell participants that now that they have a better idea of what this workshop is about, and how you will work together, you will spend time in this session discussing the benefits of handpump projects, what a successful handpump project is, what the general steps to arrive at this end product--a successful project--are and who plays what role in arriving there.

B) State the objectives of the session and give information from the overview.

2. Lecturette: Handpump Technology and the Development of Water Resources — Time: 15 min.

Make the following key points in your own words. Add any specific information about handpump programs of the country you are now in.

- Water is vital. It is needed for drinking, cooking and washing as well as watering livestock, irrigating fields, and supplying factories. The body's need for water is more urgent than the need for anything except oxygen. A well-nourished person can live up to a month without food, but only a few days without water.

- People become sick or their bodies function less well if water intake is sharply curtailed. Beside being needed for drinking, water is also required for keeping the house and its surroundings clean.

- Today the problems of community water supply have become acute. The news media have stories almost daily about water--insufficiency, pollution, purification problems, and conservation.

- A recent survey by WHO found over one billion people living in rural areas of developing countries without reasonable access to safe and adequate drinking water.

- The relationship of water supply to the transmission and control of disease is well established. In countries surveyed by WHO, waterborne, water-washed, and water-related diseases are generally among the three leading causes of sickness and death, particularly among children.

- A United Nations Water Decade goal is to bring the percentage of the rural population with ready access to safe water up to 36 percent. Even this modest goal requires millions in capital expenditures in areas where per capita incomes are low. Every effort must be made to keep the per capita costs of water supply down if an appreciable proportion of this growing population is ever to have adequate water.

- Knowledgeable observers agree with a recent analysis by the World Bank, "In areas where groundwater is readily available at moderate depth, constructing a number of wells fitted with handpumps can be a cost-effective means of providing a good water supply." Although piped systems providing water to households or public standposts are an ultimate goal, realistically many of the unserved billions will have to use handpumps as an interim if not a final measure.

- Millions of people already depend on handpumps for drinking water. Major handpump programs are under way or planned in many countries including Bangladesh, Burma, India, Indonesia, Pakistan, the Philippines and Thailand; Ghana, Kenya, Malawi, Mali, Tanzania, and Tunisia; Bolivia, Costa Rica, Honduras, Ecuador, and Nicaragua. Bangladesh alone plans to install over 400,000 handpumps during this decade.

3. <u>Discussion: Benefits of Handpump Projects</u> Time: 45 min.

A) Write the following statement on flipchart paper: A successful handpump project is one that ______________________________. Ask the group for ideas on how to complete the sentence and record answers quickly. Get as many responses as possible.

B) Ask the participants "If this is what we mean by 'success', what are some of the possible underlying reasons <u>why</u> a project is successful?" Answers could include:

- extension worker was respected by villagers
- villagers felt it was their project
- villagers contributed money
- pump required very little maintenance
- villagers understood the importance of clean water

C) Ask participants to relate some of their own experiences regarding the benefits of handpump projects.

D) Emphasize that in order to work toward successful handpump projects, it is important to understand the attitudes and perceptions of the major actors involved, including ourselves. Post all or some of the following questions on flipchart paper and tell participants that we will use the questions to help stimulate discussion.

- Why do you think handpump projects, rather than other kinds of water projects, should be promoted in this country/region/area?

- What are village women likely to like and dislike about using a handpump?

- Would a handpump project have appeal for village men?

- Are there any negative consequences of a handpump project? For whom? (See Trainer Note 1.)

- What are the views of ministry officials in respect to handpumps? What benefits do they see from promoting handpump projects?

- Are there significant differences in the views and attitudes of the major actors (village women, village men, ministry officials, you) regarding the desirability and benefits of handpump projects? If so, how could these differences affect your ability to promote handpump projects?

- What could you do?

4. <u>Small Group Task: Water Diseases</u> Time: 45 min.

A) Introduce this activity by stating that one important benefit of handpump projects, brought up in the last discussion, was good health. Some experts have said that up to one half of all childhood deaths in countries of the developing world could be prevented by providing access to clean water.

B) Make the following key points in your own words:

- Water- and sanitation-related diseases are major causes of illness and death among people in both rural and urban areas in many developing countries. The health and well being of people cannot be improved without understanding these diseases and knowing how they are transmitted from one person to another.

- Over the next hour we will review what causes these diseases, how they are spread and the factors influencing their transmission.

C) Ask participants what specific water and sanitation related diseases occur in their areas. List them on flip-chart paper.

D) Pass out <u>Handout 3-1: Water for the World: Means of Disease Transmission</u>. Give participants 15 minutes to read the handout.

E) Ask if there are any questions about the information in the handout. Review the major categories of disease transmission (i.e., waterborne, water-washed, water-contact, water-related/insect vector, and sanitation related) and ask if the categories are clear.

F) Ask the whole group the following questions:

- Should any disease be added to the list of diseases generated by the participants in Step C above?

- Which of the diseases are the most prevalent?

G) Explain to the participants that there will now be a discussion of how handpump projects can affect the prevalence of disease.

5. Discussion: How a Handpump Project Can Interrupt Disease Transmission — Time: 15 min.

Ask participants the following questions:

- Which diseases are most affected by the use of a handpump? Why?

- Which diseases are least affected by the use of a handpump? Why?

- What is needed in addition to the handpump in order to decrease water-related diseases?

- Why is it important that an extension worker understand how water-related diseases are transmitted?

6. Lecturette: The Project Cycle — Time: 20 min.

A) Tell participants that "if we can all agree that 'successful' means the items on their 'success' lists, we now have a better idea of what the end product looks like." Then look at a framework or review a series of steps for arriving there.

B) Post a flipchart with the phases and major activities of the project cycle (see Handout 3-2: The Project Cycle) and use the chart to make the following points:

   - No two development projects are exactly alike. Furthermore, handpump projects vary from country to country and even within a country.

   - On the other hand each project passes through a cycle that, with some variations, is common to most. Each phase leads to the next, and the last phase, evaluation, produces new ideas and project approaches making the cycle self-renewing.

   Project phases include the following:

   - Pre-Planning and Assessment: The activities under this phase have to do with gathering and giving information so that the handpump project will meet the needs of the users. In collaboration with the community, initial discussions are held to establish whether potential users have an interest in undertaking the project, to identify possible resources, to assess the technical feasibility, and to make some preliminary decisions regarding overall project design. This is done by conducting an assessment for project feasibility.

   - Planning and Design: At this phase collaboration continues between the villagers, extension workers, and any others involved so that the best possible plan can be developed to meet the specific requirements and needs of everyone--particularly the villagers. The plan includes developing a cost estimate, a work plan for construction, and an apron design.

- Construction: Here we are talking about all of the activities that must occur from apron construction through pump installation.

- Maintenance and Repair: Once the handpump has been installed, the project is still not complete. This phase has to do with the activities required to keep the project going and to insure that it will be successful. There are activities which have to do with keeping the pump running, activities that monitor how the pump and the water are being used, and how the responsible committee or group in the village solves problems that arise.

- Evaluation: The activities under this phase of the project cycle all have to do with learning from experience and avoiding past mistakes. The lessons of experience must be built into the planning and design of future projects.

C) Pass out Handout 3-2: The Project Cycle and give participants a few minutes to read it. Answer questions.

7. Discussion: The Project Cycle — Time: 20 min.

A) Initiate group discussion by saying:

"Let's go back to the first phase of the project cycle (Pre-Planning and Assessment). Part of this phase involves gathering information about who is doing what in handpump programming in your country and assessing the available resources. In order to make sure we are coordinating efforts as well as possible, from the very beginning, it is important for the left hand to know what the right hand is doing. In countries where several different ministries and donor organizations are involved, this is sometimes difficult."

B) Ask participants the following questions:

- What do you see as your role in planning and implementing handpump projects?

- Given your role, what resources are available to you? (List on flip-chart paper. See Trainer Note 2.)

C) Ask participants to identify information that still needs to be gathered or clarified about who is doing what and make a list of these items. Also identify with the participants how the information can best be gathered.

D) End the discussion by stating that "We will be continuing to talk about phase one (Pre-Planning and Assessment) in following sessions. Tomorrow, however, we will skip over the first two phases and start work on construction." Remind participants that "as explained in the previous session, we will begin on construction in order to provide enough time for the cement used in apron construction to cure. This requires our doing some of the activities in the project cycle out of the normal sequence."

8. Generalization/Application Time: 20 min.

Ask participants to think about insights they gained from this session. Then ask them to pair up with another individual to share their thoughts.

9. Closure Time: 5 min.

Refer back to the objectives of the session and ask participants if they were met.

Remind participants that the next sessions will be held at the well sites and are the first of the actual "hands on" practical sessions. Answer any questions about workshop arrangements or other immediate concerns participants may have.

MATERIALS

1. Handout 3-1: Water for the World: Means of Disease Transmission

2. Handout 3-2: The Project Cycle

3. Flipchart paper

4. Marker pens

5. Tape

6. Note books

7. Prepared flipcharts for:
   - session objectives (step 1)
   - questions to stimulate discussion (step 3)
   - instructions for small group task (step 4)
   - the project cycle (step 7)

TRAINER NOTES

1. If participants have no thoughts about training objectives, make the following points:

   - The need to ensure equity within the community in the costs and benefits of the project should be in the forefront of attention at the planning and design stage.

   - Some ways in which a handpump project would possibly lead to a worsening of the relative position of the poor include:

     - voluntary work demanded at peak times in the agricultural work cycle may lead to substantial loss of production

- equal contributions exacted from all inhabitants for the construction and operating costs of the project may mean a charge which poor families cannot afford

- access to the new water supply might be restricted or monopolised

2. Save these lists for use in Session 16: "Linking up to Regional and National Efforts."

Water for the World

Means of Disease Transmission
Technical Note No. DIS. 1.M.1

Water- and sanitation- related diseases are major causes of illness and death among people in both rural and urban areas in many developing countries. The health and well being of people cannot be improved without understanding these diseases and knowing how they are transmitted from one person to another.

This technical note describes what causes these diseases, how they are spread and the factors influencing their transmission. Methods for preventing the transmission of the water- and sanitation- related diseases can be found in the technical note, "Methods of Improving Environmental Health Conditions," DIS.1.M.2.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

BACTERIA - One-celled microorganisms which multiply by simple division and which can only be seen with a microscope.

FECES - The waste from the body moved out through the bowels.

LARVAE - Young forms that come from the eggs of insects and worm parasites.

PARASITES - Worms, insects or mites which live in or on animals or people.

There are about 30 diseases that are related to water and sanitation. Table 1 lists the 21 which are most important. Each of them affects from millions to hundreds of millions of people every year. All of these diseases are caused by living organisms that must spend much of their life in or on a human body. They include viruses so tiny that they can pass through the finest filter, bacteria and protozoa that can be seen only with the aid of a microscope, tiny mites that are barely visible to the eye and worms that may be a meter long.

The transmission of all of these diseases is related in some way to water supply and sanitation, usually to inadequate disposal of human wastes and to contaminated water supplies. The diseases are transmitted through contact with or consumption of water, contact with infected soil, the bites of insects that breed in or near water and poor personal and family hygiene. Man is usually the source of the organisms that cause these diseases and human activity is an important factor in the transmission of them.

Following the order shown in Table 1, the transmission of the diseases will be discussed for each of the five categories.

Waterborne Diseases (Water Quality Related)

In the waterborne diseases, the microorganisms which cause the disease are swallowed with contaminated water. All but one, Guinea worm, are caused by organisms found in human excreta, the source of the contamination. The infective stage of Guinea worm is not from fecal contamination, but is from a tiny larva that develops in a water-flea after the larva is discharged into the water. The larva comes from a blister on the skin of a person infected with the meter-long adult worm.

Cholera and typhoid fever are the waterborne diseases which are most feared because, when untreated, they have high death rates. However, the diarrheas and dysenteries are more important because of the infant deaths and huge numbers of illnesses they cause. In the developing countries,

Table 1. Water and Sanitation-Related Diseases

Category	Disease: Common name	Disease: Medical name	Type of Organism	Transmission
Waterborne (Water quality related)	Cholera Typhoid fever Paratyphoid fever Bacillary dysentery Amebic dysentery Diarrhea Diarrhea Jaundice Guinea worm	Cholera Typhoid Paratyphoid Shigellosis Amebiasis Salmonellosis Giardiasis Hepatitis Dracunculiasis	Vibrio Bacteria Bacteria Bacteria Protozoan Bacteria Protozoan Virus Worm	By consuming (drinking) fecally contaminated raw water containing an infective dose of the vibrio, bacterium, protozoan or virus; except Guinea worm where transmission is by swallowing water flea infected with worm larva that was shed from skin blister on infected human.
Water-washed (Water quantity; and accessibility related)	Bacillary dysentery Diarrhea Viral diarrhea Trachoma Pink eye Itch	Shigellosis Salmonellosis Enteroviruses Trachoma Conjunctivitis Scabies	Bacteria Bacteria Virus Intracelluar bacteria Bacteria Mite	Anal-oral or skin-to-skin direct contact transmission resulting from poor personal cleanliness and hygiene caused from lack of water for sufficient washing, bathing and cleaning.
Water-contact (Body-of-water related)	Blood fluke disease	Schistosomiasis	Worm	Eggs in feces or urine hatch larvae in water, penetrate suitable snail, multiply greatly in snail, free-swimming larvae leave snail, penetrate skin when person has contact with infected water.
Water-related insect vectors (carriers) (Water-site related)	Yellow fever Malaria Filarial fever Sleeping sickness River blindness	Yellow fever Malaria Filiariasis Trypanosomiasis Onchocerciasis	Virus Protozoa Worm Protozoa Worm	Mosquitoes, tsetse flies and blackflies, which breed in or near water, pick up disease organisms when they bite infected person; organisms grow in vectors and are inoculated into another person when insect bites.
Sanitation-related (Fecal polluted soil related)	Hookworm Roundworm	Ancylostomiasis Ascariasis	Worm Worm	Eggs or larvae become infective when feces are deposited on soil; eggs are eaten from contaminated hands or vegetables, or larvae penetrate skin that comes in contact with infected soil.

the diarrheas and dysenteries cause hundreds of millions of illnesses and millions of infant deaths each year.

The basic transmission of waterborne disease is person to person. The microorganisms for infected people contaminate water which is consumed by other people. Figure 1 shows a common way that water becomes contaminated. The contamination of water supplies occurs:

1. Where latrines and privies are located uphill from or very close to a water source such as a spring, stream, pond or well. Liquids carrying the organisms seep from the latrines into the water supply.

2. Where privy pits, soakage pits, or sewage absorption systems penetrate the water table of an aquifer located near the surface and shallow wells and springs whose water comes from the aquifer are contaminated.

3. Where wells and springs are unprotected so that surface run-off enters these water sources. The run-off after rainfall carries disease-causing organisms into the water source.

4. Where sanitation is poor. If people defecate on the ground or in bodies of water rather than in safe latrines or privies, disease-causing organisms can get into water supplies.

5. Where Guinea worm occurs, water is contaminated when the skin of an infected person with a blister caused by the worm is immersed in water and great numbers of larvae are released into the water. Some of the larvae are eaten by tiny water fleas (Cyclops). The larvae in the water fleas grow, shed their skins, and become infective. When a water flea containing an infective larva is drunk with water from the contaminated source, the little worm is transmitted to a new person where it grows to maturity under the skin.

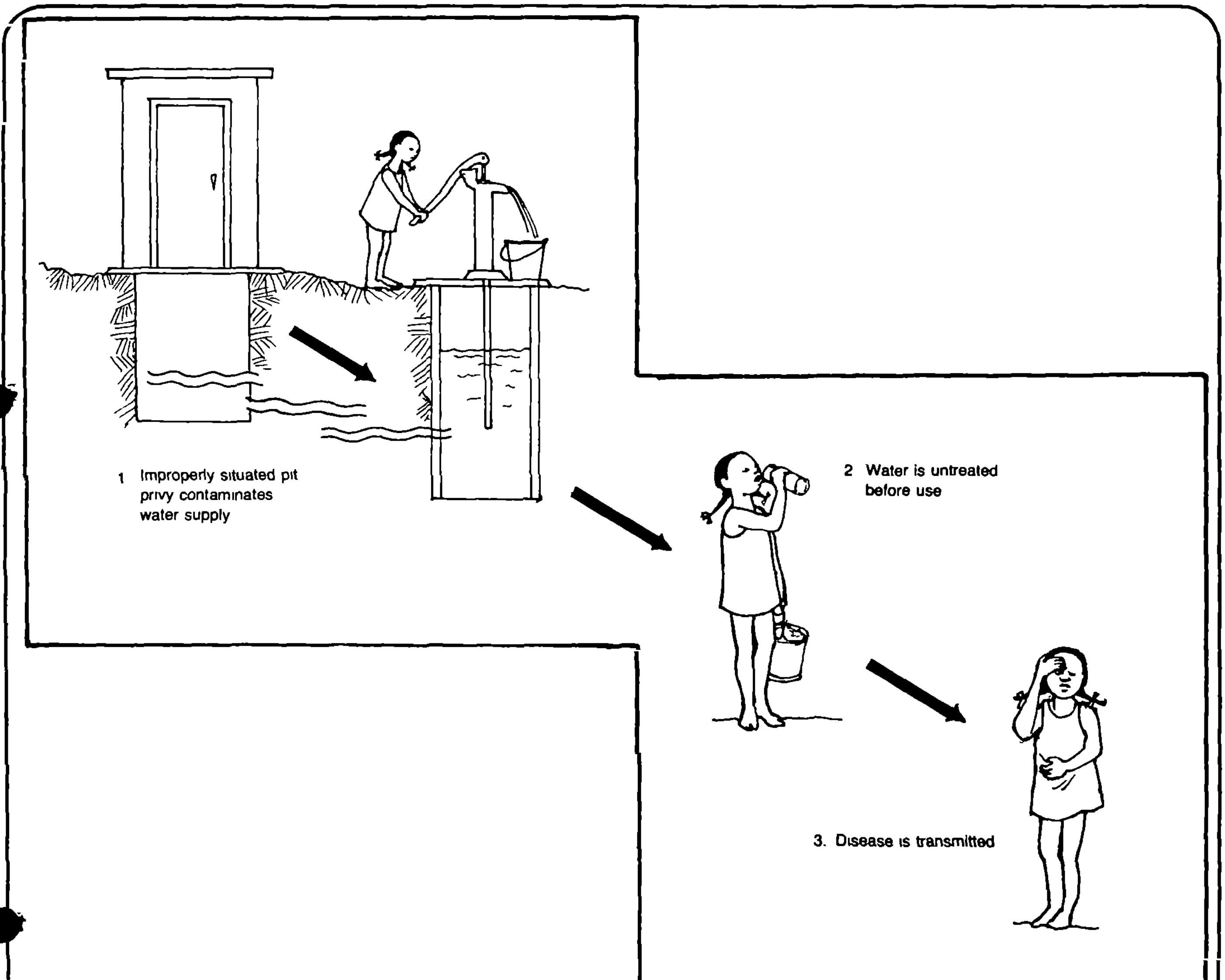


Figure 1. Transmission of Waterborne Disease

Water-Washed Diseases (Water Quantity and Accessibility Related)

Water-washed diseases are diseases whose transmission results from a lack of sufficient clean water for frequent bathing, hand washing before meals and after going to the toilet, and for washing clothes and household utensils. Several common diseases fall into this category. Shilgellosis (bacillary dysentery), salmonellosis (food poisoning), trachoma, and scabies are all diseases that can be passed by direct contact between people or by the direct contamination of food by dirty hands or flies. Figure 2 shows one way water-washed diseases are spread. The diseases in this group are transmitted:

Figure 2. Transmission of Water-Washed Diseases

1. When a water supply produces insufficient quantities to meet peoples' needs or when the water supply is located at a distance from the users. The availability of only small amounts of water makes the practice of good personal and household hygiene difficult, or even impossible.

2. When feces are not disposed of in a sanitary way. Uncovered or unprotected latrines or stools passed on the ground are breeding places for flies and sources of bacteria. Bacteria and viruses are passed from feces to people by flies, contaminated fingers and food. Food contamination with salmonella quickly grows great numbers of the bacteria. When eaten, the food causes food-poisoning diarrhea with life-threatening consequences, especially for small children.

3. When people are ignorant of the need for personal hygiene and, for whatever set of reasons, either do not bathe frequently or use the same water and towels to wash more than one person, then trachoma and conjunctivitis are passed around within a family or other groups living together and scabies get passed from the skin of one person to the skin of another.

Water-Contact Diseases (Body-of-Water Related)

Water-contact diseases are diseases which are transmitted when people have contact with infected water. The single most important water-contact disease is Schistosomiasis (blood fluke disease). It is very widespread in Asia, Africa and South America with hundreds of millions of people at risk of getting the disease and millions suffering from it. Figure 3 shows how schistosomiasis is transmitted. Briefly, transmission is as follows: Schistosome eggs passed in urine or feces fall into water where a first stage larva hatches. The first stage larva, to survive, must find and penetrate a specific type of snail. In the snail, the first stage larva changes into a large number of sacs in which many thousands of forked-tailed second stage larva are produced over a period of months to years. Each day, several hundreds of these second stage larvae escape from the snail to swim about in the water seeking the warm skin of a human hand or food into which to penetrate. Once through the skin, the little worm enters the person's blood stream, grows to maturity (worms are about a centimeter long), works its way into the blood vessels of the intestine and urinary bladder, and lays its eggs in the wall of those organs. The eggs then cut their way through the tissues to the inside of the intestine or bladder and are passed with the feces or urine. So the transmission cycle continues.

Schistosomiasis is transmitted in areas:

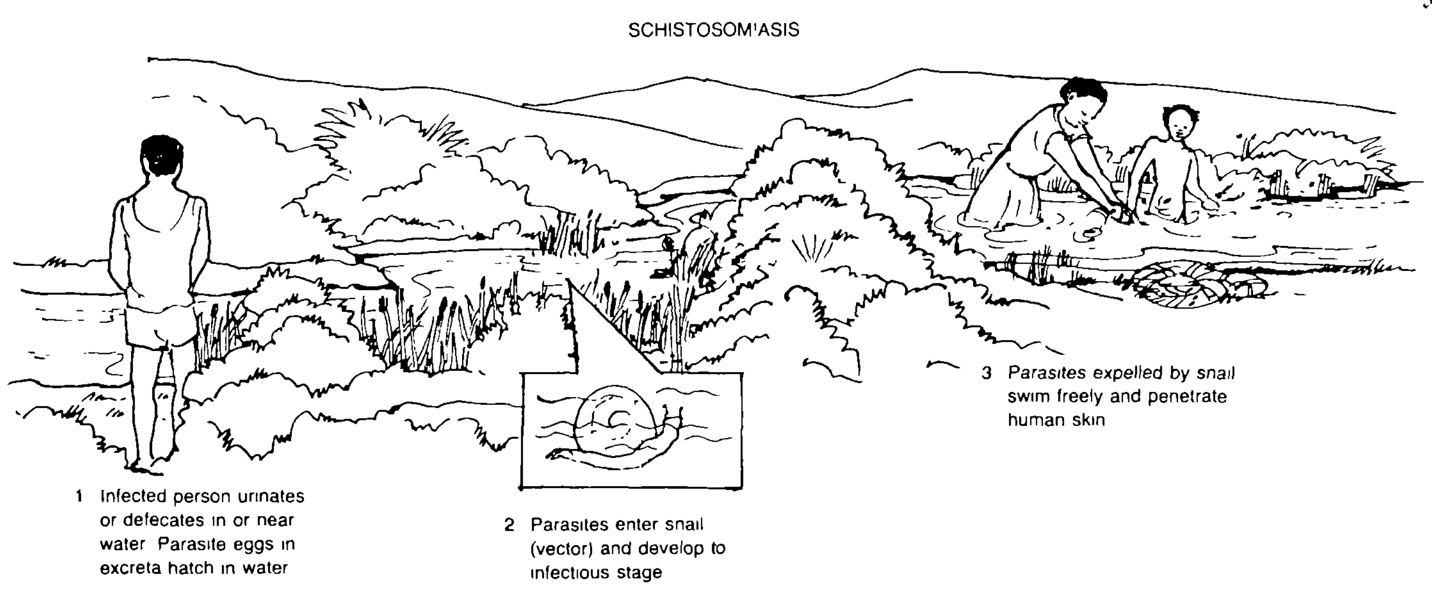


Figure 3 Transmission of Water-Bused/Water-Contact Diseases

1. Where poor sanitation is practiced so that feces or urine find their way into bodies of water that contain snails, or where rats or wild animals get the worms and keep the snails infected.

2. Where the appropriate type of snail is abundant and can become infected.

3. Where people enter infected water to bathe, wash clothes, dip up water, cultivate crops or swim.

4. Where irrigation projects or man-made lakes have extended the bodies of water in which snails can grow and have the chance to be infected from man or wild animals.

Water-Related/Insect Vector (Carrier) Diseases (Water Site Related)

Water-related insect vector diseases are those that are transmitted by insects which breed in or near water. Transmission occurs when the insect becomes infected with the disease organism from biting a person or animal, and then bites another person. The parasites are injected into the skin or bloodstream by the insect bite. The insects breed in water that is used as water supplies (streams and rivers) and, in the case of mosquitoes, in water storage jars, and water tanks, or in shaded high humidity areas near streams or lakes.

The most common diseases in this category are:

• African trypanosomiasis (sleeping sickness) which is transmitted by the tsetse fly which thrives on high humidity and breeds in river areas under lush vegetation growing at water sites.

• Onchocerciasis (river blindness) which is transmitted by blackflies which breed while attached to rocks and vegetation in fast-flowing rivers and streams. Figure 4 shows how onchocerciasis is transmitted.

• Malaria which is transmitted by female anopheline mosquitoes which breed in a wide variety of water collections.

• Arboviruses (yellow fever) which is also transmitted by mosquitoes. The type of mosquitoes that carries this disease is different from that which carries malaria. Mosquitoes that carry yellow fever breed in highly polluted stagnant water and usually rest in areas far from their breeding places.

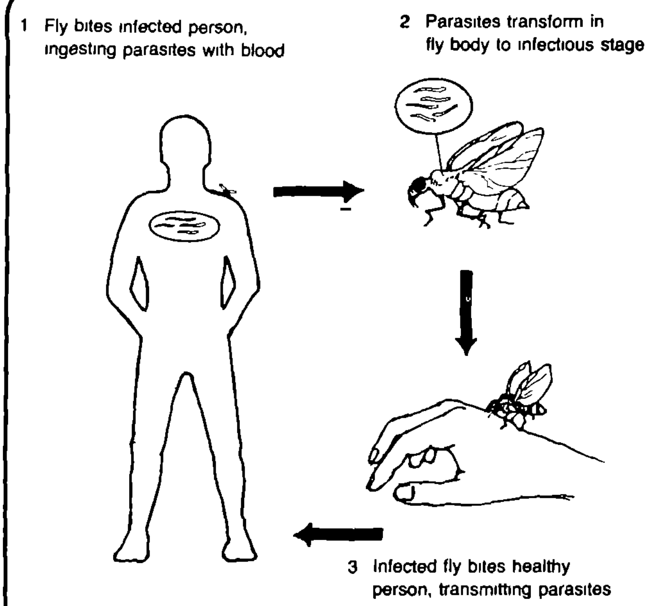


Figure 4. Transmission of Water-Related (Insect Carried) Diseases

• Filariasis which is a worm infection spread by mosquitoes. The mosquitoes that carry the parasite breed in any stagnant pond or pool or in water in cans, coconut husks, dishes, gutters or wherever water is standing.

The transmission of water-related insect vector diseases occurs in many types of situations in which the insect vectors are able to breed in large numbers, can bite persons infected with the protozoan or worm that causes the disease, and later, after the parasites have developed in them, have the opportunity to bite other people. In many situations, the water supply site where people come to get their water, is the place where the insects get their opportunity to bite both infected and other people. The household environment is also a place where some of these diseases are transmitted.

Sanitation-Related Diseases (Fecal Polluted Soil Related)

Sanitation-related diseases are specifically those that are transmitted by people lacking both sanitary facilities for waste disposal and knowledge of the need to dispose of wastes in a sanitary manner. The infective stage of the worm which causes those diseases develops in fecally contaminated soil. The most common diseases in this category are hookworm and roundworm.

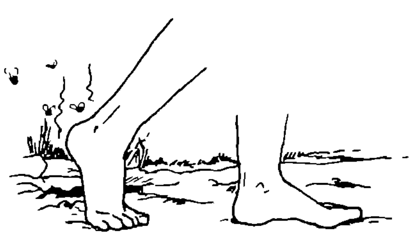
Hookworm larvae develop and live in damp soil that has been contaminated with feces containing hookworm eggs. They penetrate the bare feet of people walking or standing on the infected soil. See Figure 5. Entrance can also occur through the hands or other skin areas.

Roundworm or ascariasis is transmitted by swallowing eggs which have become infective by developing on polluted soil. The eggs are eaten by children who play on the infected soil, drop food on the soil and then eat it, or eat from dirty hands or eat contaminated raw vegetables.

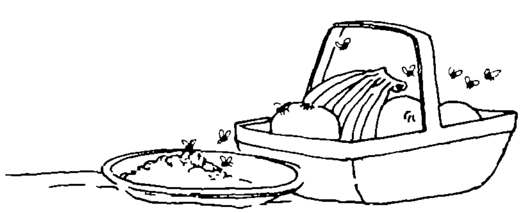
Both diseases occur:

1. Where there are not latrines and the soil is polluted, where latrines are not sanitary or where they are not used.

2. Where fresh untreated feces are used as fertilizer.



a Hookworm is transmitted through the feet of people walking barefoot in contaminated soil



b Roundworm is often transmitted by contaminated flies which land on food

Figure 5. Transmission of Sanitation-Related Diseases

3. Where people are not educated to wash their hands before eating.

Summary

This technical note has discussed several diseases which are common in many countries. They are all directly related to local environmental conditions and are all passed from person to person. The cycle, or chain of transmission, involves both direct transmission of the disease or else depends on an agent, or vector, for the transmission.

Once the chain of transmission is understood, means to break the chain should be adopted. Generally, relatively simple environmental measures need to be developed to stop the spread. The methods of doing this are discussed in "Methods of Improving Environmental Health Conditions," DIS.1.M.2.

Notes

Technical Notes are part of a set of 'Water for the World' materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled ' Using 'Water for the World' Technical Notes Other parts of the 'Water for the World' series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D C , 20523, U S A

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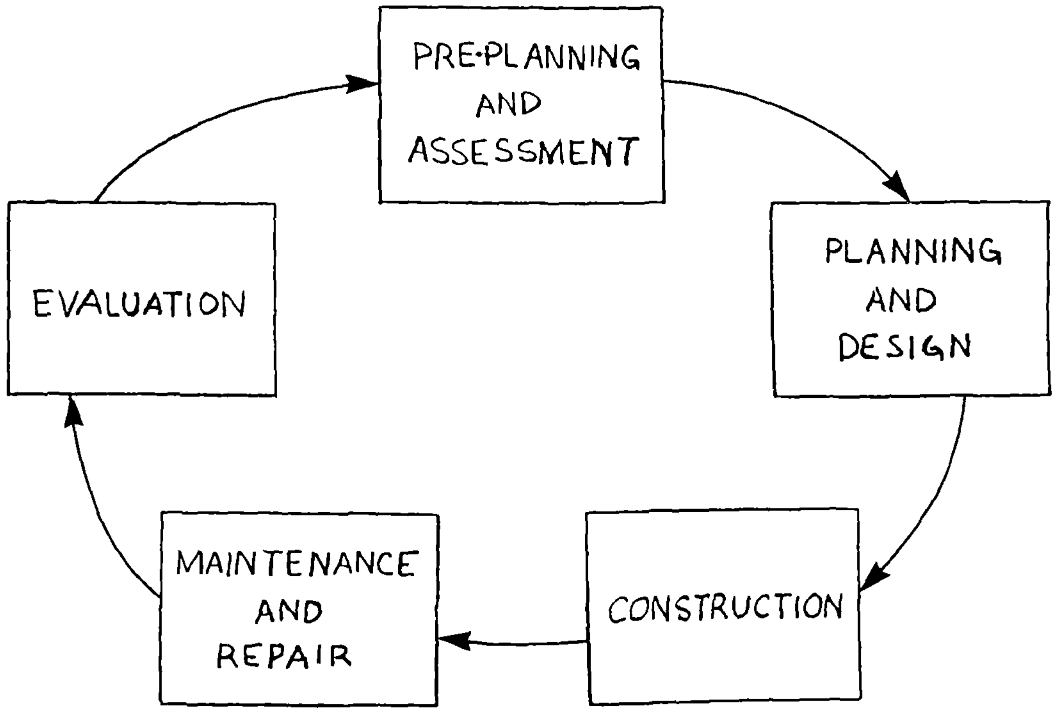
THE PROJECT CYCLE



PRE-PLANNING AND ASSESSMENT

- Meet with and explain handpump project to village leadership.
- Identify with community basic resources needed for a handpump project.
- Conduct with community initial village assessment for project feasibility, determine well recharge rate.
- Obtain commitment to handpump project from village.
- Make commitment to village regarding support.

PLANNING AND DESIGN

- Meet with local users to find out their concerns and desires regarding a hand-pump project.
- Rough design apron slab.
- Find material quantities and develop cost estimate for proposed wells.
- Present cost estimate for each well to village leadership, facilitate decision to proceed.
- Finalize apron design.
- Develop with community work plan for construction including materials, tools, labor and what to do with well users during construction.
- Facilitate procurement of materials, tools and labor (make sure everyone does their job to get ready for construction)

CONSTRUCTION

- Organize work force, assign responsibilities, explain construction tasks
- Reline the well.
- Construct the apron, allow three days for curing
- Finish the well site.
- Install pump
- Disinfect well.

MAINTENANCE AND REPAIR

- Select caretakers with community.
- Train caretakers in maintenance, repair and disinfection.
- Design/implement with community necessary maintenance schedule.
- Train users in proper handling and storage of water, other user education.
- Be prepared to solve any operational problems that arise or make repairs.

EVALUATION

- Reflect on project with community, noting what changes should be made before beginning next hand-pump project.
- Determine ways to integrate hand-pump projects into other community health and sanitation programs
- Identify future work for improving village water resources.

SESSION 4

SYNOPSIS OF SESSION 4: Determining Well Recharge Rate

Total Time: 3 Hours 25 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	10 Min.		Session Objectives
Demonstration: Well Recharge	Demonstration of sufficient and insufficient recharge rate	15 Min.	Three three-gallon buckets or bowls Two small cups	Sketch in Handout 4-1
Lecturette: Ground Water and Wells	Lecturette	30 Min.	Handout 4-1: How Recharge Demonstration Corresponds to Well Handout 4-2: Selecting a Well Site List of governmental and private hydrogeology consulting organizations	
Lecturette: Determining Well Recharge Rate	Lecturette	15 Min.		Tasks involved for determining well recharge rate
Large Group Task: Finding Recharge Rate	Explanation of procedures to determine recharge rate	15 Min.	Handout 4-3: Well Recharge Rate Handout 4-4: Suitability of Well Recharge Rates for Various Numbers of Users	Replica of Handout 4-3
Problem Session: Finding the Recharge Rate	Individuals solve sample problems	25 Min.	Handout 4-5: Problems of Determining Well Recharge Rate	
Discussing the Problem Session	Small groups discuss answers	15 Min.	Handout 4-6: Answers to the Problems of Determining Well Recharge Rate	

SYNOPSIS OF SESSION 4: Determining Well Recharge Rate (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Field Work: Determining Recharge Rate	Well recharge rate is determined by participants at a well site that already has a handpump	1 Hour	Measuring tape and/or string Handout 4-3: Well Recharge Rate Handout 4-4: Suitability of Well Recharge Rate for Various Numbers of Users	
Generalization/ Application	Trainer Questions and Participants	15 Min.		
Closure	Questions and Answers	5 Min.		

Session 4: Determining Well Recharge Rate

Total Time: 3 hours 25 min.

OBJECTIVES

By the end of the session the participants will be able to:

1. understand basic concepts of groundwater flow

2. determine if a well has sufficient recharge rate to install a handpump

OVERVIEW

The recharge rate is the rate at which water enters the well from the ground. When water is pumped from the well faster than the rate at which the well recharges, the level of the water in the well goes down. If this is continued long enough, the water level drops below the end of the cylinder or suction pipe. Water cannot be pumped when this happens, which results in inconvenience to the users who have to wait for the water level to rise again. In severe cases, the well will not provide enough water for the users to live on. This inconvenience, or lack of sufficient quantities of water, usually results in the users seeking another, perhaps contaminated, water source. An adequate recharge rate provides sufficient water for all the needs of the users and does not require that they wait for excessive periods while the well recharges.

There are several ways to determine well recharge rate. Often the driller keeps a log when drilling a well which contains a record of the well recharge rate. If it is a dug well or if the well logs are incomplete or unavailable it is necessary to measure the recharge rate. Sometimes a water agency will have the mechanical pumps and water level measurement gear to measure recharge rate. When this equipment is available it should be used in place of the method described in this session because of its greater accuracy. When there are no viable outside sources of assistance, however, the method in this session will yield sufficiently accurate results to identify the less productive wells and help the extension workers and village leaders to knowledgeably plan a course of action. This method was selected because it can be used under usual field conditions.

This session comes before doing the assessment for project feasibility so that participants will have the skills to determine well recharge rate and can explain this aspect of the assessment to villagers. In the project cycle, determining the well recharge rate is done during the assessment for project feasibility.

The determination of the well recharge rate is of prime importance when selecting a well to receive a handpump. Because of the effort involved in setting up for determining the well recharge rate, easy-to-obtain information regarding the well site is gathered first (e.g. location with respect to accessibility, sources of contamination, known flood level and drainage;

physical characteristics of the well; number of users). If the well meets all these criteria, the recharge rate is measured. If the recharge rate is insufficient, the village, with the help of the extension worker, should decide if another well is to be used or if a driller or digger is to be called in to attempt to increase the recharge rate.

In the field activity the suitability of the well for use as a village water source is determined on the basis of well recharge rate and the expected number of users.

This session makes use of a well which already has a handpump. This well should be identified in advance of the workshop. Also, in advance of the workshop, the trainer must identify organizations which can help the participants with selecting the well site with respect to hydrogeological aspects (step 3). Training the participants in hydrogeological well site selection is beyond the scope of this workshop.

PROCEDURE

1. Introduction — Time: 10 min

Describe the session objectives.

Develop an introduction from the material in the overview including the following key points:

- what is a well recharge rate?
- the importance of determining the well recharge rate as part of the assessment for project feasibility
- the consequences of selecting a well with an inadequate recharge rate
- the setting of the session in project cycle and in workshop schedule

2. Demonstration: Well Recharge — Time: 15 min.

Setting up the demonstration:

Three large containers (three three-gallon buckets or bowls) and two small cups are needed for this demonstration. It is better if one container is glass (mixing or punch bowl). Set the containers on a table with the glass container in the middle. Draw a line around the glass container about 1-2 inches below the rim to represent the static water level. Fill the glass container to the line with water. Fill one of the outside containers with water and leave the other empty.

Draw a picture on flipchart paper or the blackboard to illustrate how the containers are related to the aquifer, well, pump, and water buckets or jugs. See the sketch in Handout 4-1: How Recharge Demonstration Corresponds to Well as an example. Explain to the participants that the glass container in the middle represents the well and that the line is the static water level. Water can never go any higher in the well than the static water level unless the groundwater level increases (such as during the rainy season). The outside container full of water represents the groundwater reservoir. This is the water that refills (recharges) the well after water has been removed by pumping. The empty container represents the buckets and jugs that the villagers bring to the pump to fill with water. The two cups are used to transfer water between the containers. One cup represents the pump and is used to remove water from the well and the other represents water movement from the aquifer into the well. Remind the participants that the well cannot be filled any higher than the static water level.

Example #1 - "Sufficient Recharge Rate": Ask for two volunteers. Give them each a cup. Tell one volunteer that he is the pumper and his rate is to be a cup every 5 seconds for 30 seconds and then no "pumping" for the next 30 seconds. The recharger's rate is to be a cup every 10 seconds with no breaks. Have a volunteer call out the time every 5 seconds.

Explain that the example represents an average pump on an adequate well. Begin the example. After 30 seconds point out the level to which the water has fallen in the "well." During the next 30 seconds call to the participants attention that the well is recharging back to its original level. Continue the example for another minute so the participants can observe the recharge again. Repeat that this example represented an adequate recharge rate for the rate at which water was pumped from the well. Ask what factors influence pumping rate. Answers should include the capacity of the pump cylinder, how fast the pump is pumped, the number of users, and the number of pumps on the well.

Example #2 - "Insufficient Recharge Rate": Ask for two more volunteers. Explain that the pumping rate will be increased in this example and there won't be any "rest" time like the 30-second break in the first example. The pumper is to remove a cupful of water every 2 seconds and the recharger is to put one cup in every 10 seconds. Ask for two other volunteers to time the pumper and the recharger.

Begin the example. Allow the demonstration to continue for several recharge cupfuls of water after the "well" has gone dry. Tell the pumper to respond just like a villager would. (He/she may choose to dip out partial cupfuls as the recharger pours more water into the "well," to wait until he/she gets full cupfuls or even to sit down until the well is fully recharged.)

Stop the demonstration and ask, "What did the pumper do when the well went dry? What else could he/she have done? Do you think it is good for a pumper to have to wait like this? Why? Should this well be selected for a handpump?" Their answers should be to the effect that the pumper had no choice but to wait or go somewhere else while the well recharged. It is not a good situation and should be avoided if possible.

3. <u>Lecturette: Groundwater and Wells</u> Time: 30 min.

A) Tell the participants that we have done a simulation of two wells, and we are going to look at what happened, why, and what can be done to improve well recharge rates. Pass out Handout 4-1: How Re-charge Demonstration Corresponds to Well and use it and the flipchart from Step 2 to help. Explain the following key points to the participants:

- The ground contains water in various quantities and availability, depending on its geological structure. It is called groundwater. Quantity and availability of groundwater are affected by the porosity and permeability of the soil. Porosity refers to the soil's ability to store water. Permeability is the ability of water to pass through a material. Soil materials comprised of sand and gravel usually are the most forous porosity and permeable.

- Surface water is absorbed by the ground and flows downward by gravity. At a certain depth the ground cannot hold any more water. It is said to be saturated and is called an aquifer. It is this aquifer which yields water to springs and wells.

- The movement of the water in an aquifer is downhill. Springs and wells in low spots and valleys usually yield more water than those higher on the hill. When water is pumped out of a well, it creates a "low spot" which the aquifer tries to fill.

- The water level in the well when it has not been pumped for a long time is called the static water level and corresponds to the groundwater table level (the upper limit of the aquifer). The static water level is higher in the wet season and lower in the dry season just like the groundwater table.

- When a well is pumped, the water level in the well decreases. This is because it takes time for the water to flow from the aquifer into the well. When the aquifer material is less permeable (clay, rock, etc.) it takes longer for the water to fill the well again. When pumping has stopped, the water level in the well will rise to the static water level if given enough time.

- In the first demonstration, water was able to flow into the well at the same rate at which it was being pumped out (6 cups per minute). At times, the pumping rate was greater than the recharge rate (6 cups per 30 seconds for pumping and 3 cups per 30 seconds for recharging) but over a one-minute period the pumping and recharge rates were equal. If pumping were to continue for a longer period of time, all the water would have been pumped out of the well.

- In the second demonstration, water was pumped out of the well at a greater rate than it was flowing in. The well went dry. The recharge rate was insufficient for the pumping rate.

- To increase the recharge rate of a well, the well is usually dug or drilled deeper. This does two thing:

- it increases the surface area of the well, exposing more of the aquifer and increasing the total flow of water into the well (the flow of water per unit of well wall area usually remains fairly constant);

- it increases the storage capacity of the well thereby making more water available during periods of heavy pumping which can be replenished during light pumping periods such as at night.

- Another method of increasing the recharge rate of the well is to make the aquifer around the well more porous and permeable. This is often called developing the well. Developing the well involves removing the smaller particles from the material around the well, often by forcing water through it in a pulsing motion. These particles enter the well and are pumped out, leaving the coarser material behind. In effect, this makes more room for water storage between the particles and removes some of the hindrances to water movement toward the well.

- Because dug wells have larger surface areas than drilled wells they are preferable to drilled wells for handpumps where the water table is not too deep (less than 35 to 50 meters). They also have the added advantages of using local labor with existing skills and are usually lower in cost to construct and maintain. Dug wells have the disadvantages of being labor-intensive requiring considerable organization of the village or labor force, slow to construct, potentially dangerous due to cave-ins and lack of oxygen in the well and are limited in depth to just a few meters below the water table (usually not a problem for handpumps because the pumping rate is so low).

B) Pass out Handout 4-2: Selecting a Well Site, which includes basic criteria for well site selection. Tell the participants, "This handout contains all the information you need to select a well site. In areas where water is traditionally hard to find or in areas where you have not been successful finding water, it is wise to consult a hydrogeologist. Governmental and private hydrogeology consulting organizations which you may contact are (list the organizations available to the participants and what type of assistance the participants should expect from each organization)."

4. Lecturette: Determining Well Recharge Rate   Time: 15 min.

Make the following points

- Tasks involved for determining well recharge rate (post on flipchart paper or on a blackboard):

- determine number of potential users
- temporarily install pump
- measure static water level
- measure well diameter
- pump for specified period
- measure water level at end of pumping
- allow water to rise several minutes; record elapsed time

- measure rise in water level
- consult charts to see if rise (recharge rate) is acceptable for the number of potential users
- remove pump

- It usually requires half a day to do all these tasks in the field. To reduce the overall time for the workshop, we will not install or remove the handpump. We will begin with measuring the static water level and conclude with determining the acceptability of the recharge rate.

- The method to determine the recharge rate employed in this session makes use of equipment that usually exists in the field, such as a handpump and a measuring tape. After measurement of the static water level the pump is pumped for 360 strokes. Immediately after pumping has stopped, the water level is measured the second time. After the water level in the well has risen for a specified period of time, the water level is measured again. The difference between the two levels is the rise in the water level. Using the rise in the water level and the well diameter, the well recharge rate is found on the well recharge rate chart. Knowing the well recharge rate and the expected number of users, the suitability of the well can be estimated from the suitability chart. With this information, the extension worker can guide the village leadership to make a knowledgeable decision about the well. The final decision is left up to the villagers because they are the ones using the well day after day.

- A way must be provided for the water level to be measured very quickly. When there is an access hatch, the string or measuring tape can be lowered through it. If there is none, the pump must be placed on a raised platform of 30-40 centimeters in height so the string or measuring tape can be easily let down under the pump.

- The values in Handout 4-3: Well Recharge Rate are based on the pump being pumped for 360 strokes for a drilled well after which the water level is allowed to rise for one minute before the final measurement is taken. For dug wells, the pump is pumped for 360 strokes and the water level allowed to rise for ten minutes before the final measurement is made.

5. Large Group Task: Finding the Recharge Rate — Time: 15 min.

A) Post the flipchart of the well used in Step 2 to help explain how to find the recharge rate.

B) Pass out Handout 4-3: Well Recharge Rate. Draw a replica of the handout on flipchart paper showing the well diameters on the left. Have the participants find the well diameter on their charts. Point out that to locate the distance the water rose after pumping stopped it is necessary to go to the right from the well diameter until they reach the number nearest to the number of centimeters the water rose in the one-minute or the ten-minute period. Then follow that column up to the value on top of the chart to find the well recharge rate in liters of water per minute.

Go very slowly when explaining how to use the chart so no one gets lost. For example, if the water level in a one-meter diameter dug well rises 18 cm in the 10 minutes following pumping, the recharge rate is 14 liters per minute.

C) Now, pass out Handout 4-4: Suitability of Well Recharge Rate for Various Numbers of Users. To determine if the recharge rate is suitable for the potential number of users find the recharge rate on the lefthand side of the chart and the potential number of users on the top of the chart. Go to the right of the recharge rate until directly below the potential number of users. The regions of the chart are marked "seldom lines," "some lines," "long lines," and "not recommended". For the above example, if 200 people used the well, would lines at the pump be expected? If so, ask if the participants think the average villager would tolerate the inconvenience of this well if a pump was installed? If the participants do not know, what steps would they take to find out?

D) IMPORTANT!! Tell the participants that the two charts just used to find the recharge rate and the suitability of the well for various numbers of users have certain limitations:

- If the distance that the water in the well rises after pumping has stopped, during the one-minute or ten-minute period, is more than two thirds of the distance back to the static water level, the charts do not apply and the well's recharge rate is sufficient for at least 200 users.

- The suitability chart is based on a consumption rate of 20 liters per person per day (5 gallons per person per day). If the consumption is considerably different (say 5 liters per day more or less) the chart will have to be modified accordingly (see Trainer Note 1).

- The suitability chart also assumes minimal water storage capacity in the well. The greater the storage capacity the lower the acceptable recharge rate can be for a given number of users.

6. Problem Session: Finding the Recharge Rate — Time: 25 min.

Pass out the sample problems in Handout 4-5: Problems of Determining Well Recharge Rates. Let the participants work on the problems individually for 15 to 20 minutes.

7. Discussing the Problem Session — Time: 15 min.

Pass out the answer sheet to the problems (Handout 4-6). Have the participants gather into groups to discuss the answers. Answer any questions. See Trainer Note 2 for an idea to help explain one of the harder problems. The trainer should check with each group to make sure participants understand the answers.

(Note: The problems include examples of both dug wells and drilled wells, and both shallow well pumps and deep well pumps. If any of these are not included in the workshop the problems will have to be modified accordingly.)

8. Field Work: Determining Recharge Rate Time: 1 hour

See Trainer Note 3 on how to set up the fieldwork.

A) Take the participants to a well site that already has a handpump. This is the first time in the workshop that the participants have an opportunity to actually see a functioning handpump and well site. Capitalize on this by asking the following questions at the well site:

- Do you see sources of contamination near the well site? Is it closer than the minimum recommended distance? If so, what do you think can be done?

- Do you think this site is accessible for repair and for use? Why? How could it be improved?

- How does the apron design compare with the standard design we discussed in Session 2: "Work Site and Handpump Orientation"? Should anything be changed? How?

Show where the opening for measuring the water level is. For pumps temporarily installed over a well, point out how the pump is installed over the well and explain the use of the trough to carry water away from the well.

B) Tell the participants that in the following activity they will help with obtaining the rate of recharge. Although the trainer(s) will be explaining the steps of the activity, some of the participants will actually be doing them. The others will be observers for most of the steps. Ask for volunteers to do the following:

pump the pump
measure water level

C) Demonstrate how to measure the well diameter in meters for dug wells or in millimeters for drilled wells or have a participant demonstate it.

D) Demonstrate how to measure the depth to the water level using a depth probe, weighted string, or equivalent. Allow sufficient time for most participants to measure the depth to the water level in centimeters and concur on its actual depth.

E) Have the volunteers that will pump the pump begin. Make sure that the pump is continually pumped. Have the volunteers rotate pumping so no one gets too tired. Count the number of strokes aloud until the 360 strokes are reached.

F) Have the measuring group get into position during the last hundred strokes. As soon as the pumping stops they should be ready to mark the string or tape. Have one of these group members keep track of the time between the second measurement (when pumping stops) and the third (60 seconds after pumping stops for a drilled well or 10 minutes after pumping stops for a dug well). Determine the difference between the two marks. All measurements are to be in centimeters.

G) Repeat the practice using different participants to measure the changes in the water level. This step is to allow all the participants a chance to practice measuring the changes in water levels.

H) Have the participants determine the recharge rate from the chart. Then compare the recharge rate to the number of actual users of the well to determine if it is adequate. Ask the users if there are lines and, if so, why.

9. Generalization/Application Time: 15 min.

Ask the participants when they should measure well recharge rates using this method. Answers should include:

- When the rate is not available from driller's logs or other sources.
- When another method is not available.

Then ask what to do if the well does not meet recharge requirements. The participants should suggest reporting their finding to the village leaders. Together they can then decide to use another well, install the pump anyway (depending on other criteria, such as an agency requirement), seek drilling assistance and so on.

10. Closure Time: 5 min.

Refer to the session objectives asking if the participants believe they were met during the session. Ask if any areas remain unclear and suggest that they see the trainer about these areas in the near future.

MATERIALS

1. Measuring tape and/or string to measure depth to water level
2. Handout 4-1: How Recharge Demonstration Corresponds to Well
3. Handout 4-2: Selecting a Well Site
4. Handout 4-3: Well Recharge Rate
5. Handout 4-4: Suitability of Well Recharge Rates for Various Numbers of Users
6. Handout 4-5: Problems of Determining Well Recharge Rate
7. Handout 4-6: Answers to the Problems of Determining Well Recharge Rate
8. List of Governmental and Private Hydrogeology Consulting Organizations
9. Flipchart paper
10. Marker pens

11. Tape

12. Prepared flipcharts for:
   - session objectives
   - sketch in Handout 4-1 (step 2)
   - tasks for determining well recharge rate (step 4)

TRAINER NOTES

1. To adapt the suitability chart to different user consumption rates, use the following formula:

   - Divide the actual consumption rate by 20 liters per day (the rate assumed by the chart) to find the correction factor.

   - Divide the well recharge rate found from the "Well Recharge Rate" chart by the correction factor.

   - Using the new recharge rate, find the suitability of the well for a given number of users on the suitability chart.

   Example: The consumption rate of an area is 25 liters per day per person and the well recharge rate is 10 liters per minute. What can be the maximum number of users of the pump in the "Seldom lines" region of the suitability chart?

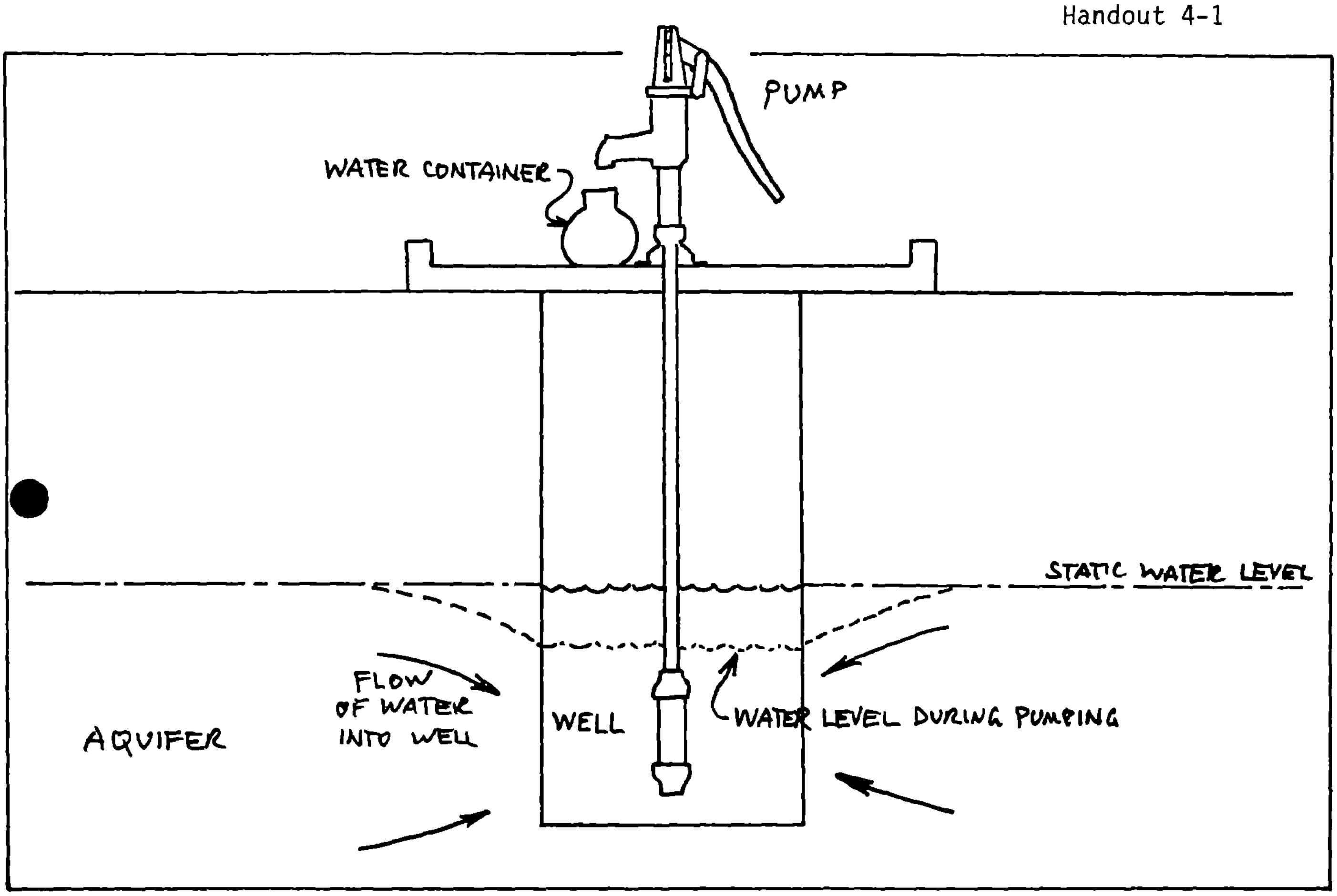
   $$\frac{25}{20} = 1.25 \text{ (correction factor)}$$

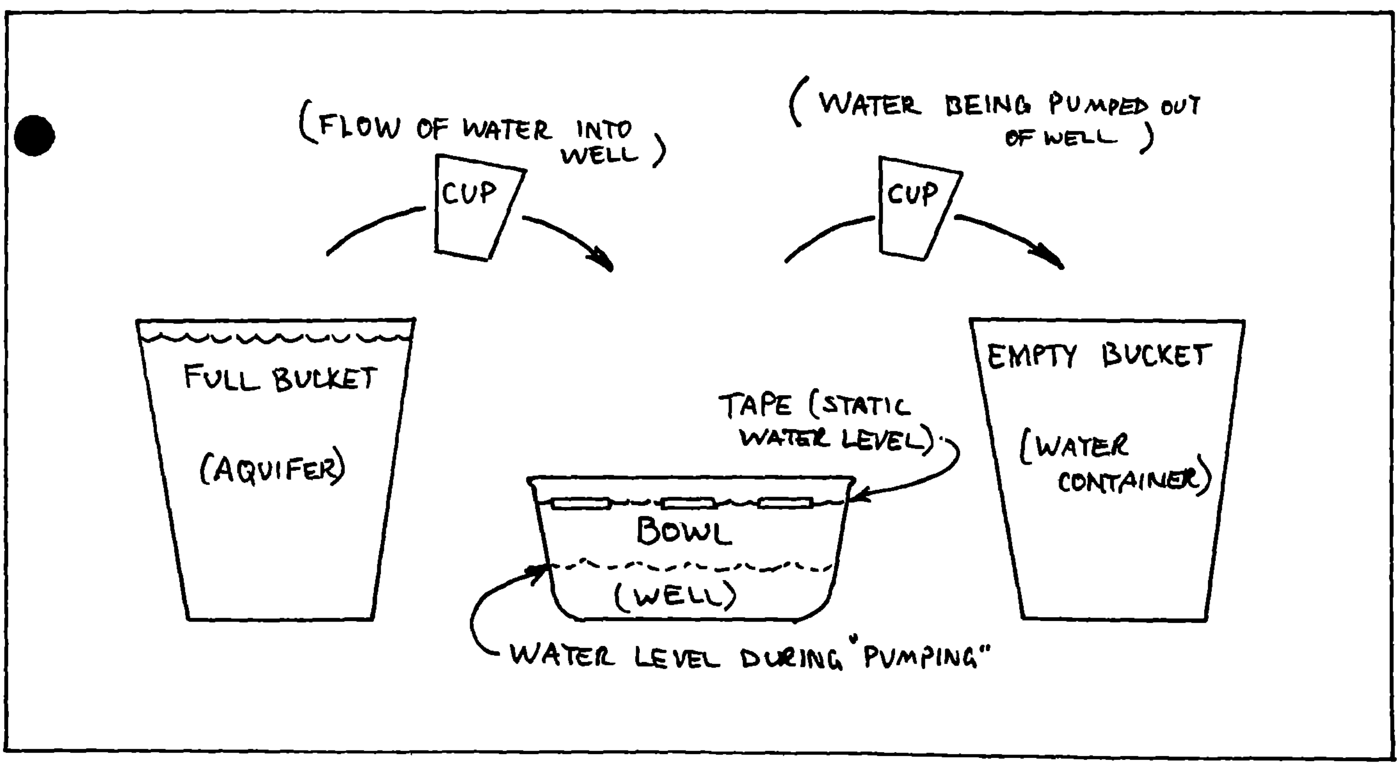
   $$\frac{10\ \text{l/min}}{1.25} = 8 \text{ liters per minute}$$

   From the suitability chart, 71 or 72 people would be the maximum number of users in the "seldom lines" region.

2. For problem #4 in Handout 4-5, it may be helpful to use the containers to explain the answer. Using the first example, "pump" for 30 seconds at a rate of 2 cups every 5 seconds (pretend it is 360 strokes) then mark or measure the water level. Allow the well to "recharge" for 1 minute at a rate of 1 cup every 10 seconds. Remind the participants that the well will only fill up to the static water level. Ask how many cups were poured in after "pumping" stopped. Three were poured in during one minute, therefore by measuring the rise in one minute, one would conclude that the recharge rate was 3 cups per minute. Ask how many cups could have been poured in during the one minute period. The answer is six which is the true recharge rate for this example. For the problem, there is not enough information to determine the recharge rate, but we know that it is sufficient. Tell the participants this rule-of-thumb: If the water level rises more than two thirds of the way back to the static water level, then the recharge rate should be sufficient.

3. The activity should be set up on a completed well but can be set up on a well that does not yet have an apron. For the latter, a pump of the type that the participants will be installing must be temporarily installed on the well before the session begins. It must be installed in such a way that the water level in the well can be measured quickly and without removing the pump. For completed wells without an access hatch it will be necessary to construct a 30-40 cm high platform on which to mount the pump. This platform may be nothing more than two boards whose ends are placed on boxes to obtain the desired height. A trough to carry away the water pumped from the well must be constructed. In areas where water is scarce, the villagers may want to collect this water.





HOW RECHARGE DEMONSTRATION CORRESPONDS TO WELL

Water for the World

Selecting a Well Site
Technical Note No. RWS. 2.P.3

Selecting a well site properly is important to ensure that the well will tap into a reliable source of good quality ground water, and to ensure that the water will not be contaminated in the future. Selecting a site involves considering existing wells, local geography, quality and quantity of ground water, possible sources of contamination, accessibility to users, and proposed methods of well construction.

This technical note describes the main considerations in selecting a well site. Read the entire technical note before beginning the selection process.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

CONTAMINATE - To make unclean by introducing an infectious (disease-causing) impurity such as bacteria.

DRAWDOWN - The distance between the water table and the water level in a well during continued pumping.

GROUND WATER - Water stored below the ground's surface.

IMPERMEABLE - Not allowing liquid to pass through.

PERMEABILITY - The ability of soil to absorb liquid.

POROSITY - A soil's ability to store water.

WATER TABLE - The top, or upper limit, of an aquifer.

General Information

If possible, the well site should be selected by a qualified engineer who has made a thorough field investigation. This investigation may be expensive and time-consuming, but it is one of the most important steps in developing a source of ground water. The investigation, or part of it, may have been done during the earlier planning stages. See "Planning How to Use Sources of Ground Water," RWS.2.P.1.

Whether an engineer or someone else selects the site, a map of the village and surrounding area should be obtained or produced. Add to the map all relevant features discussed in this technical note. See Figure 1.

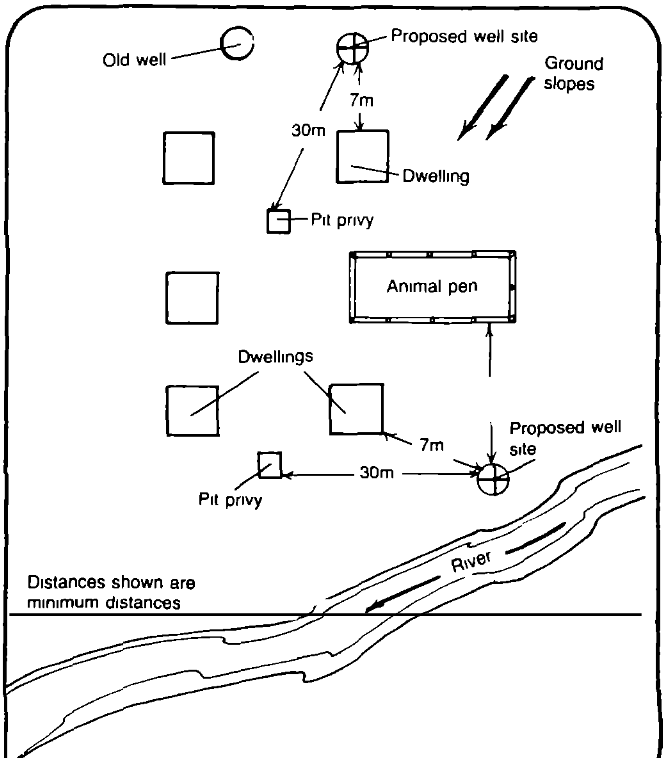


Figure 1. Location Map

Existing Wells

The primary objective when sinking a new well is to sink it where ground water is likely to be found. Existing wells are the best indication of the presence of ground water. Where possible, sink a new well near an old one--ground water will probably be reached at about the same depth. The history of the old well will provide information on seasonal changes in the water table, which may indicate that the new well should be deeper than the old one.

If the new well is to be used in addition to the old one, care must be taken not to sink it too close to the existing well. Otherwise, the yield of one or both wells may be adversely affected. This is due to the effect that a well has on the surrounding water table.

When water is pumped or lifted out of a well, the water level in the well falls below the original level, called the static level, until it stabilizes at a new level, called the pumped level. The distance between the static level and the pumped level is the drawdown. The water table surrounding a well curves down to the pumped level, forming a cone of depression. See Figure 2. If the cones of depression of two wells overlap, the pumped level in one or both wells will be lowered and the yield will be decreased. Draw all existing wells on your map, similar to Figure 1.

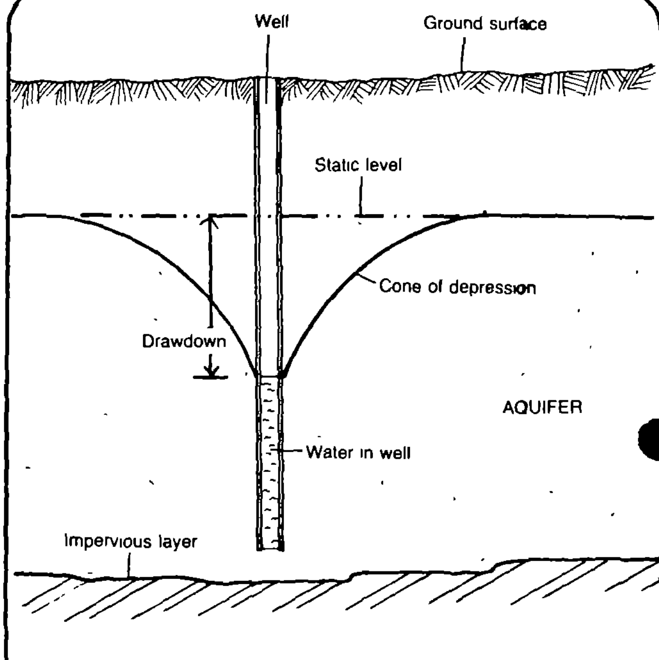


Figure 2. Cone of Depression

Local Geography

If no wells exist, the presence of ground water can be indicated by surface water, topography, and certain types of vegetation.

Surface water. A successful well can generally be sunk near a river because the river will replenish the ground water and reduce changes in the water table. Water taken from such a well is usually cleaner and cooler than water taken from the river. If the well is deep, water may be available even when the river is temporarily dry.

Topography. Ground water gathers in low areas. Therefore, the lowest ground is generally the best place to sink a well. In hilly areas, valley bottoms are the best places for wells. An exception to this could be where there is a spring on the side of a hill. The spring may indicate lateral movement of ground water over a layer of impermeable soil. If so, a successful well could be sunk uphill from the spring. This may have the advantage of bringing the source of water closer to the community or dwelling.

On your map, draw all rivers, springs, and topographical features.

Vegetation. Certain types of vegetation can indicate that ground water lies near the surface. The most useful indicators of ground water are perennial plants (those present year-round), especially trees and shrubs. Annual plants, such as grasses, are not good indicators, because they come and go with the seasons. The dry season is probably the best time to survey vegetation for indications of ground water.

Quality of Ground Water

Once ground water is located, its quality must be tested before constructing permanent wells. The water must be clean, clear, and good-tasting, and be free from disease-causing organisms. For information on testing water, see "Determining the Need for Water Treatment," RWS.3.P.1, and "Analyzing a Water Sample," RWS.3.P.3. If the ground water is contaminated, another source may have to be found.

Quantity of Ground Water

The quantity of a groundwater source is nearly as important as its quality. Unfortunately, the only way to test the yield of an aquifer is to dig a well and pump it. See "Testing the Yield of Wells," RWS.2.C.7. You can, however, make a rough estimate of the yield by identifying the sediment and rock which compose the aquifer.

The two most significant elements of an aquifer are its porosity and permeability. Porosity governs the amount of water that an aquifer can contain. Permeability governs the amount of water that can be brought to the surface. For example, some aquifers may contain large quantities of water, but their rate of yield is too slow to suit the needs of the user. Porosity and permeability depend on a number of factors including particle size, arrangement and distribution.

Table 1 shows the estimated yields of aquifers composed of different types of sediment. The table should not be used for exact calculations but only for indications of yield.

Table 1. Estimated Yields of Aquifers

Sediment Composing the Aquifer	Estimated Yield (liters per minute)
Sand and gravel	11400; could be less based on pump and well design
Sand, gravel, and clay	1900-3800
Sand and clay	1900
Fractured sandstone	1900
Limestone	38-190; more if near stream, or if there are underground caverns
Granite or hard rock	38 or less
Shale	less than 38

If the quantity of ground water is insufficient, another well site will have to be found. The new site may replace or supplement the old site.

Possible Sources of Contamination

A well should not be dug in areas where the ground water is likely to be contaminated. A well site should be uphill and at least:

50m from a seepage pit or cesspool;
30m from a subsurface absorption system;
30m from a pit privy;
30m from animal pens, barns, or silos;
15m from a septic tank;
7m from a drain, ditch, or house foundation.

The well site should not be subject to flooding during the wet season or any other time. This will be of greatest concern where the well is in a low area or near a river that yearly overflows its banks. The site can be protected from flooding by building small dams or ditches to prevent flooding the well. If not, another site should be considered.

Draw all possible sources of contamination on your map, as in Figure 1.

Accessibility to Users

The well site should be as close as possible to the village or dwelling. As the distance between the well and the user increases, the per capita water consumption decreases. This is shown in Table 2. The table should not be used for exact calculations but only for indications of consumption.

Political considerations may influence accessibility. There may be pressure to put the well near the dwelling of the village chief or other influential member of the community. A compromise may be necessary.

Methods of Well Construction

The proposed method of well construction must be suitable to the soil conditions at the well site. If not, another site must be found or another method of construction must be considered. Table 3 shows some of the limitations of well construction methods based on soil conditions. For more information, see "Selecting a Method of Well Construction," RWS.2.P.2.

Table 2. Water Consumption and Distance to Water Source

Distance to Source	Estimated Consumption (liters per person per day)
More than 1000m	7
500-1000m	12
Less than 250m	20-30
In the yard of the dwelling	40

Table 3. Well Construction Methods and Soil Conditions

Construction Method	Unsuitable Soil
Hand Dug	Hard rock, large boulders
Driven	Hard rock, heavy clay, boulders, coarse gravel
Jetted	Hard rock, boulders
Bored	Hard rock, boulders larger than auger
Cable Tool	None

Summary

When all alternative well sites have been determined, draw them on your map, as in Figure 1. Then select the best site. When examining a site, you will no doubt find that even though it may rate well in some ways, it rates poorly in others. Selecting the best site is often a matter of judgment and experience. You must weigh the relative advantages and disadvantages of each site. Figure 3 is a simplified example of four alternative sites from which a village must select one.

Site #1 would allow easy access to ground water because the water table lies close to the surface of the ground. However, limited water would be available because the layer of impermeable rock also lies near the ground surface. Thus, slight fluctuations in the water table would drastically affect the availability of water.

Site #2 is the site closest to the village, and therefore has the greatest accessibility. However, the water table is quite deep and may be difficult to reach. The aquifer cannot be penetrated too deeply, because of the position of the impermeable layer.

At Site #3, the aquifer can be reached without digging very far down. The aquifer can be deeply penetrated. This would ensure a reliable water source. However, the site is some distance from the village, and below the homes.

At Site #4, the most water can be reached with the least difficulty. The site is at the greatest distance from the village. It is in a low spot that may be subject to flooding.

Each site has advantages and disadvantages. The project director, the villagers, and the village leaders must decide which site is best for the community.

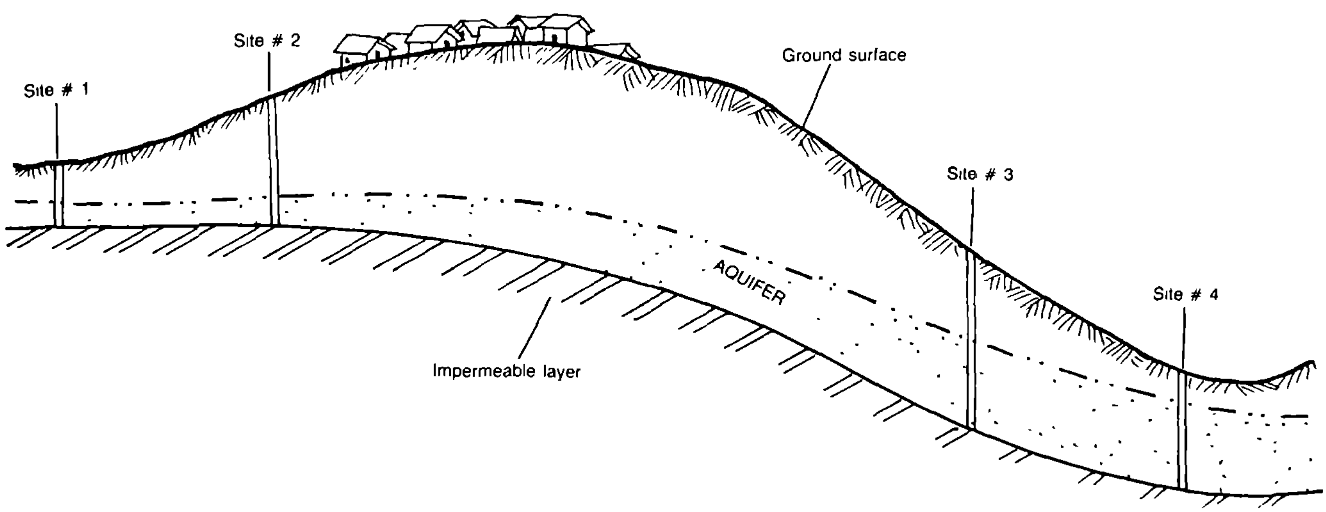


Figure 3. Alternative Well Sites

Notes

Well Recharge Rate

Drilled Wells

Well Diameter, Millimeters	Well Recharge Rate (Liters/Minute) 1	2	3	4	5	6	7	8	9	10	11	12	13	14
80	20	40	60	80	100	120	140	160	180	200	220	240	260	280
100	13	25	38	51	64	76	90	100	110	130	140	150	160	180
150	6	11	17	23	28	34	40	45	51	56	62	68	73	79
200	3	6	9	13	16	19	22	25	29	32	35	38	41	44
250	2	4	6	8	10	12	14	16	18	20	22	24	26	28
300	2	3	4	5	7	8	10	11	13	14	15	17	18	20

Distance water rose in well in one minute (To nearest cm)

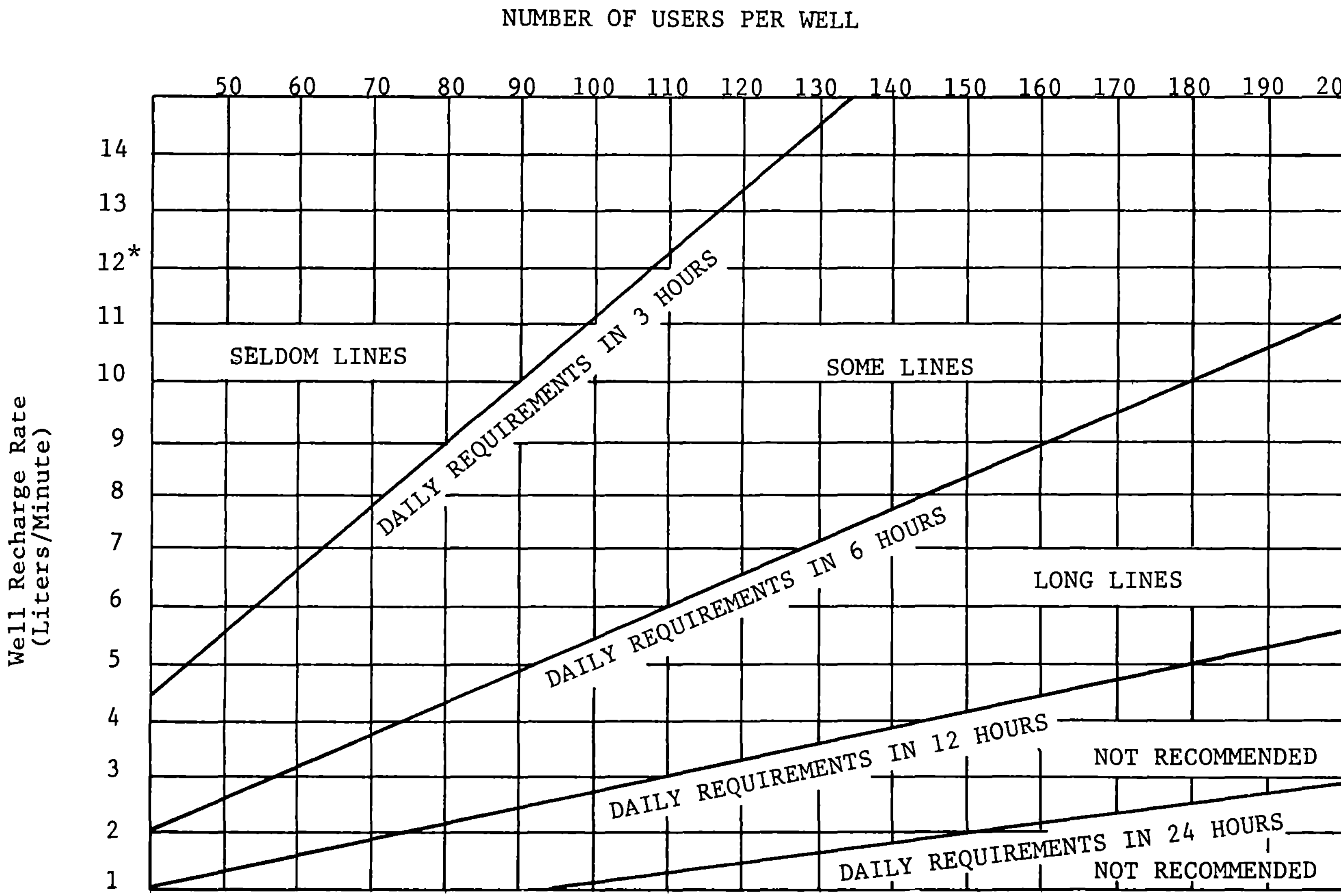
Dug Wells

Well Diameter, Meters	Well Recharge Rate (Liters/Minute) 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	1	2.5	4	5	6.5	7.5	9	10	11.5	13	14	15	16.5	18
1.25	-	1.5	2.5	3	4	5	6	6.5	7	8	9	10	10.5	11.5
1.5	-	1	2	2.5	3	3.5	4	4.5	5	5.5	6	7	7.5	8
1.75	-	-	1	1.5	2	2.5	3	3.5	3.5	4	4.5	5	5.5	6
2.0	-	-	1	1.5	1.5	2	2	2.5	3	3	3.5	4	4	4.5
2.5	-	-	-	-	1	1	1.5	1.5	2	2	2	2.5	2.5	3
3.0	-	-	-	-	-	-	1	1	1.5	1.5	1.5	1.5	2	2

Distance water rose in well in 10 minutes (To nearest 1/2 cm)

SUITABILITY OF WELL RECHARGE RATES FOR VARIOUS NUMBERS OF USERS

(Based on 20 Liters/Person/Day With Minimal Water Storage in Well)



*Above 12 liters/minute the rate at which water can be pumped into containers becomes an influential factor in the formation of lines.

Problems of Determining Well Recharge Rate

1. An 80 mm diameter drilled well is pumped for 360 strokes. After pumping the well water was allowed to rise for one minute. The static water level was 6 meters below the surface. When pumping stopped, the water level was 62 meters below the surface. The water level rose to 59-1/2 meters in the minute immediately after pumping stopped. What is the well recharge rate? Two hundred people will use the pump. Is the recharge rate sufficient?

2. The static water level of a 1.25 meter diameter dug well is 2.10 meters (210 cm) below the surface. A pump is installed and pumped for 360 strokes. The water level immediately after pumping was 2.73 meters (273 cm) below the surface. In the ten minutes after pumping the water rose 6 centimeters. What is the recharge rate? If the users will only tolerate short waits at the well for water, what is the maximum number of people who can use the pump?

3. A village of 100 has a 20-year-old drilled well on which the pump has broken. It is 200 mm in diameter and the static water level is at 30 meters. A pump is temporarily installed on the well and pumped for 360 strokes. The water level is recorded at 41.45 meters after pumping and recorded again at 41.32 meters one minute later. Should the village use this well as their primary water source? What will happen if they do?

4. A 1-1/2 meter diameter dug well is pumped with a handpump for 360 strokes. The water level drops 4 cm from the static water level of 3.35 meters by the end of the 360 strokes. After 10 minutes, the water level is again 3.35 meters from the surface. What is the well recharge rate?

Answers to the Problems of Determining Well Recharge Rate

Problem #1:

The water in the well rose 2 1/2 meters (250 cm) during the minute following pumping. Judging from the recharge rate chart, the recharge rate for an 80 mm diameter well with the above rise in water level is about 12-1/2 liters/ minute. The recharge rate is sufficient for 200 people.

Problem #2:

The recharge rate for a 1.25 meter diameter well with a rise after pumping of 6 centimeters is 7 liters/minute. With less than 120 users, some lines will occur at the pump site while the well recharges. For over 120 users, lines wil probably occur frequently.

Problem #3:

The difference in water levels from the end of pumping until one minute later is 13 cm. For a 200 mm diameter well the recharge rate is 4 liters/minute. The village of 100 should expect long lines while the well is recharging. The village should look into further developing the well or drilling it deeper.

Problem #4:

The charts do not apply to this problem because the water level rose more than two-thirds of the distance back to the static water level in the period after pumping stopped. The recharge rate is therefore sufficient for at least 200 people if the pump used to test the recharge rate is the same as will be installed on the well.

SESSION 5

SYNOPSIS OF SESSION 5: Constructing the Apron

Total Time: Dug Well: 10 Hrs 35 Min. Drilled Well: 7 Hrs 35 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Part I				
Introduction	Trainer Presentation	10 Min.		Session Objectives Construction Line Chart
Lecturette: Well Construction and Lining	Lecturette	45 Min.	Handout 5-1: Water for the World: Constructing Hand Dug Wells Handout 5-2: Lining an Existing Well Handout 5-3: Repairing the Lining of an Existing Well	Steps of Well Construction and Lining
Lecturette/Discussion: Constructing the Apron	Presentation of Apron Design and Steps for Constructing the Apron (Dug Well or Drilled Well)	30 Min.	Handout 5-4: Possible Apron Design Handout 5-5: Dug Well: Steps for Constructing an Apron for a Dug Well Handout 5-5: Drilled Well: Steps for Constructing an Apron for a Drilled Well	Steps for Constructing the Apron (Dug or Drilled Well)
Preparation for Field Work	Participants set up construction teams and plan work. Trainer shows materials and tools to be used.	1 Hour 15 Min.	Tools and materials to construct the apron (see materials and tools list) Handout 5-6: Dug Well: Team Work Plan Guide #1 Handout 5-6: Drilled Well: Team Work Plan Guide #1	Team Work Plan Guide #1 (Dug Well Ground Level Apron Design or Drilled Well Ground Level Apron Design)

SYNOPSIS OF SESSION 5: Constructing the Apron (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Field Work: Preparing for Concrete Construction	Teams complete construction task up to placing the concrete	Dug Well: 3 Hours 30 Min. Drilled Well: 1 Hour 30 Min.	Handout 5-6: Mark II Pump: Team Work Plan Guide #1 Tools and materials to construct the apron (see materials and tools list)	
Part II				
Introduction	Trainer asks teams questions about work completed so far and reviews next tasks	15 Min.		Tasks to be completed
Lecturette: Making and Using Concrete	Lecturette	10 Min.	Handout 5-9: Concrete Primer	
Preparation for Field Work	Teams plan their work	30 Min.	Handout 5-7: Dug Well: Team Work Plan Guide #2 Handout 5-7: Drilled Well and Mark II: Team Work Plan Guide #2	Team Work Plan Guide #2 (Dug Well Ground Level Apron Design or Drilled Well Ground Level Apron Design)
Field Work: Placing the Concrete	Teams complete concreting of the the apron	Dug Well: 3 Hours Drilled Well 2 Hours	Tools and materials to construct the apron (see materials and tools list)	
Application	Participants state what they learned	10 Min.		

SYNOPSIS OF SESSION 5: Constructing the Apron (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Closure	Objectives of Session are reviewed and assessment for project feasibility task instructions are explained	20 Min.	Handout 5-8: Constructing the Apron Handout 5-8: Mark II: Constructing the Apron Handout 5-9: Concrete Primer Handout 5-10: Instrument for Assessing Project Feasibility	

Session 5: Constructing the Apron

Total Time:	Dug Well:	10 hrs 35 min.
	Drilled Well:	7 hrs 35 min.
Part I:	Dug Well:	6 hrs 10 min.
	Drilled Well:	4 hrs 10 min.
Part II:	Dug Well:	4 hrs 25 min.
	Drilled Well:	3 hrs 25 min.

OBJECTIVES

By the end of this session, the participant will be able to:

1. understand basic well lining techniques
2. construct an apron for a dug or drilled well
3. properly use and handle tools to construct an apron
4. mix concrete so that an adequate quality concrete is produced
5. organize themselves effectively to complete the tasks
6. apply problem-solving skills to construction work

OVERVIEW

The apron is a slab of concrete that surrounds the pump. Its purpose is to drain surface water away from the pump and well because water around the pump base and apron may sometimes seep into the well and contaminate the water. The curb around the apron prevents water from running off the apron and onto the ground. Instead, it is channeled to a drain. The apron also provides a firm, non-slip surface from which to operate the pump.

This session begins the construction phase of the project cycle and is the first of three construction sessions in the workshop schedule. After this session, in which the apron slab is poured, the concrete must cure for several days. In the suggested workshop schedule the next construction session will be Session 10: "Finishing the Site" three days later.

The field activities of this session, like all the construction sessions which follow ("Constructing the Apron," "Finishing the Site" and "Installing the Handpump and Disinfecting the Well"), will be held at the work site. The session begins with a discussion of why an apron is necessary, how this session fits into the overall project cycle and the main activities of the session. It continues with an overview of lining the well which will not be a "hands-on" experience due to the time limitations of the workshop. Guidelines and model steps are given for the trainer to develop a lecturette on well construction and lining which is suited to the geological conditions and well construction methods of a given region or country. See Trainer Note 1 for suggestions about field trips that could be taken to supplement the lecturette. Then, after a lecturette/discussion on the steps to construct the apron, the participants will divide into teams for each well site and decide how they will perform the activities. The trainer(s) will take a supervisory and troubleshooting role as the participants "learn by doing." The construction activities are divided into two distinct parts with processing questions after each part. Part I covers the construction steps up to placing the concrete. Part II covers the actual laying of the concrete for the apron.

Because this session addresses both dug wells and drilled wells, and because there is more than one method of apron construction for both types of wells, information which pertains to a certain design or construction method is separated from the session procedures and is included in a section called "Trainer Reference Sheets." The trainer reference sheets contain the steps of apron construction, construction team work plan, and special trainer(s) guidelines for supervising the construction for both a dug well and a drilled well apron design. When apron designs and construction methods are used that are different than the two included, the trainer reference sheets can serve as a model for developing material to suit the design and methods used. Modification of the trainer reference sheets will not affect the procedures of the session, which should remain the same for any type or method of apron construction.

Review the handouts and trainer reference sheets in advance of the workshop and modify them as needed to suit your workshop needs.

To use the trainer reference sheets select either the dug well or drilled well sections found at the end of the session (or develop sheets for the apron design and construction method you will be using) and insert them in the text after the page in which they are referenced.

The session uses workmen to prepare the site for apron construction. A suggested list of tools and materials for this session is found in "Materials and Tools" located at the end of the session.

The construction sessions are among the most involved of all the sessions. They require a great deal of preparatory work by the person(s) responsible for the workshop. The types of pumps and wells to be included in the workshop need to be decided before the workshop begins. Section 1.7.5. of the "Introduction to the Training Guide," gives guidelines.

<u>PROCEDURE Part I:</u> Time: Dug Well: 6 hrs 10 min.
Drilled Well: 4 hrs 10 min.

1. <u>Introduction</u> Time: 10 min.

Give the session objectives and develop an introduction from the material in the overview covering the following points:

- why the tasks are being done
- how this session relates to the project cycle and workshop schedule

- the main steps or flow of the session

Use the Construction Line Chart (flipchart) to show the relationship of the session to the other construction sessions.

2. Lecturette: Well Construction and Lining Time: 45 min.

Note: This lecturette is applicable to dug wells and should be omitted when only drilled wells are addressed.

A) Introduce well construction and lining by making the following points:

- Because of the differences in soil type and in the state of disrepair of existing wells, many techniques are used to line (new) or reline (existing) wells. New wells dug in unconsolidated soils must be lined (or cased) as they are dug to prevent the walls from collapsing. In consolidated soils, the lining can be poured after the walls have been dug. Some old wells have existing porous linings (brick, rock, cracked concrete) that must be made impermeable. This can be done by merely repairing the cracks and leaks or by replacing the entire lining. The lining or relining of the well can take several hours to several weeks to complete depending on the method employed and the extent of the work.

- It is important that cracks in the well lining be repaired to prevent water from entering the well from a point near the surface. This water may contaminate the well. In most places, the soil acts as a natural filter, removing many harmful impurities from surface water. The extent of filtration is dependent on several variables, one of which is the distance the water travels through the soil. A well lining without cracks will force surface water to travel a further distance through the soil before it can enter the well. For most situations, the lining should extend at least three meters below the surface of the earth.

B) Explain the following:

- We will not have any "hands-on" practice in constructing and lining dug wells in this workshop due to time limitations.

- We believe it is important that you have a basic understanding of dug well construction and lining methods.

- The treatment of the construction and lining methods will be brief. You are not expected to be experts at the end of this session. You will have a general background on the various methods most often used here in ____________ (name of country or region).

- These construction and lining methods will be covered in a lecturette. Please feel free to ask questions.

C) Develop a lecturette that describes and explains the steps of well construction and lining that the participants are likely to encounter. Illustrate the major steps on flipchart paper or a blackboard.

The following outline is provided to help the trainer organize the lecturette:

I. Construction and/or Lining Methods

A. soil conditions
B. methods that work best in each soil type
C. method selection

II. Construction Methods and Specific Tasks (see page 3 of Handout 5-1: Water for the World: Constructing Hand Dug Wells for an example of construction tasks)

III. Details of Lining Steps for Existing Wells

A. lining steps for existing wells without lining (see Handout 5-2: Lining an Existing Well as an example of the steps to line an existing well).

B. lining steps for an existing well with a decayed lining (see Handout 5-3: Repairing the Lining of an Existing Well, as an example).

D) Pass out Handouts 5-1, 5-2 and 5-3: Constructing Hand Dug Wells, Lining an Existing Well and Repairing the Lining of an Existing Well.

3. Lecturette/Discussion: Constructing the Apron Time: 30 min.

A) Present the design for apron construction and explain how it was chosen, including:

technical considerations
community considerations

Remind participants of the design considerations presented in Session 2 and explain how this apron design takes them into account.

B) Present other possible apron designs and describe the conditions under which they would be used. Pass out Handout 5-4: Possible Apron Design. Ask participants if there is any additional input that would be needed from the community before finalizing the apron design for the two well sites.

C) Present the steps for constructing the apron (put on flipchart paper or chalkboard). Include the key points given beside each step. See the trainer reference sheets for step 3.

Note: Insert Trainer Reference Sheets for Step 3 after this page.

D) Pass out Handout 5-5: Steps for Constructing an Apron for a Dug Well or Steps for Constructing an Apron for a Drilled Well and give participants 5 to 10 minutes to read it. Ask if there are questions. Tell participants that during the field work they will complete all of the steps up to mixing and placing concrete.

4. Preparation for Field Work (See Trainer Note 2) Time: 1 hour 15 min.

A) Setting up Construction Teams:

Tell the participants that construction teams will now be set up. The teams will be made up of participants with different levels of experience. Have the participants separate into groups with more than ten years construction experience, two to ten years construction experience and less than two years experience. From these three groups, have the participants form two teams with members from each group of construction experience. Once teams are formed, ask members to state skills each is particularly interested in learning or practicing. Give the teams about 20 minutes for this discussion.

B) Explain that the two teams, one assigned to each well site, will be doing the tasks found in the work plan guide for either dug or drilled wells. Suggest that in order to use the time well, and accomplish all of the tasks, they will need to organize and delegate work among team members. Suggest that they use the plan found in the trainer reference sheets for Step 4 to divide the work. (Put plan on flipchart paper or blackboard.)

C) Show participants the tools and materials they will be using to construct the apron and complete the site. Review any tools and materials with which the participants are not familiar or commonly misuse. Explain their proper usage or function. Use the following list as an aid to developing your lecturette.

- Saws:
  - Cut material using full, smooth unforced strokes.
  - Have someone firmly hold the material being cut.

- Level:
  - Hand held levels should be laid on a long straight board to determine slope of apron area.
  - Water-filled clear plastic tubing is good for measuring point-to-point slopes such as from a stake on one side of the apron to another stake at the opposite side. A long straight board is needed to determine the slope over the apron area. Caution: always be careful that the water does not run out of the ends of the tube.

- Pliers:
  - When using the pliers to twist the tying wire around the rebar, be careful not to break off the nose of the pliers.

- Anchor bolts:

  - Used to anchor the pump to apron. Their "L" shape (or "T" shape) design resists pulling out of and turning inside the concrete.

- Rebar:

  - Rebar is used in concrete when the concrete is subjected to tension loadings. The concrete slab over the well opening is subjected to compression in the top part of the slab (concrete is very strong in compression) and tension in the bottom part (concrete is weak in tension) due to its own weight and people and a pump standing on it.
  - Rebar is placed in the lower half of the slab where the slab is in tension.
  - Usually the rebar is raised 2-3 cm from the bottom of the slab so that concrete can be packed all around the rebar. The rebar can be raised by placing it on small rocks or on a thin layer of concrete.
  - Rebar should be overlapped 10-15 cm (4-6 in) and tied with wire when an additional length must be added to an existing length of rebar.
  - All rebar joints should be tied with tying wire.

D) Explain to participants that the use of problem-solving skills during the next several days will be essential. These are skills we will be asking each team to demonstrate. Choose one or more of the following problems (or create your own, suitable to the workshop situation) and ask participants how they would solve it.

- You have completed grading the apron site and laying the formwork for the apron. As you bring the concrete materials, a local woman tells her husband that she won't be able to wash clothes at the concrete wash basin near the pump because the new apron is too high and she will have to stoop uncomfortably low to use the basin. How might you resolve this problem?

- The pump is the village's only source of water. It is the dry season and rainwater cannot be collected. What can be done so that the villagers might have water while construction activities take place (especially allowing time for concrete to set)?

- Sand, gravel and cement are being stored in a house 50 meters from the well. A mud fence prevents the materials from being transported by truck to the well. Should the concrete be mixed at the house and carried over the fence or mixed at the site? Why?

E) Tell participants that upon arrival at the well sites they should take 15 to 20 minutes to plan their work. Pass out Handout 5-6: Team Work Plan Guide #1 (Dug Well--Ground Level Apron Design or Drilled Well--Ground Level Apron Design.) Emphasize that while there is a tendency to begin the work immediately, time spent in first planning who does what, will increase the team's efficiency. The following steps should be done during the planning time:

- Pick one member to be team leader for the day. The team leader's job is to:
  - see that everyone is involved
  - delegate work so that participants gain experience in doing unfamiliar tasks
  - participants are both learning and getting the work done

- Identify people in the group who have experience with the various tasks and divide them equally among the three groups. Assign team members to three groups.

- Pick one team member to be responsible for picking up and returning the tools needed for the day.

5. <u>Field Work: Preparing for Concrete Construction</u>

Time: Dug Well: 3 hrs 30 min.
Drilled Well: 1 hr 30 min.

The trainers should move between the two well sites while participants are working on the tasks. The role of the trainers is to:

- Act as resource person if particinants are unsure of some steps

- Pose questions:
  - If you continue to do what you are doing, what do you think will happen?
  - Is there a more efficient way of doing that task?

- Closely observe the work being done to spot problem areas or lack of understanding.

In particular, the trainers should watch out for the items found in the trainer reference sheets for Step 5.

<u>PROCEDURE Part II:</u> Time: Dug Well: 4 hrs 25 min.
Drilled Well: 3 hrs 25 min.

6. <u>Introduction</u> Time: 15 min.

A) Ask teams the following questions about the work they have completed so far on the apron:

- What did you do yesterday? How far did you get?

- With what decisions were you faced? What choices did you make? Why?

- How effectively did your team work? What could you do to improve your effectiveness?

- What is left to do?

B) Review the next tasks to be completed, which are listed in the trainer reference sheets for Step 6. (Put on flipchart paper or blackboard.)

7. Lecturette: Making and Using Concrete Time: 10 min.

Develop a lecturette on concrete construction from Handout 5-9: Concrete Primer, including the following points concerning the apron construction:

- Concrete is made of cement, sand, and gravel.

- These three ingredients are usually mixed in ratios of 1:2:3 (1 bucket of cement, 2 buckets of sand, 3 buckets of gravel) or 1:2.5:5 for apron construction. For our workshop, we will use ________.

- The size of the gravel and sand is very important. Gravel should be 1" or less in diameter or it will be too difficult to pack around the rebar. Sand that is too fine (silty) will weaken the concrete. An extra sack of cement added to the total mix, however, will lessen the effect of silt if cleaner or washed sand is unavailable.

- If too much water is added to concrete, the cement will settle out making the concrete weaker. Too little water will make the concrete too stiff to fill the formwork and to pack around the rebar.

- Concrete should be placed and not dropped into the forms. Also, it should be worked only enough for gaps around the rebar and forms. Overworking or dropping the concrete will cause the cement to settle out.

- Before beginning to place the concrete, plastic should be placed on the ground or the ground wetted to reduce the rate at which water in the concrete will be absorbed by the ground.

- Concrete is most easily placed with a trowel, tamped with a short piece of rebar or the trowel point, and smoothed with a screed. The apron surface should be left slightly rough to prevent users from slipping. The surface can be roughed by the trowel or screed or by using a bristle broom.

- The concrete for the apron can be sloped using several methods. One is to mark the proposed concrete depth on the form material and use a long board to determine the high and low spots in the freshly poured apron. Another method is to drive small rebar sections into the ground, with the top of the rebar marking the depth to which the concrete will be poured.

- Concrete continues to harden as long as it is kept moist. It should be kept moist (cured) for a least three days but seven days are preferred. When concrete is allowed to dry, the process of hardening stops and cannot be restarted.

- When concrete placement is finished, wash all the tools in water to remove all the concrete.

8. Preparation for Field Work Time: 30 min.

A) Suggest the plan found in the trainer reference sheets for Step 8 to assist each team to accomplish the next set of tasks (put plan on flip-chart paper or chalkboard).

B) Tell participants that again, upon arrival at the well sites, they should take 15 to 20 minutes to plan their work and to choose a new team leader and a new person to be responsible for tools. Encourage them to try out an unfamiliar task. Pass out Handout 5-7: Team Work Plan Guide #2. (Dug Well--Ground Level Apron Design or Drilled Well--Ground Level Apron Design.)

9. Field Work: Placing the Concrete Time: Dug Well: 3 hrs
Drilled Well: 2 hrs

A) The trainer(s) should move between the two well sites while participants are working on the tasks. The role of the trainer(s) is to:

- act as resource person(s) if there are steps participants are unsure of

- pose questions, i.e.:

  - If you continue doing that task the way you are, what do you think will happen?
  - Is there a more efficient way of doing that task?

- Closely observe the work being done to spot problem areas or lack of understanding

B) In particular, the trainer(s) should watch out for the following:

- proper concrete mixture

- concrete not too watery

- concrete thoroughly mixed

- concrete well tamped around rebar and forms but not over worked

10) Application Time: 10 min.

Ask what the participants learned during the session. In what areas did they have difficulty? In what areas do they think they need more practice?

11) Closure Time: 20 min.

A) Review the objectives of the session. Ask how each one was met or not met. Pass out the Handouts 5-5, 5-6, 5-7, 5-8: Constructing the Apron, and 5-9: Concrete Primer for the participants' information.

B) Pass out Handout 5-10: Instrument for Assessing Project Feasibility, and make the following points:

- The project feasibility instrument is a model that we will use, develop and apply to the decision making process you choose in deciding whether and how to proceed with a handpump project.

- As you will notice, there are five general areas listed with specific items under each one. The five areas for assessment are:

  - well characteristics
  - water characteristics
  - location of well
  - community interest and support
  - community resources

- We will discuss the project feasibility instrument in depth in the next session. The task between now and the next session is to decide why each item listed in the instrument is important and what criteria could be used to analyze the information once it has been gathered.

C) Take an example from the model project feasibility instrument to further explain the task (see Trainer Reference Sheet 9 at the end of this session). This model is to be used only by the trainer to assist in explaining Handout 5-10.

D) Give the following instructions:

- Fill out column C (why important) and column D (criteria) individually.

- Be ready to give your answers in the next session.

MATERIALS

1. The materials and tools needed in the session are listed in detail in "Materials and Tools" found after the Trainer Notes for this Session.

2. Handout 5-1: Constructing Hand Dug Wells

3. Handout 5-2: Lining an Existing Well

4. Handout 5-3: Repairing the Lining of an Existing Well

5. Handout 5-4: Possible Apron Design

6. Handout 5-5: Dug Well: Steps for Constructing an Apron for a Dug Well

   Handout 5-5: Drilled Well: Steps for Constructing an Apron for a Drilled Well

7. Handout 5-6: Dug Well: Team Work Plan Guide #1

   Handout 5-6: Drilled Well: Team Work Plan Guide #1

8. Handout 5-7: Dug Well: Team Work Plan Guide #2

   Handout 5-7: Drilled Well: Team Work Plan Guide #2

9. Handout 5-8: Constructing the Apron

10. Handout 5-8: Mark II: Constructing the Apron

11. Handout 5-9: Concrete Primer

12. Handout 5-10: Instrument for Assessing Project Feasibility

13. Flipchart paper

14. Marker pens

15. Tape

16. Flipcharts prepared for:

    - session objectives
    - lecturette on well construction and lining (step 2)
    - construction steps (step 3 and step 6)
    - team work plans (step 4 and step 8)

TRAINER NOTES

1. If time and conditions permit, take the participants to sites with wells in different stages of construction and lining or several times to one well at different stages of construction and lining during the two weeks of the workshop.

2. For the field work the tools and materials need to be brought to the site before the session begins. A participant from each team should be made responsible for bringing the tools from the storeroom and returning them when the session is over.

Materials and Tools*

Materials	Quantity	Tools	Quantity**
Cement	(Depends on well and apron size)	Trowel	3
Sand		Shovel	4
Gravel		Bucket	4
Planking (dug well)		Wood Saw	2
Joists (if well over 1 meter diameter - dug well)		Square	2
		Tape measure	4
Rebar (dug well)		Key hole saw (dug well)	1
Tying wire (dug well)		Marker or pencil	4
Anchor bolts		Hammer	2
Straw or burlap		Clear plastic hose or level	1
		Wire brush	3
		Hack saw (dug well)	3
		Wire cutter (dug well)	3
		Pliers (dug well)	4
		Rebar benders (dug well)	1
		Pick/maddox	2

*The materials and tools listed are representative of those needed to construct the apron for a dug well. Those items used only for dug wells are indicated by the note, "dug well." Material and tool requirements may need to be modified depending on the well and form requirements.

**Quantities listed are per work site. If there are two or more work sites, the quantities should be increased proportionately.

Trainer Reference Sheets for Step 3

(Dug Well - Ground Level Apron Design)

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
  - remove all vegetation
  - remove all loose soil
  - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
  - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
  - most large forms will be built in place
  - assemble other form on flat surface to minimize warpage during assembly

D) Cut and place planking over well opening:

- Why? - to support concrete while it hardens and cures
- Key points to remember:
  - planking must be adequately supported
  - planking must be easy to remove when apron has cured

E) Locate and place pipe section and access hatch form:

- Why? - pipe section provides water barrier and acts as form for concrete to make hole for suction or drop pipe; access hatch form used to make hatch opening
- Key points to remember:
  - must be sufficient space between pipe section and access hatch for cover to fit on finished well
  - both access hatch opening and pipe section located over well
  - pipe section placed over deepest part of the well

F) Cut hole under pipe section:

- Why? - for cylinder or suction pipe to pass through

G) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
  - apron form tilted to provide slope for apron
  - lowest side faces toward drain

- place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

H) cut, place and tie rebar:

- Why? - to give tensile strength to concrete (so it won't crack when in tension)
- Key points to remember:
  - rebar extends 10-15 cm past sides of well
  - rebar raised about 2 cm above the planking
  - rebar clean and free of rust

I) Place anchor bolts:

- Why? - to hold pump securely on apron
- Key points to remember
  - bolts placed so pump spout will not be over access hatch
  - use pump base as template for placing bolts if template unavailable

J) Construct access hatch cover:

- Why? - to keep people from falling in the well and to prevent contaminants from entering well through the access hatch
- Key points to remember:
  - Steps:
    - make forms
    - cut, bend, place and tie rebar
    - forms constructed to proper size so hatch fits opening
    - rebar placed 2 cm from bottom
    - rebar clean and free of rust

Trainer Reference Sheets for Step 3

(Drilled Well - Ground Level Apron Design)

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
  - remove all vegetation and loose soil
  - slope the area toward the drain with a 1:30 slope
  - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
  - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
  - assemble form on flat surface to minimize warpage during assembly

D) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
  - place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

E) Place anchor bolts:

- Why? - to hold pump securely on apron
- Key points to remeber
  - bolts placed so pump spout will face toward drain
  - use pump base as template for placing bolts

Trainer Reference Sheets for Step 3

(Drilled Well - Mark II Pump)

A) Clear and level the apron site:

. Why? - to give firm foundation to apron
. Key points to remember:
  - remove all vegetation and loose soil
  - slope the area toward the drain with a 1:30 slope
  - tamp the soil

B) Excavate pit around casing pipe

. Why? - to provide large, sturdy foundation for pump

C) Fill pit with concrete, place pump pedestal

. Why? - to firmly anchor pump

. Key points to remember

  - factors that influence concrete strength:
    - quality of water, aggregate
    - quantity of water
    - mixture of cement, sand and gravel
    - dropping vs. placing concrete
  - tamp concrete to fill voids
  - pedestal must be level (vertical)
  - cover pedestal so children can't put stones in the well

D) Measure and cut form material:

. Why? - so finished concrete apron will be desired size and shape
. Key points to remember:
  - cut all edges square

E) Assemble forms:

. Why? - to hold wet concrete in place
. Key points to remember:
  - assemble form on flat surface to minimize warpage during assembly

F) Place apron forms:

. Why? - to give shape to concrete
. Key points to remember:
  - place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

Trainer Reference Sheets for Step 4

(Dug Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A: Apron Form Group	• clear and level site	30 minutes
	• measure and cut apron forms	40 minutes
	• assemble forms	20 minutes
	• cut, place and tie rebar for apron (Help Group B)	1 hour
Group B: Planking	• cut and place planking over well	1 hour
	• construct access hatch opening form	15 minutes
	• locate and place pipe section and access hatch	10 minutes
	• cut hole under pipe section	10 minutes
	• cut, place and tie rebar for apron (primary responsibility)	1 hour
	• place anchor bolts	10 minutes
Group C: Hatch Cover Group	• construct access hatch cover forms	15 minutes
	• cut, place and tie rebar for hatch cover	1 hour
	• cut, place and tie rebar for apron (Help Group B)	1 hour

Trainer Reference Sheets for Step #4

(Drilled Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A: Clear and Slope Group	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	30 minutes
	• place anchor bolts	5 minutes
Group B: Form Group	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes

Trainer Reference Sheets for Step 4

(Drilled Well - Mark II Pump)

Group	Task	Approximate Time
Group A:	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	20 minutes
	• excavate pit	20 minutes
	• place pump pedestal	15 minutes
Group B:	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes
	• mix and place concrete for pedestal	30 minutes

Trainer Reference Sheets for Step 5

(Dug Well - Ground Level Apron Design)

A) Apron Form Group:

- apron area properly sloped (Approx. 1:30), well tamped, without low spots

B) Planking Group:

- safety as the participants work over an open well
- planking firmly supported and reinforced
- planking and supports constructed for easy removal after concrete sets
- access hatch located far enough from pipe section so access hatch cover will fit without touching the pump base
- access hatch and pipe section located over well opening
- rebar properly spaced and tied
- anchor bolts properly spaced and leveled

C) Hatch Cover Group:

- form constructed to fit over lip of access hatch on well
- rebar not touching form, properly spaced and tied
- rebar properly bent for handle

Trainer Reference Sheets for Step 5

(Drilled Well - Ground Level Apron Design)

When conducting the field work, the trainer(s) should watch out for the following:

A) Clear and Slope Group

- apron area evenly sloped

B) Form Group

- forms square and well braced

Trainer Reference Sheets for Step 5

(Drilled Well - Mark II Pump)

When conducting the field work, the trainer(s) should watch out for the following:

A) Group A

- apron area evenly sloped
- pump pedestal level

B) Group B

- forms square and well braced
- concrete made with correct mixture and not too watery

Trainer Reference Sheets for Step 6

(Dug Well - Ground Level Apron Design)

A) Mix and place concrete for apron:

- Why? - makes durable, relatively inexpensive apron
- Key points to remember:
  - factors that influence concrete strength
    - quantity of water
    - quality of water, aggregate
    - mixture of cement, sand and gravel
    - dropping vs. placing concrete
  - mark depth of concrete on inside of forms
  - tamp concrete so it fills out forms and flows around rebar
  - level low spots in concrete
  - finish concrete because plaster wire not be applied to surface

B) Mix and place concrete for access hatch cover:

- Why? - make durable, relatively inexpensive cover that can be made with materials already at site
- Key points to remember:
  - factors that influence concrete strength same as for apron
  - fill forms to top
  - tamp concrete so it fills out form and flows around rebar

C) Cover concrete for curing:

- Why? - concrete continues to gain strength as long as it is wet
- Key points to remember:
  - do not walk on concrete until it has cured 24 hours

Trainer Reference Sheets for Step 6

(Drilled Well - Ground Level Apron Design and Mark II Pump)

A) Mix and place concrete for apron:

- Why? - makes durable, relatively inexpensive apron
- Key point to remember:
  - factors that influence concrete strength:
    - quantity of water
    - quality of water, aggregate
    - mixture of cement, sand and gravel
    - dropping vs. placing concrete
  - mark depth of concrete on inside of forms
  - tamp concrete so it fills out forms
  - level low spots in concrete
  - finish concrete because plaster will not be applied to surface

B) Cover concrete for curing:

- Why? - concrete continues to gain strength as long as it is wet
- Key points to remember:
  - do not walk on concrete until it has cured 24 hours

Trainer Reference Sheets for Step 8

(Dug Well - Ground Level Apron Design)

Group	Task	Time
Group A	• mix and place concrete for apron	
Apron Group	- clear mixing site	10 minutes
	- bring sand, gravel, cement, water	ongoing
	- mix concrete	ongoing
	- transport concrete to apron area	ongoing
	- place and tamp concrete	ongoing
	- place secondary froms (to make lips around access hatch and apron's outer edge)	10 minutes
	- finish concrete surface	20 minutes
	- cover concrete for curing	10 minutes
Group B	• mix and place concrete for access hatch cover	
Hatch Cover Group	- clear mixing site	5 minutes
	- bring sand, small gravel, cement, water	15 minutes
	- mix concrete	20 minutes
	- transport concrete to hatch cover	ongoing
	- place, tamp and finish concrete	20 minutes
	- cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

Trainer Reference Sheets for Step 8

(Drilled Well - Ground Level Apron Design and Mark II Pump)

Task	Approximate Time
Clear mixing site	10 minutes
Bring sand, gravel, cement, water	ongoing
Mix concrete	ongoing
Transport concrete to apron area	ongoing
Place and tamp concrete	ongoing
Place secondary forms (to make lip around apron)	10 minutes
Finish concrete surface	20 minutes
Cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

"Model" Instrument for Assessing Project Feasibility

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
Well Characteristics	• Yield of well	To determine if well can support the intended number of users Is there enough water?	Must provide adequate water for number of users based on well recharge rate chart.	• Measure recharge rate	Can have impact on both whether to proceed with particular village and how to proceed dependent upon if there are other well sites and/or resources for drilling If insufficient recharge for the number of users, decide with villagers whether to increase the recharge rate by additional drilling, digging, etc. or to select another site	
	• State of disrepair of well	A well in "good" repair will cost less and require less manpower and time to prepare for receiving a handpump	Dependent upon the resources available that can be provided by village, extension worker, and water agency Well in better state of repair should be chosen over one in worse state if all other factors are equal	• Examine well for decayed, cracked or missing lining and/or casing	Can have impact on both whether to proceed with particular village and how to proceed dependent upon resources available and if wells in better state of repair are acceptable.	
	• Type of well and diameter	For cost estimation and construction planning Diameter of well influences apron diameter or width which affects cost and construction design.		• Observation • Measurement	Has impact on how to proceed A large well diameter may require special technique for construction (for example, additional re-bar or special reinforcement) May impact on whether to proceed with very large diameter well if significantly smaller well is available and suitable.	
Water characteristics	• Chemical water quality	To determine if water is safe to drink	Meets specifications set by water agency.	• Test water with test kit	Can have impact on both whether to proceed with particular village and how to proceed dependent upon if there are other well sites in village with acceptable water quality or if resources exist to drill deeper	
	• Taste, odor and appearance of water	Water that tastes, smells, or looks "unacceptable" will not be used	Users must like taste, smell and odor of water to use water for drinking	• Ask users	Can have impact on both whether to proceed with particular village and how to proceed dependent upon if taste can be improved or if another well site exists. If water taste unacceptable, determine why Try to determine if bad taste is due to a factor that can be corrected by installing an apron and handpump Look for other sites if taste cannot be improved.	
Location of well	• Distance from source of contamination	To prevent contaminants from entering the well.	Distance of 15 meters or distance specified by water agency	• Measure distance from well to source of contamination	If source of contamination too close move source or select another well Can have impact on both whether to proceed with a particular village and how to proceed dependent upon whether source of contamination can be removed or if other well sites exist	
	• Accessibility	All users have unhindered access. Site convenient to users. Site accessible for repairs	• Located on public land • Centrally located • Accessible to repair equipment • Near road or path and not "fenced in" by houses. No heavy under bush near well	• Observation • Ask users	Has impact on both whether to proceed with a particular village and how to proceed dependent upon if arrangements can be made for "donating" private land and guaranteeing access or if another well site exists Also dependent upon opinions of users.	
	Above known flood level	So well will not be recontaminated with flood waters	Well should be above seasonal (or longer) flood levels	• Ask users	Has impact on how to proceed Well site below known flood level should be built up or a new, higher well site selected.	
	On small hill	So water can drain away.	Water should drain away from well site.	• Observation	Has impact on how to proceed Well site can be built up so that a small mound is created	
Community Interest and Support	Interest of village leadership and villagers in under taking project	To insure the support over time for the project.	Response of village leadership in initial meeting	• Hold meeting • Ask elders, school teachers, village based health workers about past efforts.	Has impact on both whether to proceed with a particular village and how to proceed depending upon if leadership states it is or is not interested If lack of immediate positive response it could indicate more information and time is needed by village for decision-making	
	Number of users	Needed to determine sufficient recharge rate, project should serve as many people as possible	Number of users should be suitable for recharge rate. There should be less than 200 users per well site.	• Ask village leadership, school teacher, elders, health worker, users • Use records that indicate village population	Have both impact on whether to proceed with a particular village and how to proceed dependent on whether recharge rate is too low to serve number of users and no other well sites are available	
	Potential for water committee or other responsible organization	To manage water project fees, maintenance, repair, user education.	Positive response of village leadership in initial meeting Existance of other village committees or management groups	• Talk to villagers, health workers, teachers, and leaders about success of past development projects	Has impact on how to proceed A village with less experience in managing projects will require a different approach and strategy on the part of the extension worker than one that does Has impact on how to proceed Village that has difficulty in suggesting candidates for caretaker(s) or has no members with current maintenance skills will require a different approach and strategy than one that does	

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
	Potential for village based maintenance capability	To maintain pump and well with less outside assistance	Positive response of village leadership in initial meeting. Ability to suggest candidates for caretaker(s)	• Observe types of equipment in village and repair shops to determine present maintenance skill level • Ask village leadership	Has impact on how to proceed Village that has difficulty in suggesting candidates for caretaker(s) or has no members with current maintenance skills will require a different approach and strategy than one that does.	
	Interest in supporting/ promoting user education	To lengthen life of pump through proper usage To maintain site To promote use of improved water source To maximize benefits to users of improved water source To increase likelihood of early problem identification and problem solving.	Positive response of village leadership in initial meeting	• Hold meeting • Ask users, health workers, about their interest and also success of past programs with user education components	Has impact on how to proceed If leadership and users are not responsive, extension worker will have to design appropriate strategy	
Community Resources	• Available labor	To promote village involvement and sense of ownership and to reduce project cost to water agency	Availability of 1 skilled, 2 unskilled laborers	• Hold meeting and ask village leadership about availability.	Can have impact on whether to proceed with particular village depending upon "requirements" of water agency.	
	• Available materials	Same as above.	Availability of approximately 1 cubic meter sand and 2 cubic meters gravel for 4 meter diameter apron and well site completion.	• Same as above.	Has impact on how to proceed. Plans would have to be made for locating alternative sources.	
Community Resources (Cont'd)	• Ability to pay users fees or other costs (if appropriate)	Same as above	Positive response of village leadership. History of ability to raise and manage local funds	• Hold meeting. • Ask elders, school teacher, village-based development workers about past efforts.	Can have an impact on both whether to proceed with particular village and how to proceed depending upon "requirements" of water agency. A village with less experience in this area would require a different approach on part of extension worker than one with more.	

Water for the World

Constructing Hand Dug Wells
Technical Note No. RWS. 2.C.1

Proper construction of a hand dug well is important to ensure a year-round supply of water and to protect the water from contamination. Construction involves assembling all necessary personnel, materials, and tools; preparing the site; excavating the well shaft; and lining the shaft. Finishing the well is discussed in "Finishing Wells," RWS.2.C.8.

There are several good methods to construct a hand dug well; if you are familiar with a specific method, use it. This technical note describes one method of construction, using locally available materials, that has been employed successfully in a number of countries. Read the entire technical note before beginning construction.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

CONTAMINATE - To make unclean by introducing an infectious (disease-causing) impurity such as bacteria.

GROUND WATER - Water stored below the ground's surface.

KIBBLE - A large bucket for lifting materials when sinking a shaft; also called a hoppit or sinking bucket.

POROUS - Having tiny pores, or spaces which can store water or allow water to pass through.

WATER TABLE - The top, or upper limit, of an aquifer.

Materials Needed

The project designer must provide three papers before construction can begin:

1. A location map similar to Figure 1.

2. A design drawing similar to Figure 2.

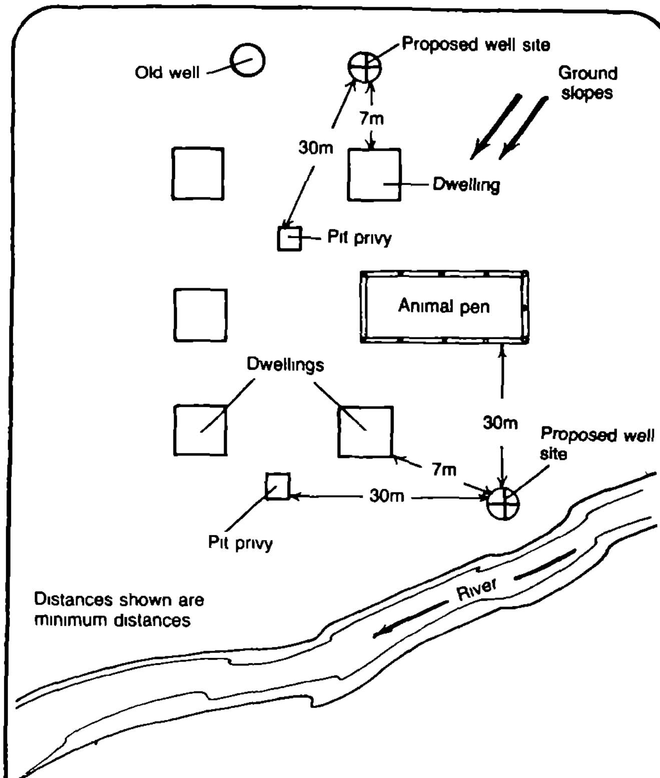


Figure 1. Location Map

3. A materials list similar to Table 1.

After the project designer has given you these documents and you have read this technical note carefully, begin assembling the necessary workers, supplies, and tools.

Construction Schedule

Depending on local conditions, availability of materials, and skills of workers, some construction steps will require only a few hours, while others may take a day or more. Read the construction steps and make a rough estimate of the time required for each step based on local conditions. You will then have an idea of when specific workers, materials, and tools must be available during the construction process. Draw up a work plan similar to Table 2 showing construction steps.

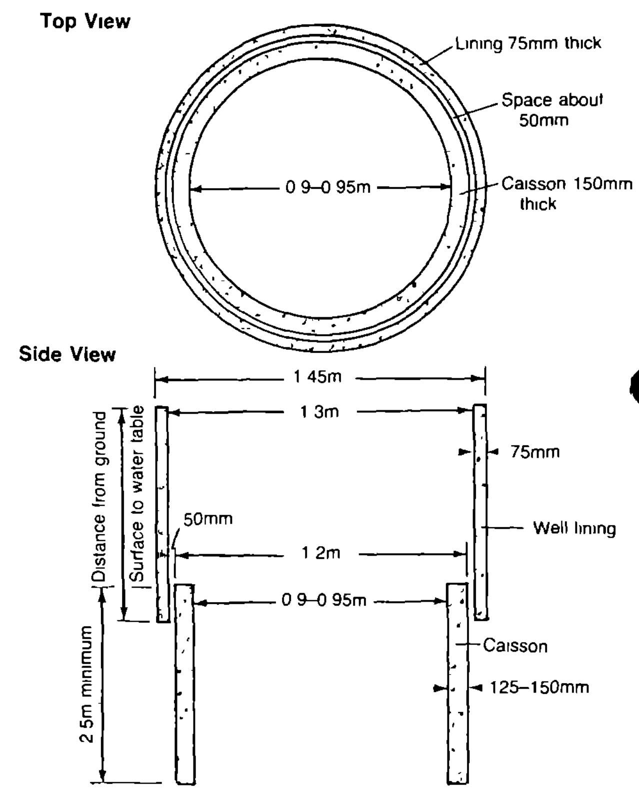


Figure 2. Design of Well Lining and Caisson

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Personnel	Foreman	1	____
	Worker, skilled in sinking well	1	____
	Worker, experienced with concrete	1	____
	Workers, unskilled	2-4	____
Supplies	Cement (Portland)	____kg	____
	Sand (clean; fine to 6mm)	____m3	____
	Gravel (clean, 6-36mm)	____m3	____
	Water (clean and clear)	____	____
	Re-rod for lining: 8mm diameter	____m	____
	Re-rod for caissons· 15mm diameter	____m	____
	Materials for storage shed	____	____
Equipment	Headframe	____	____
	Rope for caissons; 100m x 12mm diameter, steel wire with fiber core, tensil strength 7kg/cm^2	____	____
	Rope for kibbles. 100 x 6mm diameter	____	____
	Rope for trimming rods: 100m x 3mm diameter	____	____
	Steel shutters (1.3m diameter x 0.5m high) with wedges and bolts	____	____
	Steel shutters (1.3m diameter x 1.0m high) with wedges and bolts	____	____
	Steel molds for caisson rings (1.2m outside diameter, 0.95m inside diameter, 0.5m high)	____	____
	Templates for molds	____	____
	Stretcher for caissons	____	____

Total Estimated Cost = ____

Table 2. Sample Work Plan for a Hand Dug Well

Time Estimate	Day	Task	Personnel	Materials/Tools
1 day	1	Locate and prepare well site, assemble materials	Foreman (present during entire construction), 2-4 workers	Measuring tape, drawings, tools and materials for building shed
1 day	2	Erect headframe, set center point and offset pegs, build mixing slab	2-4 workers	Headframe, plumb bob, re-rod; cement, sand, gravel, water, trowel
4 hours	3	Dig shallow excavation, install temporary lining	2-4 workers	Shovels, shutters (1.3m diameter, 1.0m high) spirit level
7 days	3-9	Excavate and trim first lift	4 workers	Shovels, picks, mattock, kibble, top plumbing rod, trimming rods
2 hours	10	Install first set of shutters	4 workers	Shutters (1.3m diameter, 0.5m high), spirit level, trimming rods, shovel
6 hours	10	Install vertical and horizontal re-rods	4 workers	Lengths of re-rod; binding wire, spacing blocks and holding hooks, wire cutters
1 day	11	Install second set of shutters, pour concrete, build curb	4 workers	Oiled shutters (1.3m diameter, 1.0m high), cement, sand, gravel, water, tamping rod, re-rod, burlap covering, mattock
1 day	12	Install third and fourth sets of shutters, pour concrete	4 workers	Sets of oiled shutters, cement, sand, gravel, water
2 days	13-14	Widen top of well, add re-rods, install fifth and sixth sets of shutters, pour concrete, bend back rods and cover with layer of weak mortar	4 workers	Burlap covering, mattock, re-rod, binding wire, sets of oiled shutters, cement, sand, gravel, water
---	---	Construct second and third lifts and lining as needed	4 workers	Materials and tools as needed
1 day	15	Build caisson rings	4 workers	Molds, re-rods, oiled pipes, templates, cement, sand (none if porous concrete), gravel, water
10 days	16-25	Cure caisson rings	----	Wet burlap or straw
2 days	26-27	Install caisson rings	4 workers	Stretcher, spacers, heavy planks, wrench, mortar, trowel
2 days	28-29	Sink caissons into aquifer	4 workers	Shovels, kibble
2 hours	30	Install base plug	4 workers	Precast base plug

Caution!

1. Workers in the well shaft should wear hard hats for protection.

2. Workers at ground level must be careful not to accidentally drop or kick tools or other materials into the well shaft.

3. A kibble, rather than a bucket or basket, should be used to hoist soil out of the shaft.

4. The well must be dug at the exact location specified by the project designer.

Construction Steps

1. Using the location map and a measuring tape, locate the well site. Clear the area of any vegetation or debris that might interfere with work.

2. Assemble all laborers, materials, and tools needed to begin construction and arrange the materials in a fashion similar to Figure 3. A proper layout will save time and effort during later construction steps. A shelter should be built to protect tools and some materials from the weather, theft, or being misplaced.

Because the caisson rings must be cured for at least 10 days before they can be lowered into the well shaft, build them first even though they will not be needed until later in the construction process. See step #26.

3. Erect the headframe over the site of the well. The headframe must be sturdy enough to support the caisson rings, which may weigh over 350kg. One type of headframe that has been used successfully is shown in Figure 4. It is made of angle iron and equipped with a winch and brake. The four feet of the headframe must rest on solid ground--place stone slabs or pour concrete under them if necessary. It is important that the headframe not be moved once it is in position and the center point of the well has been fixed.

4. Build a slab for mixing concrete by first leveling an area about two meters square. Spread 50mm of well-tamped gravel, cover with a layer of cement mortar (4 parts sand to 1 part cement), and smooth with a trowel. Form a lip around the outer edge, cover the slab with wet burlap or straw, and keep moist for two or three days.

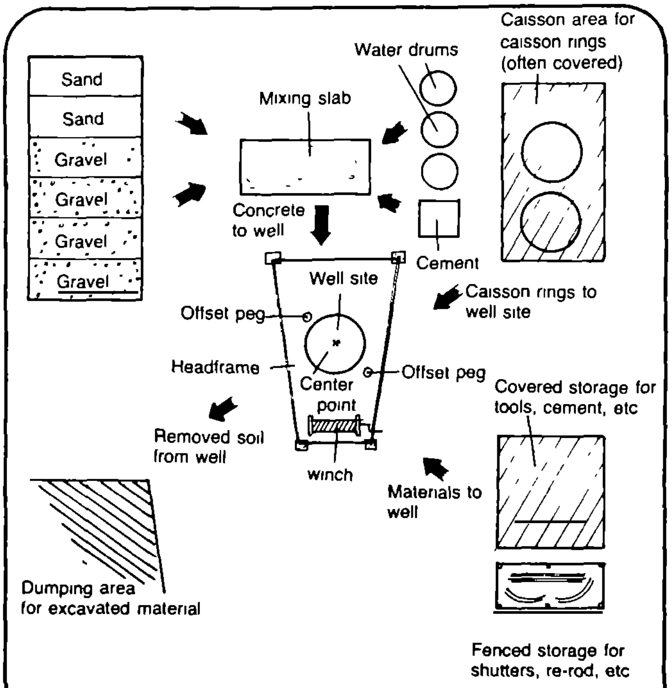


Figure 3. Layout of Well Site

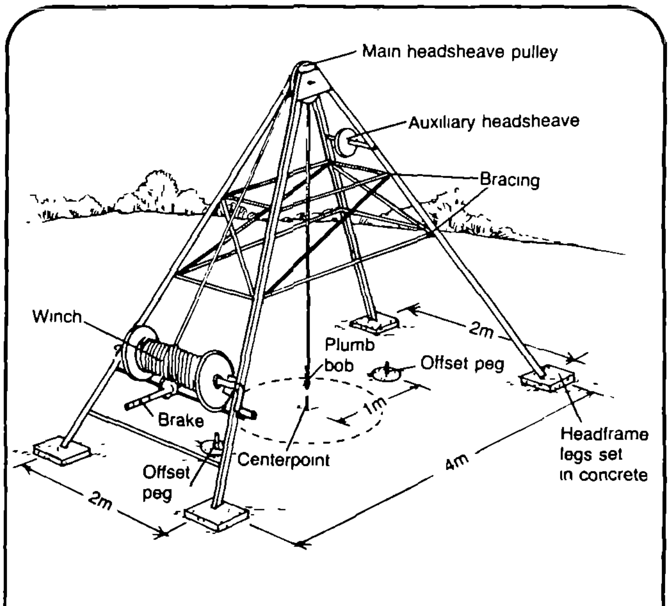


Figure 4. Headframe

5. Establish the center point of the well by lowering a plumb bob from the headsheave pulley on the side opposite the winch; that is, the side from which the main hoisting rope will descend. Mark this point on the ground with a short length of re-rod. Set offset pegs on opposite sides and exactly 1.0m from the center point. Make the top of these pegs at least 150mm above ground level to make allowance for the temporary lining that will be installed. These pegs should be set in concrete and positioned so that the top plumbing rod will fit over them as in Figure 4. Allow the concrete to set for several days before using the pegs.

6. Mark a circle of 650mm radius around the center point. Carefully excavate within this circle to a depth of 0.9m. Position a set of steel shutters 1.3m in diameter and 1.0m high inside this hole with 100mm projecting above ground to act as a temporary lining. See Figure 5. Be certain that the shutters are exactly in place and that the top is level. Firmly tamp soil around the outside. These shutters will prevent the top of the shaft from crumbling, and they will reduce the risk of tools or materials being accidentally kicked into the shaft.

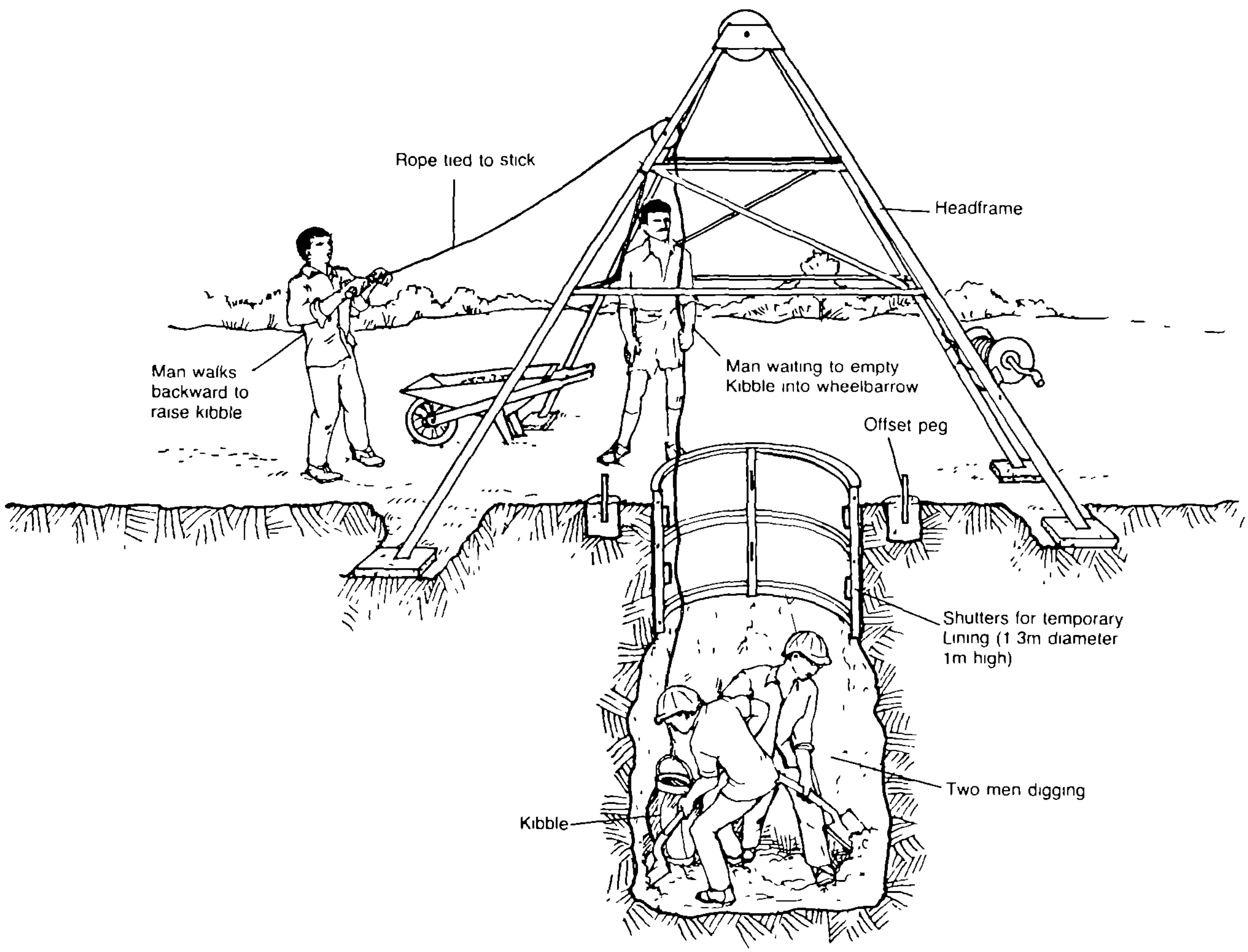


Figure 5 Excavating the Shaft

7. Begin excavating the first lift of the well. Normally, two workers using miner's picks and bars and short-handled shovels excavate the soil in layers about 100mm deep, and they keep the bottom of the excavation fairly level at all times. Soil is removed by hoisting it up in a kibble, as shown in Figure 5. The shaft is dug somewhat less than its finished diameter of 1.45m.

Every meter or so the long trimming rods, 1.45m long, are suspended from the top plumbing rod. The workers carefully trim the walls of the shaft so that the trimming rods can freely turn with their ends just missing the shaft walls, as shown in Figure 6. It is important that the trimming be done with extreme care, for even a small addition to the thickness of the lining will increase the amount of concrete used.

Depending on the condition of the soil, the first lift can be dug as deep as 5.0m, 4.1m below the bottom of the temporary lining. If the soil is crumbly or tends to cave in, the lift must be shallower. If water is struck, stop the excavation and proceed to step 25.

8. A set of shutters, 1.3m in diameter and 0.5m high, is oiled and then lowered to the bottom of the shaft. Set the shutters precisely in place by suspending the short trimming rods 1.3m long and lining up the edges of the shutters directly beneath the ends of the rods. Use a spirit level to be certain that the shutters are level. It is essential that these shutters be exactly in place and perfectly level, or else the entire lining will be out of line. See Figure 7.

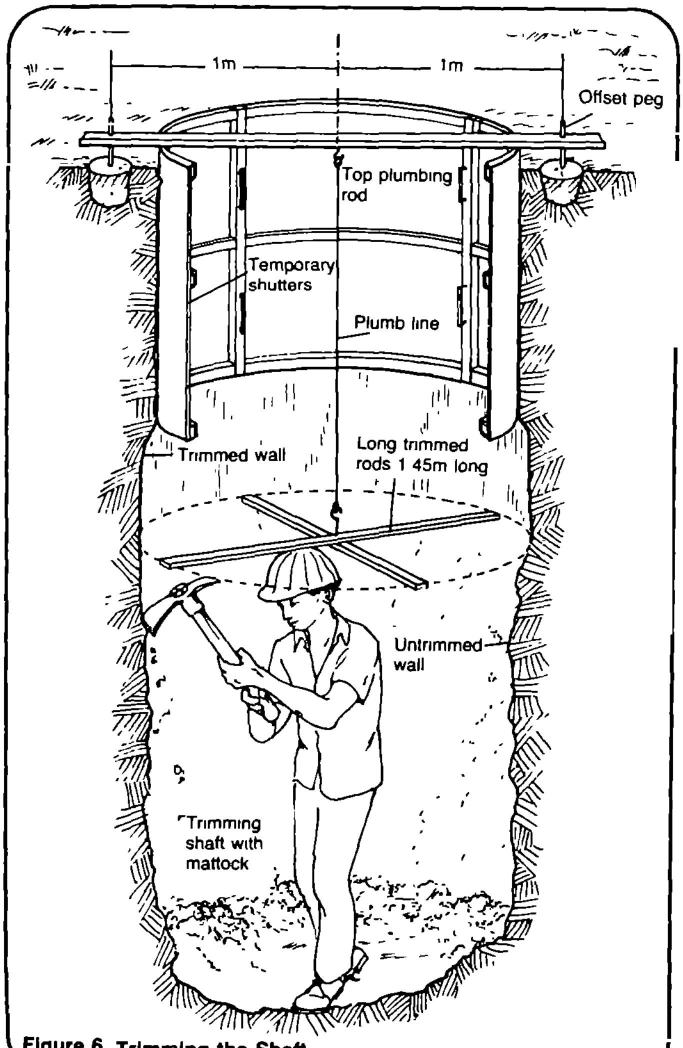


Figure 6. Trimming the Shaft

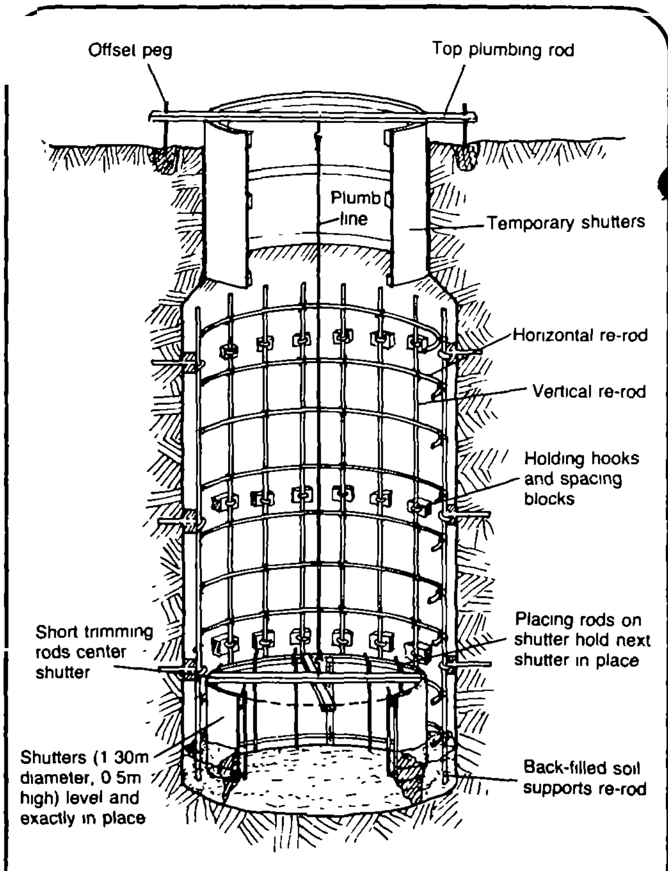


Figure 7. First Set of Shutters and Re-rod

9. Position 20 lengths of vertical re-rod, each length 4.0m long and 8mm in diameter, behind the shutters and around the shaft walls. Fix the rods to the walls about 200mm apart using spacing blocks and holding hooks. Backfill behind the shutters with soil to help hold the rods in place, as shown in Figure 7.

10. On the surface, shape horizontal re-rods into circles 1.38m in diameter. You will need three or four horizontal re-rods for each meter of depth. Lower the re-rods and fasten them to the inside of the vertical re-rods about 250-300mm apart, as shown in Figure 7. They will make the reinforcement cage strong and secure. Use a wire brush to remove all dirt from the re-rods.

11. Oil a set of shutters, 1.3m in diameter and 1.0m high, lower it into the shaft, and position it on top of the first set. Center the shutters with the short trimming rods, 1.3m long, check them with a spirit level, and bolt them in place, as shown in Figure 8.

12. Mix concrete on the mixing slab. Use one part cement, two parts sand, four parts gravel, and enough water to make a workable mix. Lower the concrete in a concrete bucket tied to a rope over the auxiliary headsheave. The main headsheave and a bosun's chair will be used later to raise and lower the workman pouring concrete. When lowering the bucket, be careful that it does not catch on any projection and spill its contents on the workers below.

Pour the concrete behind the shutters as shown in Figure 8. Pour it evenly and in shallow layers to prevent overloading one side. Tamp with a length of re-rod. Fill the space between the shutters and the shaft walls until the concrete is 10-20mm from the top of the shutters, and leave the top of the concrete rough. This will ensure a good bond with the next pour.

13. Temporarily cover the concrete with burlap or other material to keep off soil. Carefully excavate a triangular-shaped groove, 200mm deep and 200mm high at the well face, around the shaft walls just above the shutters. Set re-rod pins into the groove and fasten to the vertical re-rods. Remove the temporary cover. Fill in the groove with concrete as shown in Figure 8. This forms a curb which will help hold the lining in place and prevent it from slipping.

14. Oil the third set of shutters, 1.3m diameter and 1.0m high, lower it into the shaft, and position it on top of the second set. Center the shutters with the short trimming rods, check them with the spirit level, and bolt them in place. Pour concrete as before, and tamp to be certain all voids are filled with concrete.

15. Oil a fourth set of shutters and repeat the process of lowering and positioning them and pouring concrete as shown in Figure 8.

16. The top of the fourth set of shutters will be about 600mm below the bottom of the shutters being used for temporary top lining. Cover the concrete with burlap to keep off soil and remove the temporary lining. Excavate the sides of the well to a diameter of 1.6m from the surface of the ground down to the top of the fourth shutter. Attach lengths of vertical re-rod to the re-rod already in place. Bend the ends of all re-rods into hooks and overlap the lengths by

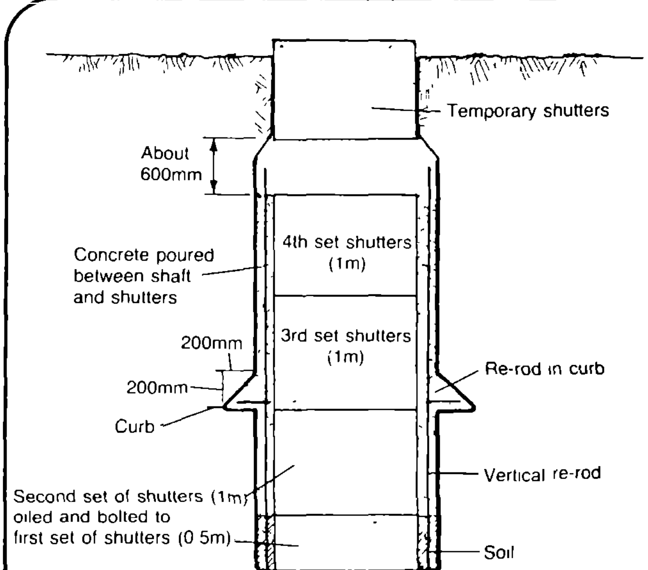


Figure 8. Shutters and Curb

at least 200mm as shown in Figure 9. The new re-rods should protrude above ground about 200mm. Position circles of horizontal re-rods 250-300mm apart and fasten them to the vertical re-rods. Remove the burlap from the concrete.

17. Oil the fifth and sixth sets of shutters in turn, set them in place, check their positioning with trimming rods and a spirit level, and bolt them together. Pour concrete as before, and carefully fill in the space behind the shutters up to ground level as shown in Figure 9. The extra thickness of concrete in the top 1.5m of the lining will provide a solid base for the wellhead. See "Finishing Wells," RWS.2.C.8.

18. Bend back the protruding vertical rods until they are level with the ground. Make a weak mortar mix (1 part cement to 15 parts sand), and use it to cover the re-rods and form a lip around the well as shown in Figure 9. This mortar layer will help keep surface water and debris out of the well, and it can be easily broken away when it is time to build the wellhead.

The first lift is now complete. Leave the shutters in place for about seven days to allow the concrete lining to cure. If you have more shutters, you can begin the second lift at once, leaving the first lift shutters in place. If not, you will have to wait seven days before beginning the second lift.

19. To begin the second lift, remove the earth-filled shutter at the bottom of the first lift, and clean the re-rods with a wire brush.

20. Excavate the second lift to a depth of 4.65m below the bottom of the concrete lining of the first lift. If ground water is encountered before you reach this depth, stop the excavation and proceed to step 25.

21. Position the vertical re-rods in the same manner used in the first lift. Bend the top ends of these re-rods into

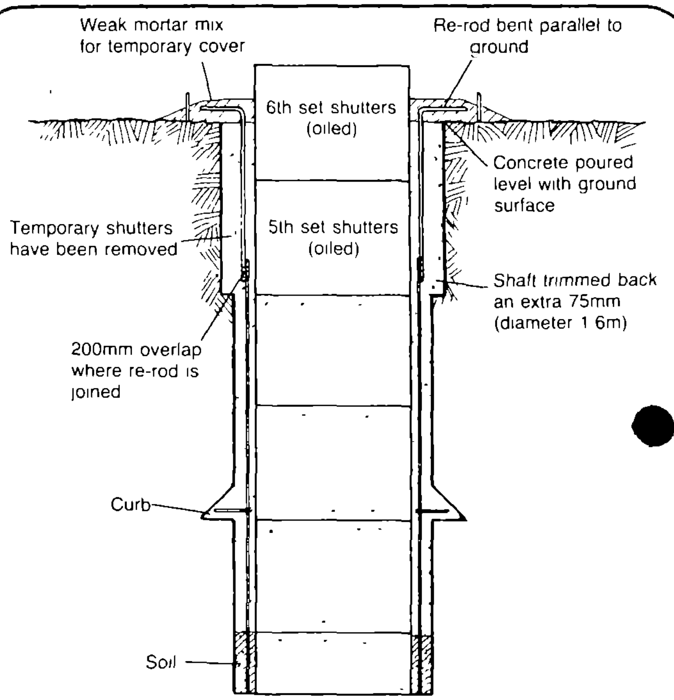


Figure 9 Completing the First Lift

hooks and leave the bottom ends of the re-rods protruding down from the concrete. The lengths should overlap by about 200mm. Fasten them together with wire. Position and fasten circular sections of horizontal re-rods in place.

22. Begin lining the second lift in the same manner as the first. Remember the first set of shutters is 0.5m high and backfilled with soil, and a concrete curb is built just above the second set of shutters.

23. There will be a gap of about 150mm between the top of the fourth set of shutters and the bottom of the concrete lining of the first lift, as shown in Figure 10. To pour concrete into this set of shutters you will need a funnel or scoop made from scrap metal. This will prevent spilling concrete.

24. The gap between lifts should be left open until the entire well is excavated and lined in case there is any movement or shifting of the lining.

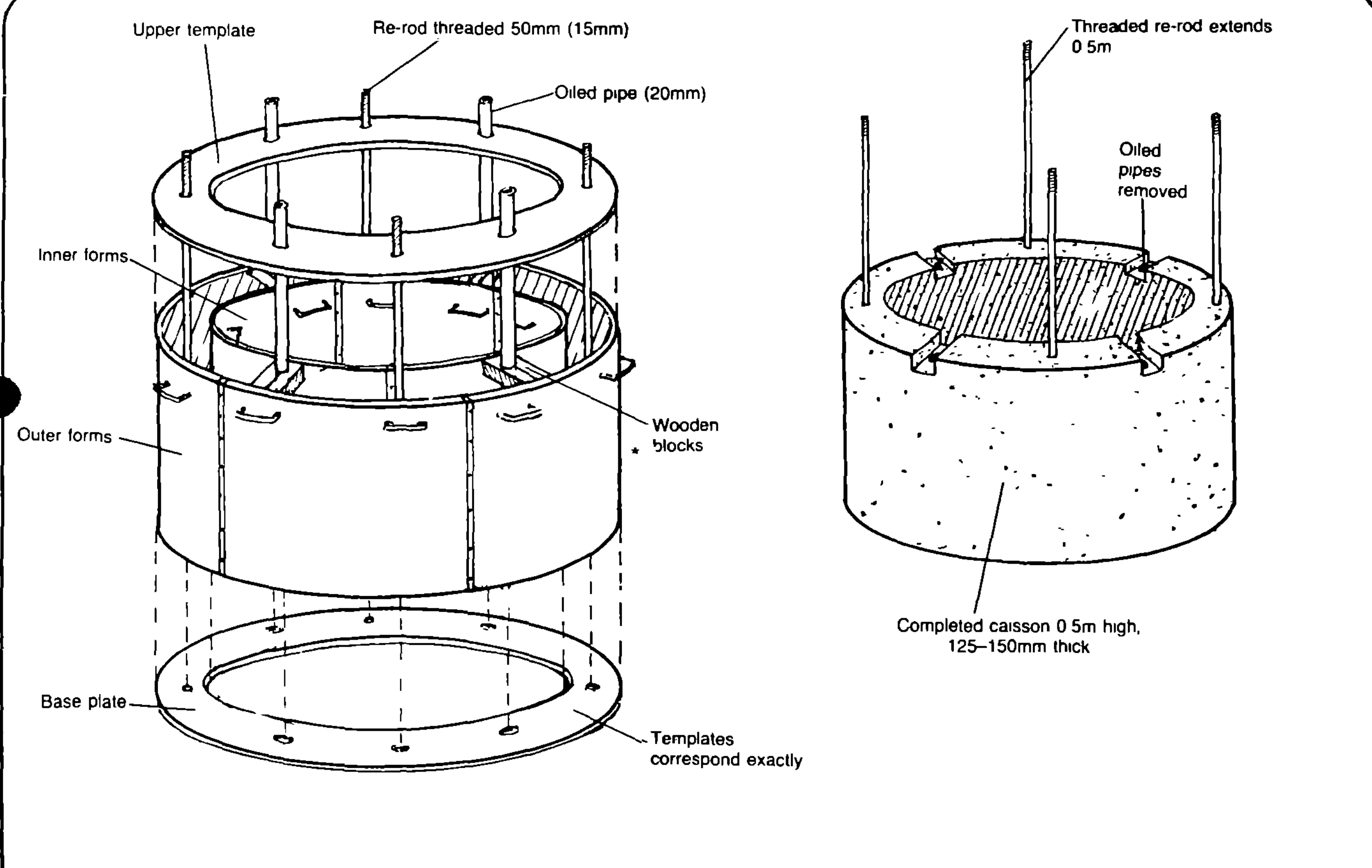


Figure 10. Casting Caissons

These gaps can be used to attach the pipe for a pump or the supports for an access ladder.

When it is time to fill the gaps, use concrete mortar and bricks or stones. Thoroughly seal the entire gap with a coating of plaster to prevent possible contamination by entry of surface water.

25. Continue the process of digging and lining until ground water is reached. If you encounter difficult ground or if the water table is reached before a full lift is excavated, the lift can be made as shallow as 650mm, 500mm for a small set of shutters and 150mm for the gap below the previous lining.

When the aquifer is reached, dig down into it to examine its composition and depth. An auger is a useful tool for this work. If the aquifer is a shallow perched layer, you must sink the well through it to a deeper aquifer. If you have indeed reached a main aquifer, line this last section of the shaft as before and build an extra-deep curb as shown in Figure 10.

26. The remainder of the well will be sunk using the caisson method. Before you can begin, the lining must be given time to harden so that you can remove the shutters. See Figure 2 for the way in which caisson rings fit into the lining.

The caisson rings may already have been cast as described in step 2. The type of rings used depends on the composition of the aquifer. The rings can be made of porous concrete, standard concrete, or standard concrete perforated with seepage holes.

26a. Cast all types of rings in a mold 0.5m high, with an outside diameter of 1.2m and an inside diameter of 0.90-0.95m. See Figure 10. If standard concrete is to be used, it can be the same mix as was used for the lining. If the rings are to have seepage holes, you must use special molds with perforations. If porous concrete is to be used, it should be made by mixing one part cement to four parts washed gravel and no sand. The mix must not be overly wet; use only enough water to make it workable. The gravel must be quite clean and of the correct size. It must all pass through a 20mm screen but none of it must pass through a 10mm screen.

26b. To ensure that the caisson rings will fit together when placed in the well shaft, equip each ring with four evenly-spaced re-rods, 15mm diameter and 1.0m long, and four evenly-spaced holes 20mm in diameter. When the rings are set one on top of the other, the re-rods from one ring will fit into the holes of the other. The holes are made with well-oiled pipes, and the pipes and re-rods are held in position by a template. A small block of wood with a hole for the pipe to pass through is positioned to form a recess in the caisson ring for a bolt which will be secured onto the end of each re-rod. Each re-rod is threaded at the top 50mm and has a hole drilled 25mm from the bottom end through which a nail or piece of thick wire is placed. This will prevent the rod from pulling out when weight is placed on it.

26c. Cast the caisson rings in the shade. Insert the re-rods and the pipes that will form the holes. If the rings are to have seepage holes, place rods or wooden pegs through the holes in the sides of the mold.

26d. When the concrete has been in the mold for 12-24 hours, remove the pipes for the holes and, if necessary, the rods or pegs for the seepage holes.

26e. The molds should not be removed for three days, and the caisson rings should not be moved during this time. If porous concrete is being used, the molds should be left in place for seven days.

26f. Remove the caisson rings from their molds. Cure the rings by keeping them moist and in the shade for seven days. If they are made from porous concrete, the rings should be cured for 14 days.

27. Roll the first caisson ring beside the well shaft and tip it on end so that the re-rods are pointing up. Lower the stretcher over two re-rods on opposite sides of the ring. The stretcher must be made of steel or wood and be capable of supporting the weight of the caisson rings, each of which may weigh over 350kg. Fit lengths of 20mm diameter pipes and washers over the re-rods so that the stretcher can be tightly bolted down as shown in Figure 10.

28. Cover the opening of the well shaft with stout logs or planks. Attach the main lowering rope to the U-bolt in the center of the stretcher. Carefully maneuver the caisson ring up onto the logs or planks until it is centered, raise it about 100mm, and remove the planks.

29. Slowly and carefully lower the ring to the bottom of the shaft. The ring must be level and perfectly centered, or you will have difficulty fitting on the other caisson rings. If necessary, raise the ring just off the bottom and wedge pieces of wood underneath until it is level and in position. Only then should you unbolt the stretcher. See Figure 11.

30. Lower the second ring in the same manner as the first. Just befor it reaches the projecting re-rods of the first ring, a worker, perhaps sitting on the stretcher, must turn it so that its holes match the projecting re-rods. Partly lower the ring onto the re-rods, then spread a 10mm layer of cement mortar on the top edge of the first ring. Lower the second ring until it rests on the first. The rods of the first ring will project up into the recesses on the top edge of the second ring. Fix bolts on the threaded ends of the re-rods and tighten until the second ring is secure and level. Fill in the recesses and cover the bolt with cement mortar.

31. Continue lowering rings and fitting them together until there are five or six rings in the shaft. See Figure 11.

32. Probe the bottom of the shaft with a pointed length of re-rod to check for hard or soft spots. When excavation starts, there may be a

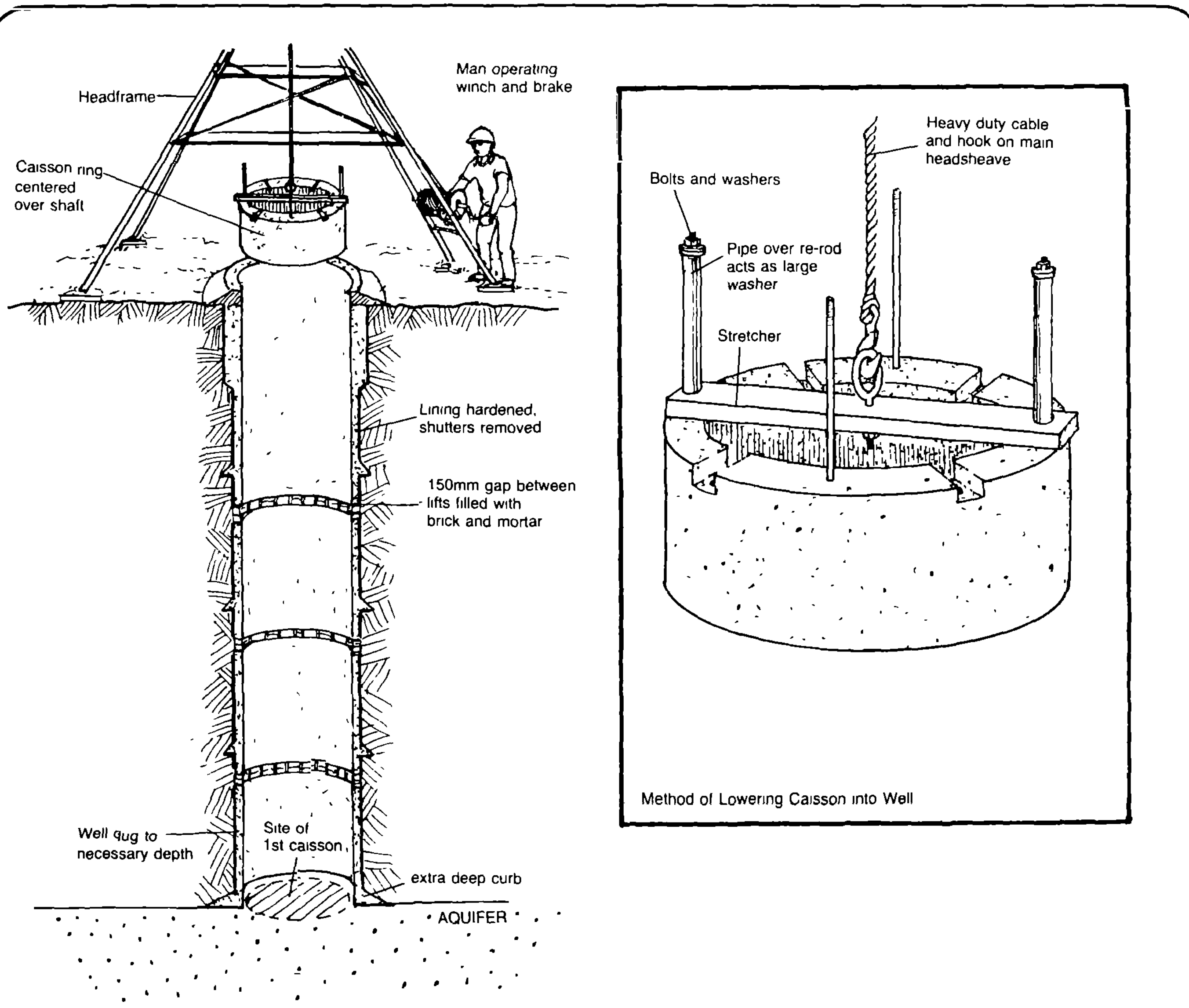


Figure 11. Installing Caissons in Completed Lining

danger that the ground will suddenly give way and that several caisson rings will drop below the bottom of the lining. This is all right as long as the top ring does not drop below the lining.

33. Begin excavating in shallow layers, first in the center of the shaft and then under the ring. Dig evenly around the ring to prevent it from sinking out of line. As you excavate, the well shaft and the caisson rings will gradually sink into the aquifer and the shaft will begin to fill with water. Dig until the water becomes too deep for working, or until you are satisfied that the well will yield sufficient water. See Figure 11.

If you wish to remove water from the shaft while excavating, bail it out with a kibble. Do not pump out water with a mechanical pump, for that can cause the aquifer to collapse.

34. Set a base plug in the bottom of the shaft as shown in Figure 12. The plug can be made of porous concrete precast at ground level, or it can be made from layers of sand and gravel. If it is precast, it should have handles for lifting and removing it. The purpose of the plug is to prevent aquifer materials from rising into the well.

35. Unless the caisson rings have been sunk during the dry season, you may have to deepen the well during

the dry season. If so, you should add more caisson rings at that time.

36. Fill the space between the caisson rings and the concrete lining with small-sized gravel.

37. To build the wellhead and finish the well, see "Finishing Wells," RWS.2.C.8.

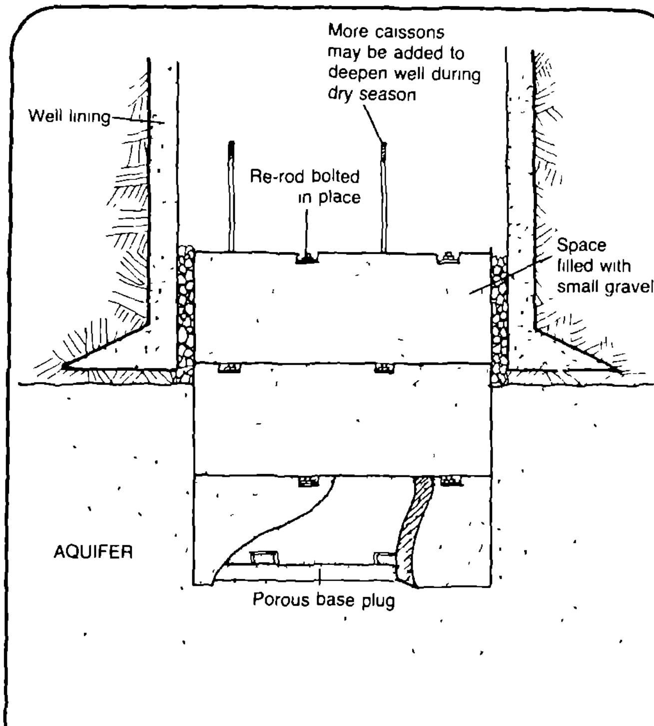


Figure 12. Caissons Sunk into Aquifer

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled "Using 'Water for the World' Technical Notes " Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D C , 20523, U S A

1982

Lining an Existing Well

1. Set up tripod over well
2. Place platform in well
3. Remove existing retaining wall
4. Excavate to desired diameter
5. Cut and place rebar
6. Place collapsable mold on platform
7. Pour first lining ring
8. Wait at least 24 hours before removing mold
9. Set mold for next lining ring
10. Pour next lining ring
11. Continue pouring lining rings until well relined to surface
12. Plaster lining as needed
13. Remove platform
14. Remove debris from well

Repairing the Lining of an Existing Well

- Determine if well lining can be repaired or should be replaced by a new lining.

- Construct scaffolding

  . Why? - to provide a firm surface from which to work on sides of the well

  . Key points to remember:
  - be careful when near an open well without a headwall
  - don't work inside well without an assistant above ground and a safety rope around waist

- Remove headwalls

  . Why? - easier to seal the well against surface contamination without headwalls, and it is easier to draw water when the users don't have to climb up or reach up to operate the pump

- Remove decaying lining

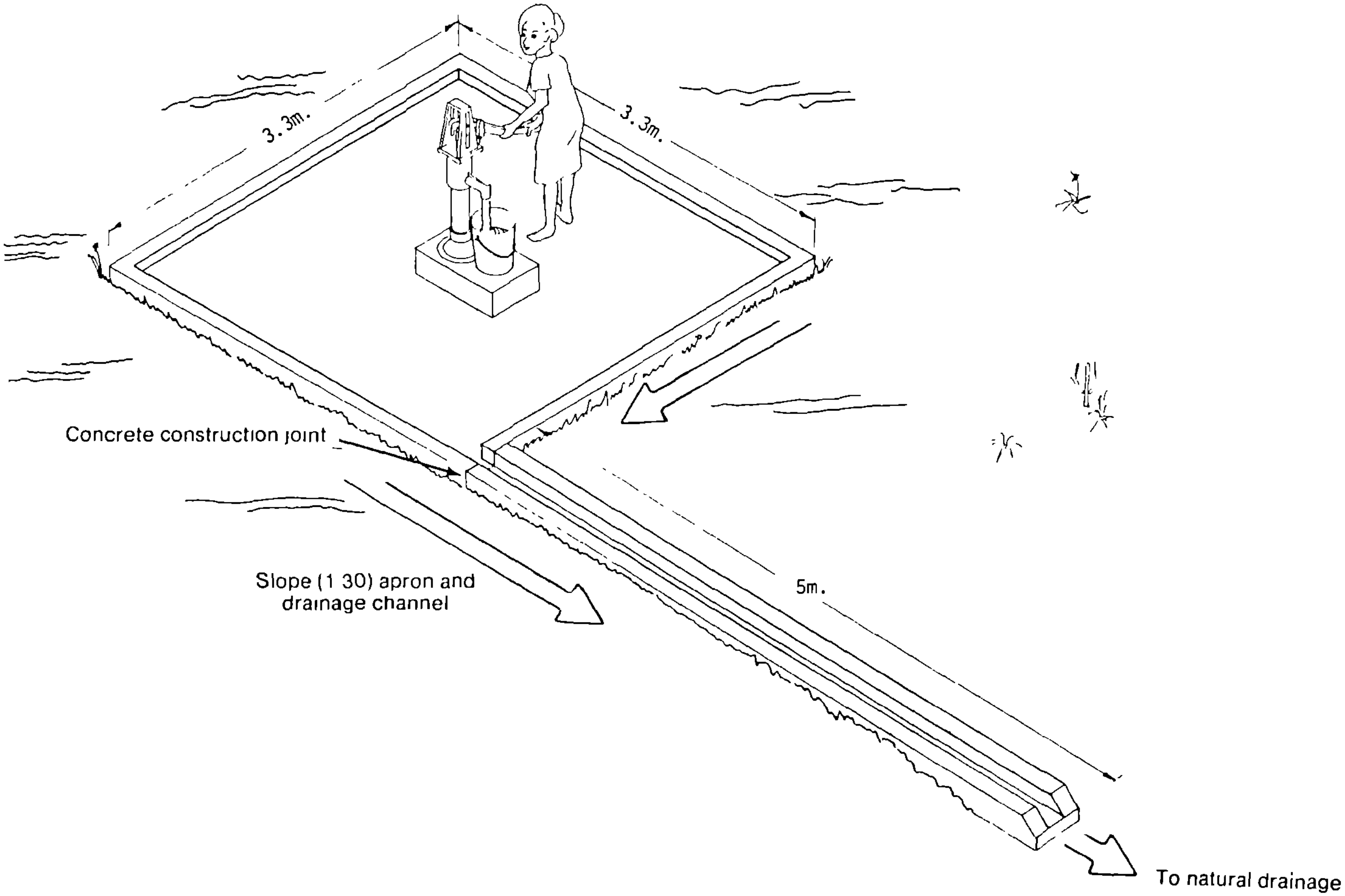
  . Why? - to provide a solid base on which to put the new lining. New lining placed over old lining will soon crack or chip off and could allow contaminated water to enter the well
  . Key points to remember:
  - don't work inside well without an assistant above ground and a safety rope around waist

- Reline the well

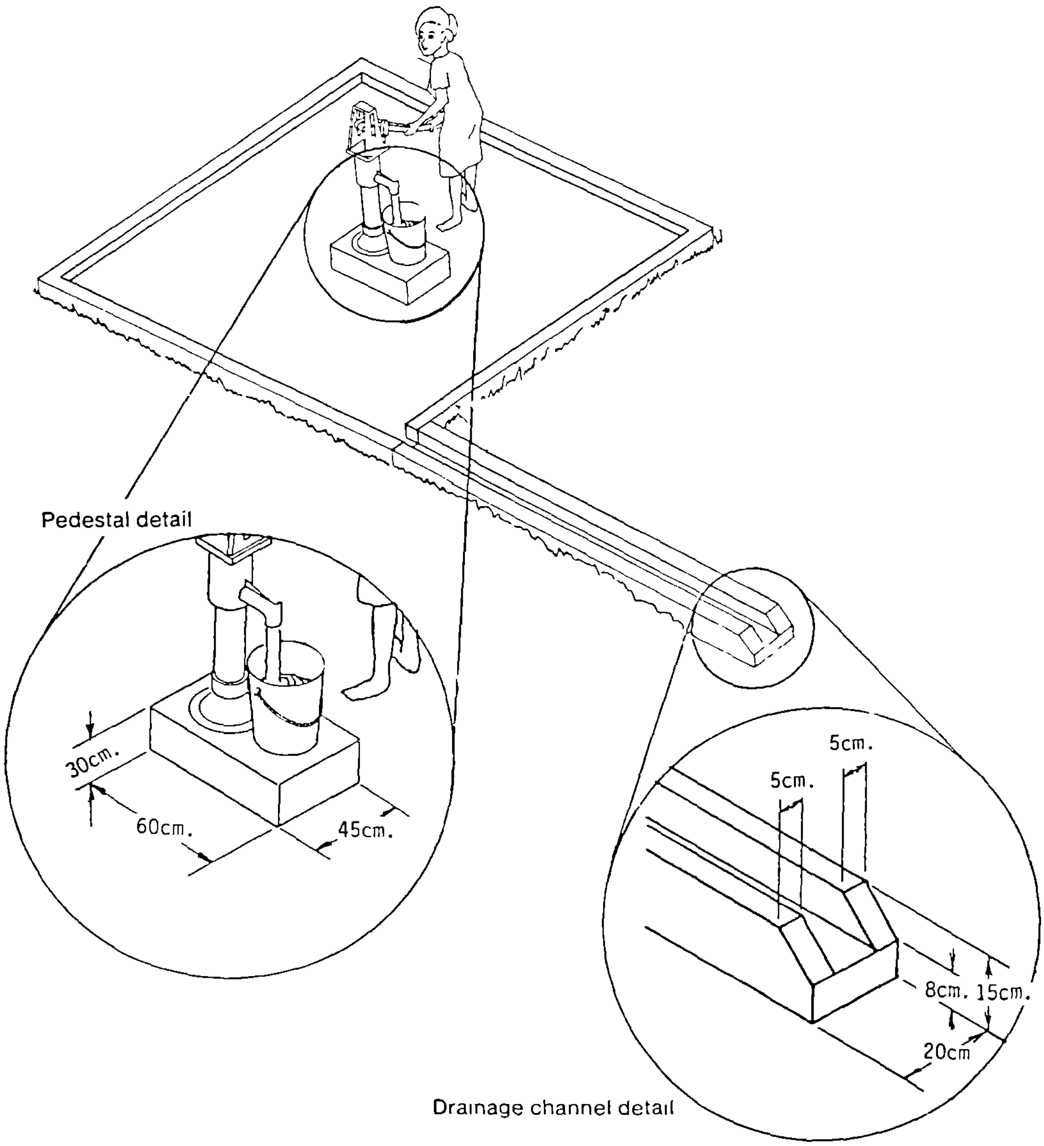
  . Why? - to prevent surface water from entering the well through the lining
  . Key points to remember:
  - don't work inside well without an assistant above ground and a safety rope around waist
  - wet wall before applying plaster
  - sling plaster onto wall for good bond and smooth out plaster with screed

- Clear debris from the well

  . Why? - to restore the storage capacity of the well
  . Key points to remember:
  - don't work inside well without an assistant above ground and a safety rope around waist

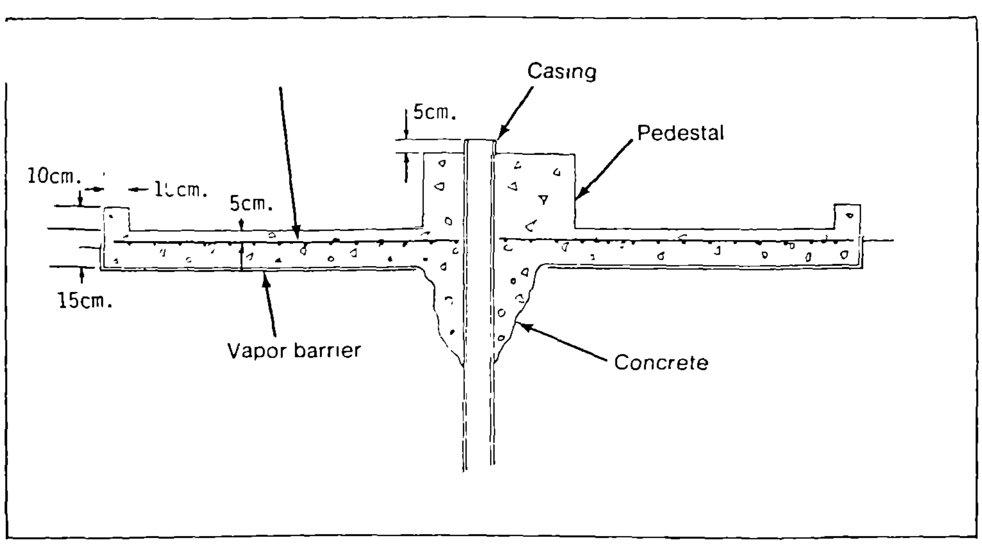


POSSIBLE APRON DESIGN, TYPE I

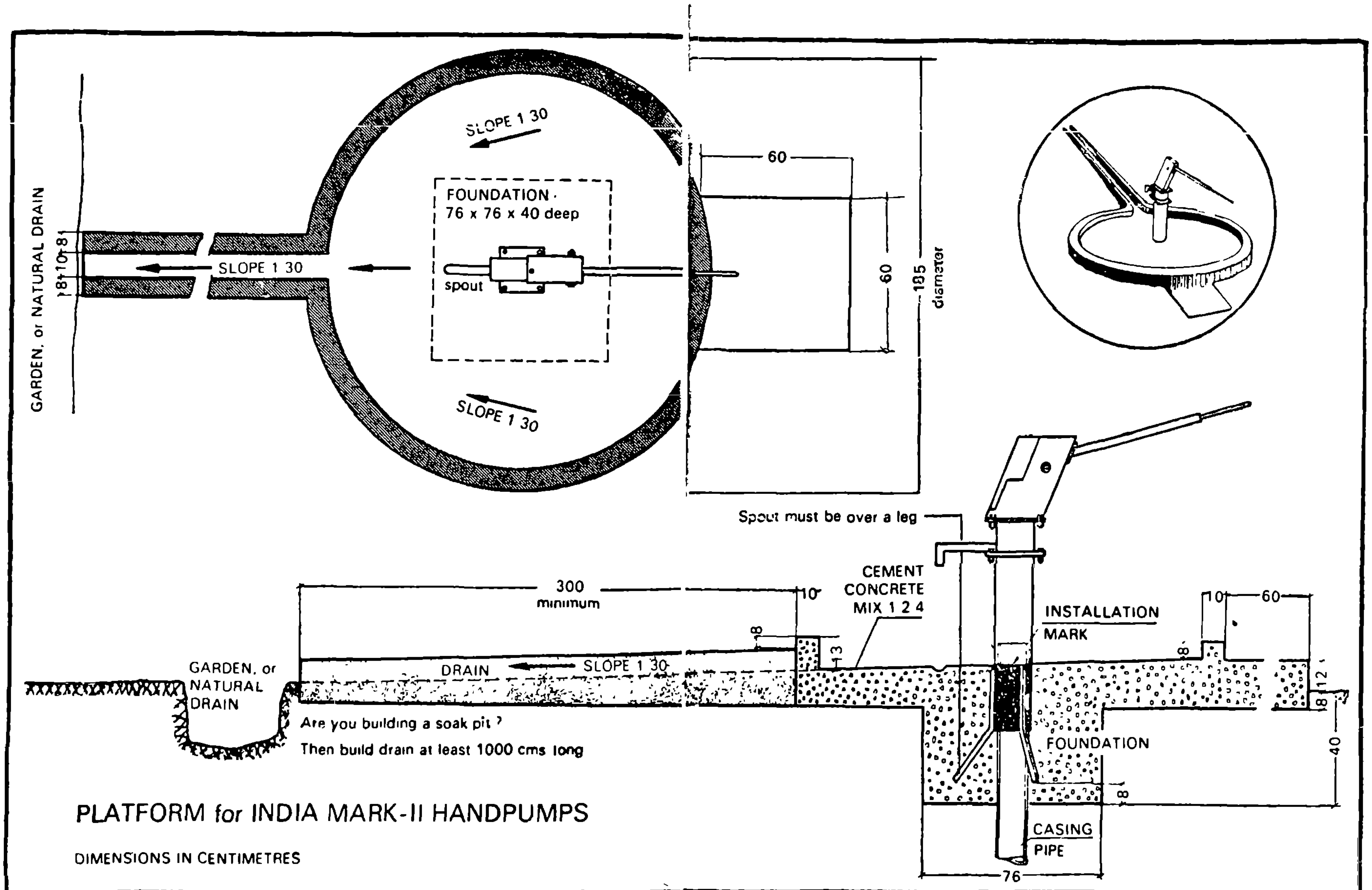


Pedestal detail

Drainage channel detail

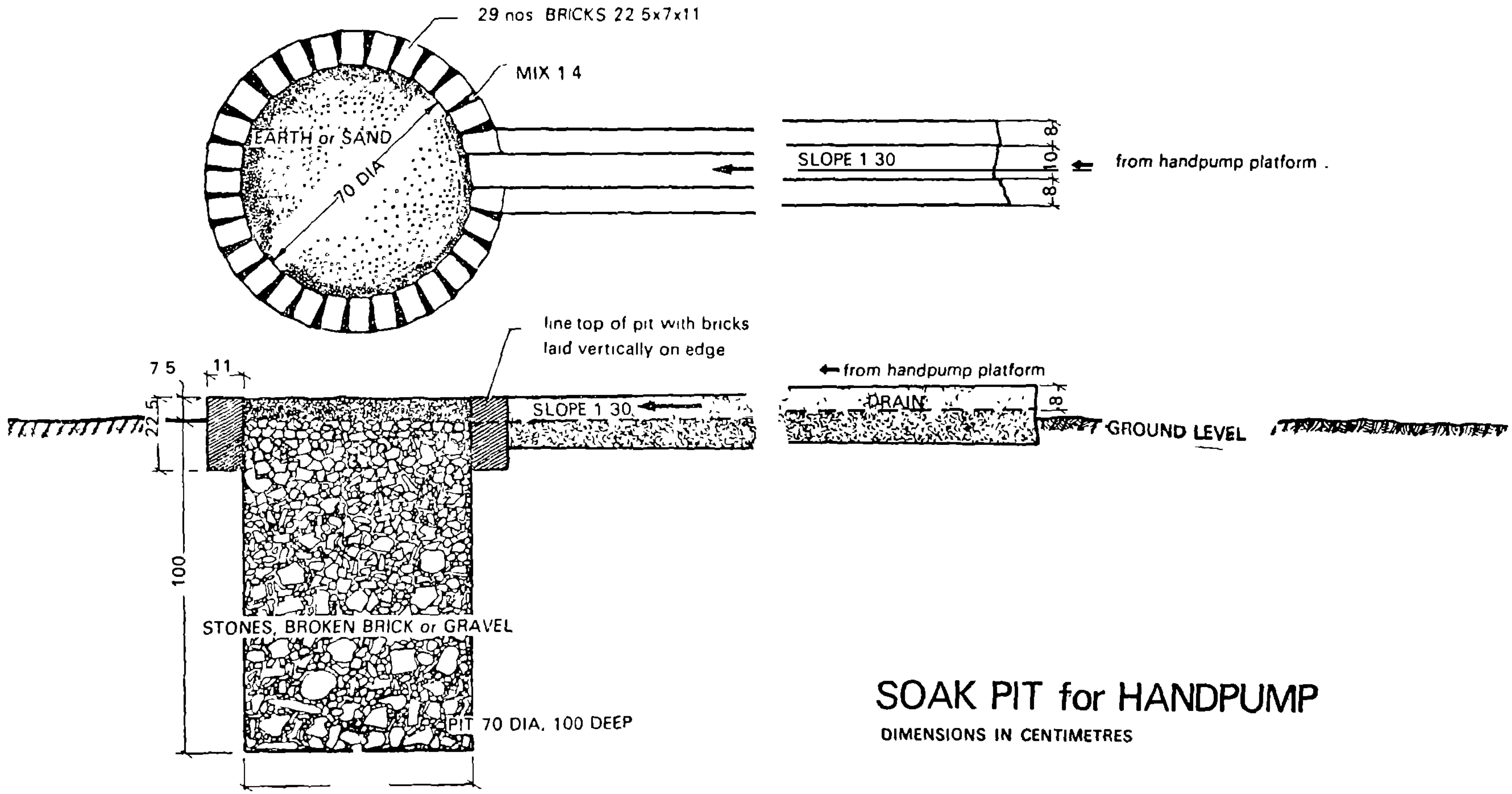


Apron cutaway detail



POSSIBLE APRON DESIGN, TYPE 2

From INALSA



SOAK PIT for HANDPUMP

DIMENSIONS IN CENTIMETRES

Steps for Constructing an Apron for a Dug Well

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
    - remove all vegetation
    - remove all loose soil
    - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
    - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
    - most large forms will be built in place
    - assemble other form on flat surface to minimize warpage during assembly

D) Cut and place planking over well opening:

- Why? - to support concrete while it hardens and cures
- Key points to remember:
    - planking must be adequately supported
    - planking must be easy to remove when apron has cured

E) Locate and place pipe section and access hatch form:

- Why? - pipe section provides water barrier and acts as form for concrete to make hole for suction or drop pipe; access hatch form used to make hatch opening
- Key points to remember:
    - must be sufficient space between pipe section and access hatch for cover to fit on finished well
    - both access hatch opening and pipe section located over well
    - pipe section placed over deepest part of the well

F) Cut hole under pipe section:

- Why? - for cylinder or suction pipe to pass through

G) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
    - apron form tilted to provide slope for apron

- lowest side faces toward drain
- place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

H) Cut, place and tie rebar:

- Why? - to give tensile strength to concrete (so it won't crack when in tension)
- Key points to remember:
  - rebar extends 10-15 cm past sides of well
  - rebar raised about 2 cm above the planking
  - rebar clean and free of rust

I) Place anchor bolts:

- Why? - to hold pump securely on apron
- Key points to remember
  - bolts placed so pump spout will not be over access hatch
  - use pump base as template for placing bolts if template unavailable

J) Construct access hatch cover:

- Why? - to keep people from falling in the well and to prevent contaminants from entering well through the access hatch
- Key points to remember:
  - Steps:
    - make forms
    - cut, bend, place and tie rebar
    - forms constructed to proper size so hatch fits opening
    - rebar placed 2 cm from bottom
    - rebar clean and free of rust

K) Mix and place concrete for apron:

- Why? - makes durable, relatively inexpensive apron
- Key points to remember:
  - factors that influence concrete strength
    - quantity of water
    - quality of water, aggregate
    - mixture of cement, sand and concrete
    - dropping vs. placing concrete
  - mark depth of concrete on inside of forms
  - tamp concrete so it fills out forms and flows around rebar
  - level low spots in concrete

L) Mix and place concrete for access hatch cover:

- Why? - make durable, relatively inexpensive cover that can be made with materials already at site
- Key points to remember:
  - factors that influence concrete strength same as for apron

- fill forms to top
- tamp concrete so it fills out form and flows around rebar

M) Cover concrete for curing:

- Why? - concrete continues to gain strength as long as it is wet
- Key points to remember:
  - do not walk on concrete until it has cured 24 hours

Steps for Constructing an Apron for a Drilled Well

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
  - remove all vegetation and loose soil
  - slope the area toward the drain with a 1:30 slope
  - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
  - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
  - assemble form on flat surface to minimize warpage during assembly

D) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
  - place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

E) Place anchor bolts:

- Why? - to hold pump securely on apron
- Key points to remember
  - bolts placed so pump spout will face toward drain
  - use pump base as template for placing bolts

Team Work Plan Guide #1

(Dug Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A:	• clear and level site	30 minutes
Apron Form Group	• measure and cut apron forms	40 minutes
	• assemble forms	20 minutes
	• cut, place and tie rebar for apron (Help Group B)	1 hour
Group B:	• cut and place planking over well	1 hour
Planking	• construct access hatch opening form	15 minutes
	• locate and place pipe section and access hatch	10 minutes
	• cut hole under pipe section	10 minutes
	• cut, place and tie rebar for apron (primary responsibility)	1 hour
	• place anchor bolts	10 minutes
Group C:		
Hatch Cover Group	• construct access hatch cover forms	15 minutes
	• cut, place and tie rebar for hatch cover	1 hour
	• cut, place and tie rebar for apron (Help Group B)	1 hour

Team Work Plan Guide #1

(Drilled Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A: Clear and Slope Group	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	30 minutes
	• place anchor bolts	5 minutes
Group B: Form Group	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes

Team Work Plan Guide #1

Group	Task	Approximate Time
Group A:	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	20 minutes
	• excavate pit	20 minutes
	• place pump pedestal	15 minutes
Group B:	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes
	• mix and place concrete for pedestal	30 minutes

Team Work Plan Guide #2

(Dug Well - Ground Level Apron Design)

Group	Task	Time
Group A Apron Group	• mix and place concrete for apron	
	- clear mixing site	10 minutes
	- bring sand, gravel, cement water	ongoing
	- mix concrete	ongoing
	- transport concrete to apron area	ongoing
	- place and tamp concrete	ongoing
	- place secondary forms (to make lips around access hatch and apron's outer edge)	10 minutes
	- finish concrete surface	20 minutes
	- cover concrete for curing	10 minutes
Group B Hatch Cover Group	• mix and place concrete for access hatch cover	
	- clear mixing site	5 minutes
	- bring sand, small gravel, cement water	15 minutes
	- mix concrete	20 minutes
	- transport concrete to hatch cover	ongoing
	- place, tamp and finish concrete	20 minutes
	- cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

Team Work Plan Guide #2

Task	Approximate Time
clear mixing site	10 minutes
bring sand, gravel, cement, water	ongoing
mix concrete	ongoing
transport concrete to apron area	ongoing
place and tamp concrete	ongoing
place secondary forms (to make lip around apron)	10 minutes
finish concrete surface	20 minutes
cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

Special Preparations

Steel Reinforcing - Reconditioned Dug Wells

Cover the well opening with wooden planks as shown in Figure 1. If the well is over one (1) meter in diameter, supporting joints should be placed under the wooden platform. The top of the platform should be level with the surface of the surrounding earth.

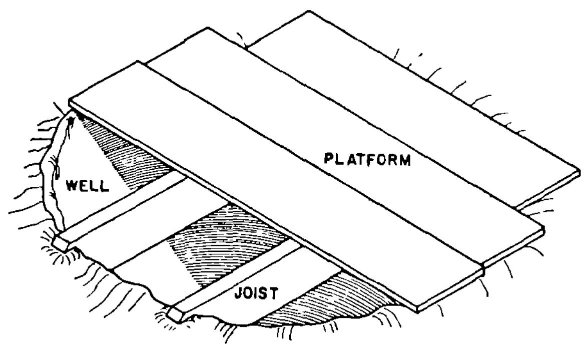


Figure 1. Platform Construction for Dug Wells

Sometimes it is desirable to have an access hatch for reconditioned wells, especially if the site is remote and the well is the only source of water in the vicinity of the community. The hatch also allows access for periodic reconditioning. See Handout 5-8 p.3 entitled "Access Hatch" for details of construction.

If an access hatch is not required, mark the location of the pump on the wooden platform. Two items should be considered in locating-the pump: a) the drop pipe or suction pipe should be in the deepest part of the well and b) the drop pipe of the medium-set and deep-set pumps should be straight even if the well is crooked to minimize wear by the plunger rod on the drop pipe. Cut a fifty-five (55) millimeter (mm) hole in the platform for shallow-set pumps or an eighty-five (85) mm hole if a medium-set or deep-set pump cylinder is to pass through.

Cut a section of ninety (90) mm (3 inch) PVC pipe and place it over the hole in the platform as in Figure 2. For shallow-set and medium-set pumps, the pipe section is thirty-five (35) cm long and for deep-set pumps it is fifty (50) cm long. The pipe section serves as a concrete form during construction and a water barrier during operation. If well casing is used, the PVC pipe section is unnecessary.

Adapted from Pashkevich and Gass

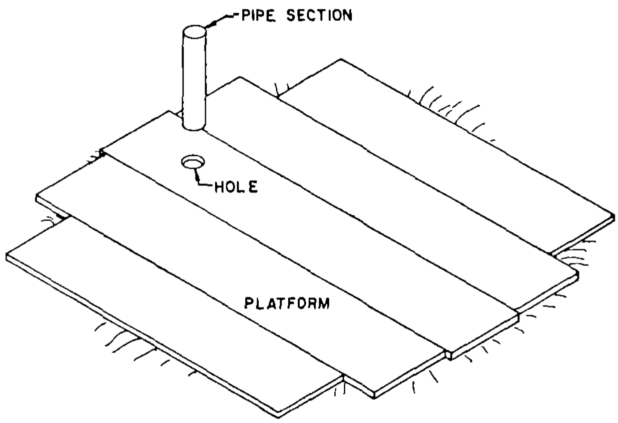


Figure 2. Locating Pipe Section

Lay out ten (10) mm diameter reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. After the bars have been cut to length and placed on center, tie them together with 16-gauge tying wire. The bars are then raised 1-1/2 to 2 cm above the planking by placing small rocks under the reinforcing bar framework. The well should now look like Figure 3.

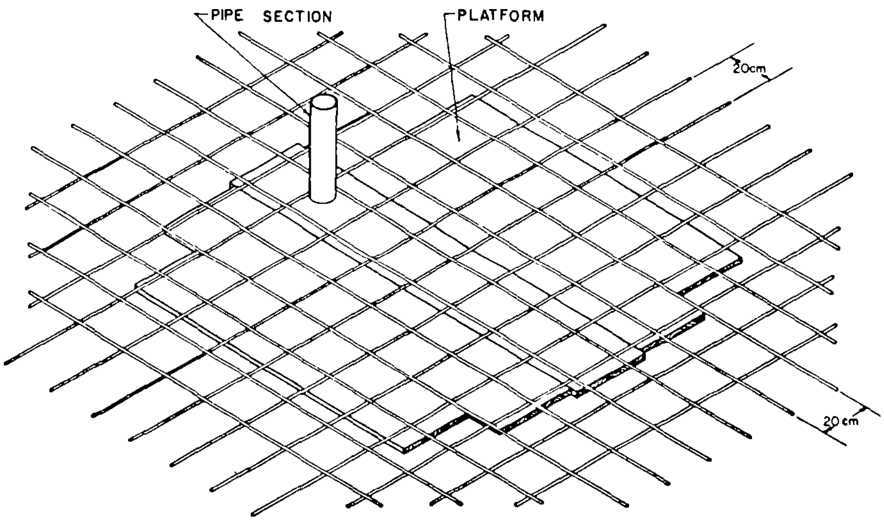


Figure 3. Reinforcement for Dug Wells

Steel Reinforcing - Filled Dug Wells

In some instances, it is advisable or more cost effective to refill a dug well. Some examples would be a very old dug well whose sides require extensive and prohibitively costly repair or a new dug well where casing the well with 90 mm (3 inch) pipe is less expensive than with concrete rings or bricks. However, an unfilled dug well has the advantage of providing a larger containment area or reservoir.

After installing the casing and gravel packing, fill and pack the well until it is level with the surrounding area cleared for the apron. As the fill may settle causing the apron to crack, it is necessary to use steel reinforcment in the apron slab.

Lay out ten (10) mm diameter reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. After the bars have been cut to length and placed on center, tie the bars together with 16-gauge tying wire. The bars are then raised 1-½ to 2 centimeters above the ground by placing small rocks under the reinforcing bar framework. The well should now resemble Figure 4.

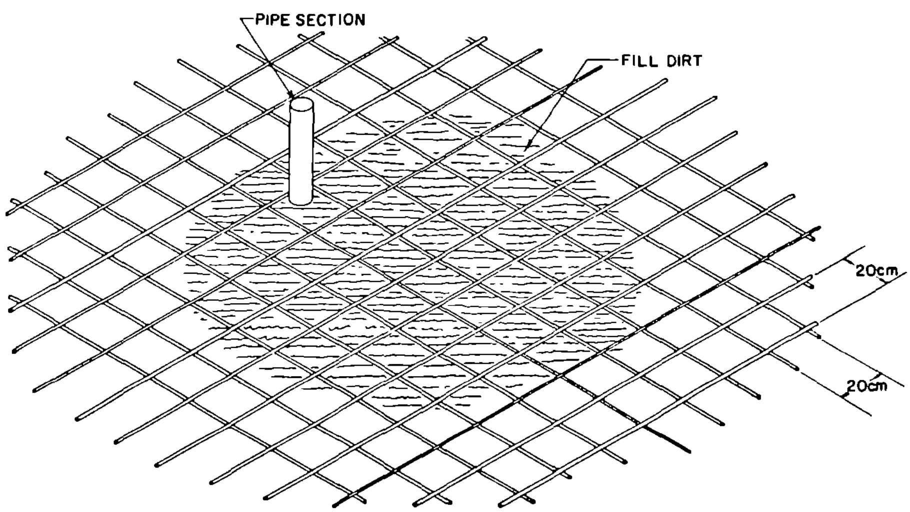


Figure 4. Reinforcement for Filled Dug Wells

Access Hatch

The location of the access hatch needs to be carefully selected. It should be on the opposite side of the pump from the drain and the pump spout should point away from it so that waste water will not be running around or on the hatch cover.

The hatch must be at least fifty (50) cm by fifty (50) cm in size to allow a man or bucket to pass inside. Having selected the hatch location, mark the location of the suction or drop pipe thirty (30) cm from the edge of the hatch opening. Be sure that the hatch and drop pipe will both be over the well opening.

Cut a hole for the suction or drop pipe in the wooden platform as described in the two preceding sections.

Construct the hatch opening form as described in Handout 5-8, p. 12-15. Place the opening form and the 90 mm pipe section in their respective locations on the wooden platform as shown in Figure 5. There should at least be twenty-five (25) cm between the pipe section and the opening form so that the hatch cover will later fit properly.

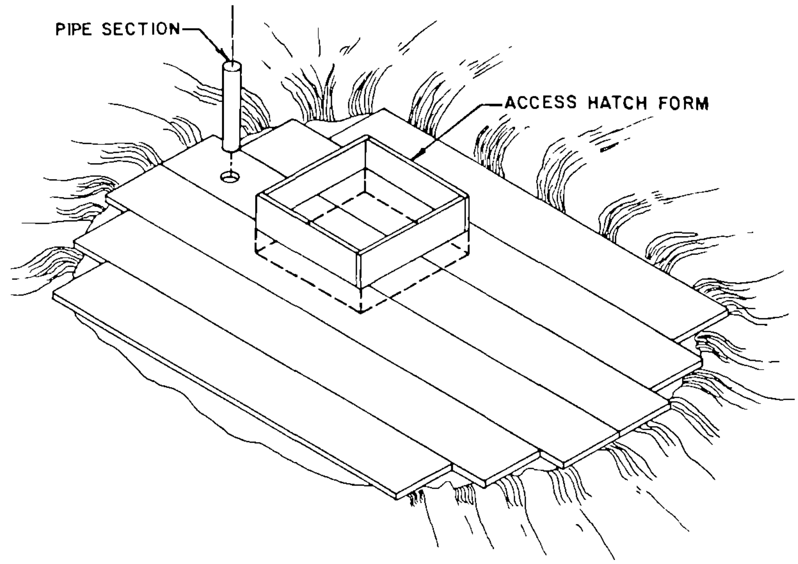


Figure 5. Locating Pipe Section and Access Hatch

Next, lay out ten (10) mm reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. As shown in Figure 6. four bars should be laid out in a diamond shape around the hatch opening for additional strength. Tie the bars together with 16-gauge tying wire. Raise the bars 1½ to 2 cm above the platform by placing small rocks under the reinforcing bar framework.

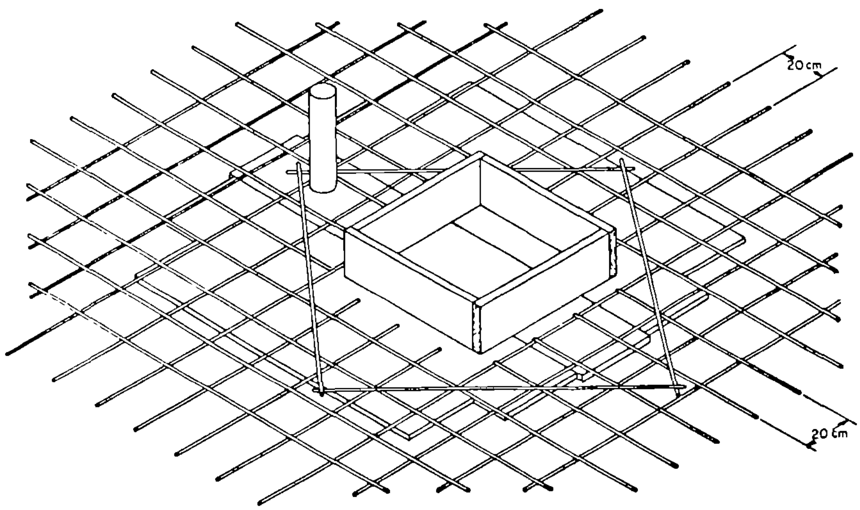


Figure 6. Reinforcement Around Access Hatch

Level a one (1) meter by one (1) meter area near the well site. Construct the hatch cover forms as described in Handout 5-8, p.12. Lay the small cover form in the center of the leveled area. Fill the inside of the form with dirt and pack it firmly. Cover the form with wet cement bags or damp newspaper. Shape them until they conform to the contour of the small cover form (Figure 7).

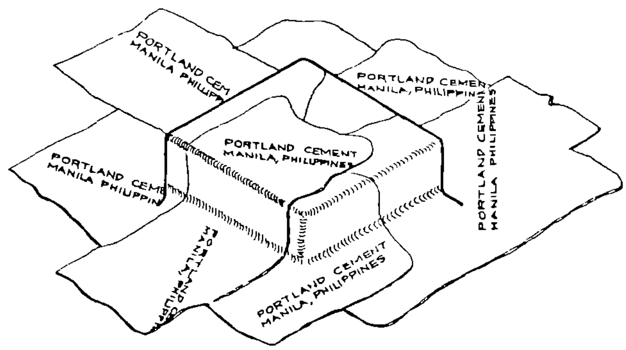


Figure 7. Inside Form for Hatch Cover

Center the large cover form around the small cover form. Place and tie 10 mm (3/8 inch) reinforcing bars on fifteen (15) cm centers. Bend one piece of bar as shown to make a handle. Pour the hatch cover when pouring the concrete for the apron. The completed cover should resemble Figure 8.

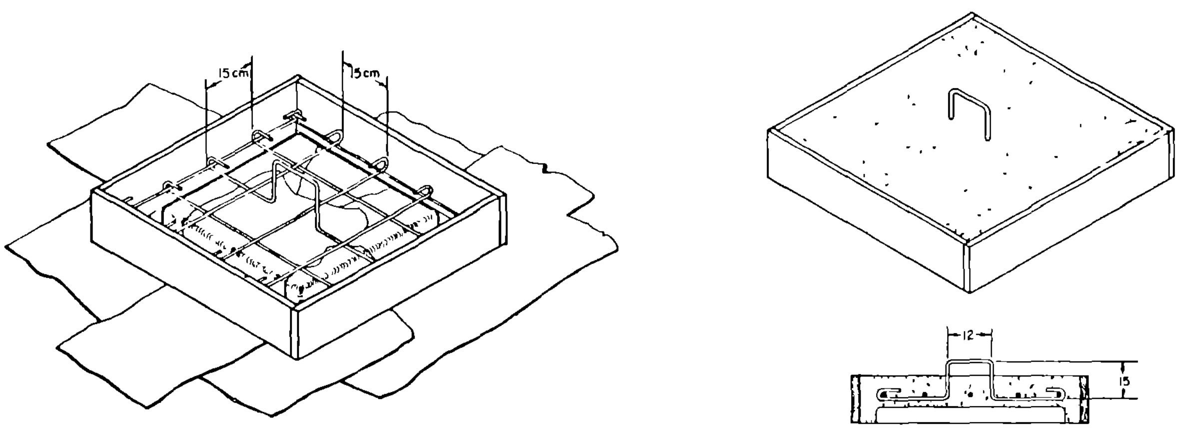


Figure 8. Hatch Cover Handle Detail

Construct a curb around the hatch opening as shown in Figure 9. using the hatch curb form described in Handout 5-8, p. 13. The curb should be five (5) cm in height and width. Plaster over the curb with a one (1) cm thick 1:3 cement/fine sand rendering.

After the concrete has set and cured for at least ten (10) days, cut out the hatch opening in the platform with a keyhole saw or similar tool.

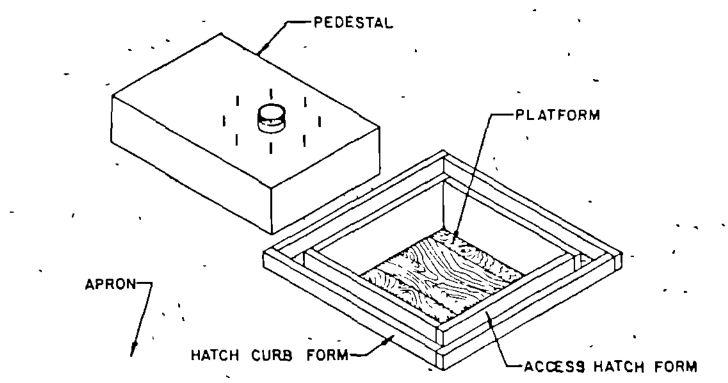


Figure 9. Constructing Hatch Curb

Site Preparation

The well should be located on a local high spot. The slight rise in elevation above the surrounding area is conducive to good drainage and the prevention of well contamination.

Remove the vegetation and loose top soil to ensure that the base for the apron slab will be well-compacted earth. The well casing should be exposed to a length of at least 35 cm above the ground. If 35 cm are not exposed, remove more top soil from the entire area.

If the pump is to be installed on a dug well, refer to Handout 5-8, p.1 ("Special Preparations") for steel work and access hatch instructions.

Place the apron form on the cleared area (see Handout 5-8, p.12-15) for the details of the apron form). Determine the apron orientation and select the location of the concrete drain. Construction is easier and drainage better if the concrete drain is located at a corner. Center the apron form around the well.

Drive stakes at the four corners of the apron form as shown in Figure 10 . The apron form is then tilted in the direction of the drain to facilitate drainage. Mark on the stake nearest the drain fifteen (15) cm above the ground. A mark is then placed on the opposite stake ten (10) cm above the first mark. Use a level or water-filled clear hose to obtain exact heights. The other two stakes are marked at points five (5) cm above the first mark. Line up the top of the apron form with the marks and nail the form to the stakes. Gravel and sand are used as fill to build up to the bottom of the raised apron form.

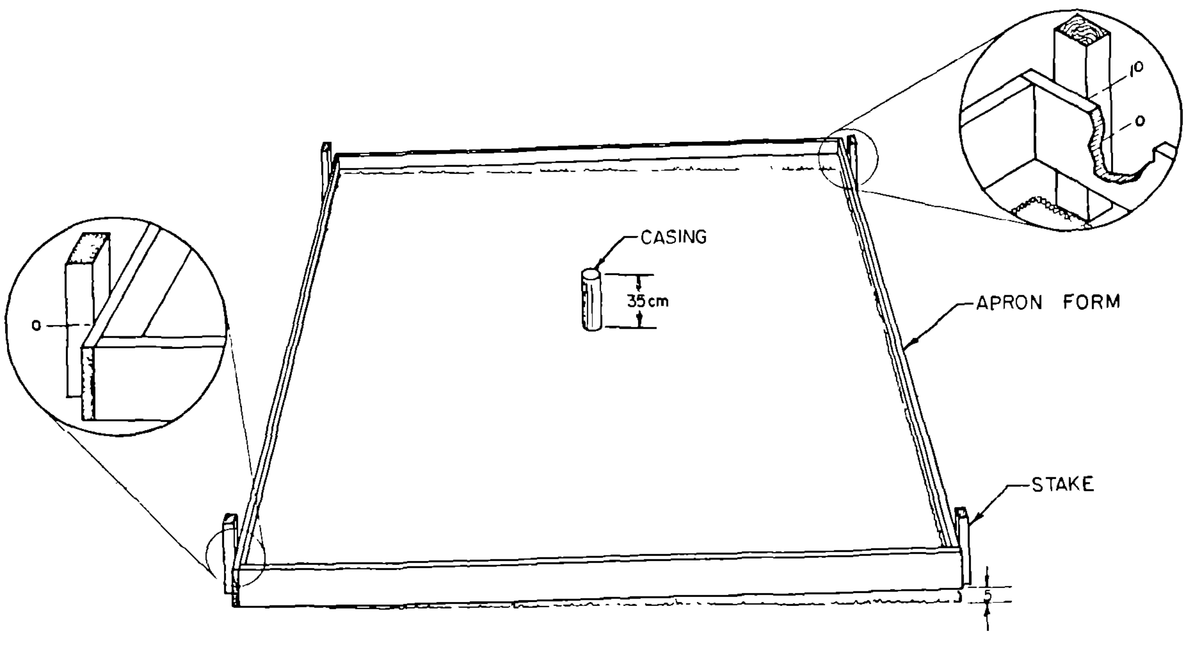


Figure 10. Sloping The Apron Form

Concreting the Apron

Shallow-Well and Medium-Set Pumps

Measure ten (10) cm up from the bottom of the apron form and place a mark on the form. Repeat this in several places around the form. Prepare a 1:2:4 concrete mixture and fill the apron form to the height of the marks. Level the concrete with a long board (Fig. 11) and fill any low spots that will prevent water from draining off the apron. Smooth the concrete because cement rendering will not be applied to the apron.

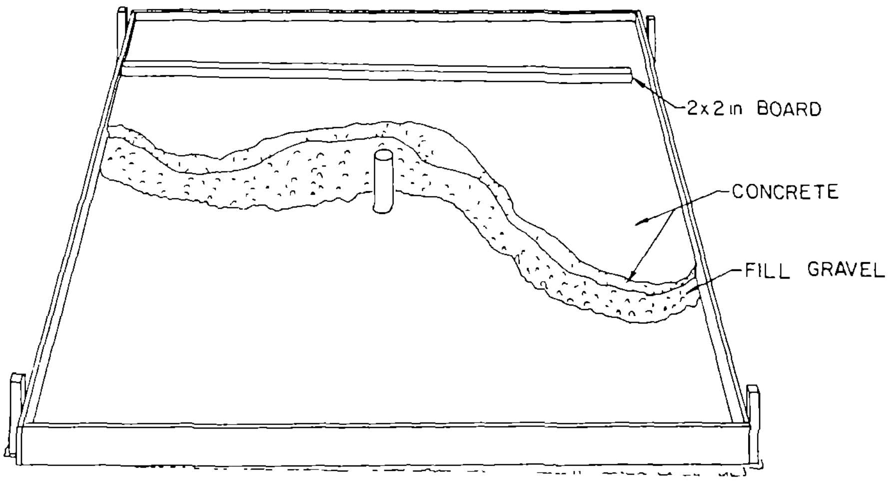


Figure 11. Pouring the Apron Slab

Prepare the anchor bolts for placement by bolting them onto the pump base. The use of the base positions the bolts both vertically and in relation to one another. The anchor bolts should be toed out as in Figure 12.

Measure up 25 cm on the casing from the apron slab. Cut off the casing at this point. Place the pedestal form (Handout 5-8, p. 13) around the casing. Center it carefully so that a bucket can be placed on the pedestal beneath the pump spout (Figure 13).

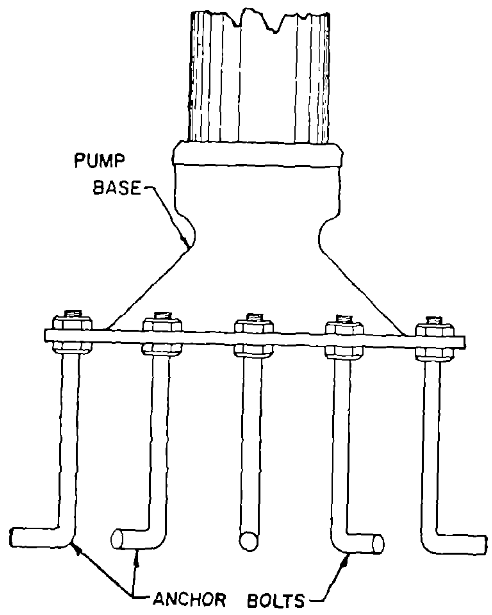


Figure 12. Preparation of Anchor Bolts for Installation

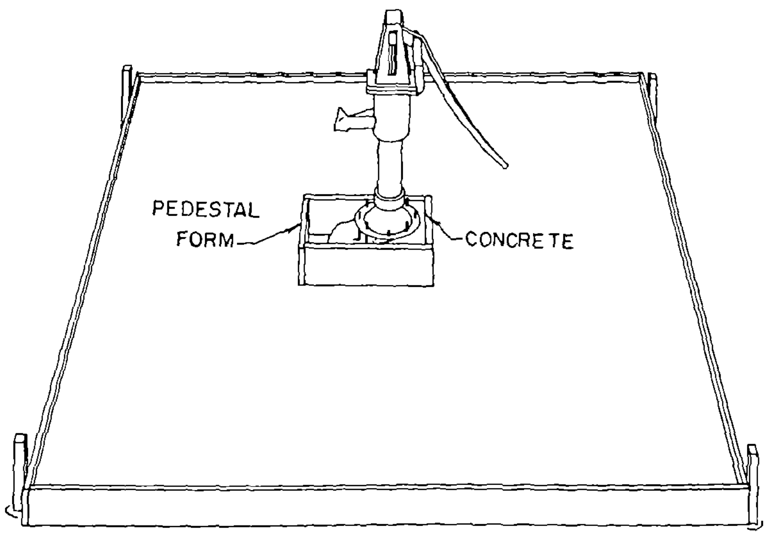


Figure 13. Pouring The Pedestal

Place the pump on the well casing. Ensure that the base is level so that the installed pump will not be tilted.

Placing the pump base on the casing before concreting the anchor bolts in place creates a water barrier to prevent rain or pumped water from entering the well (Figure 14.) However, this is not a water seal and the well could become contaminated if flood waters cover the base.

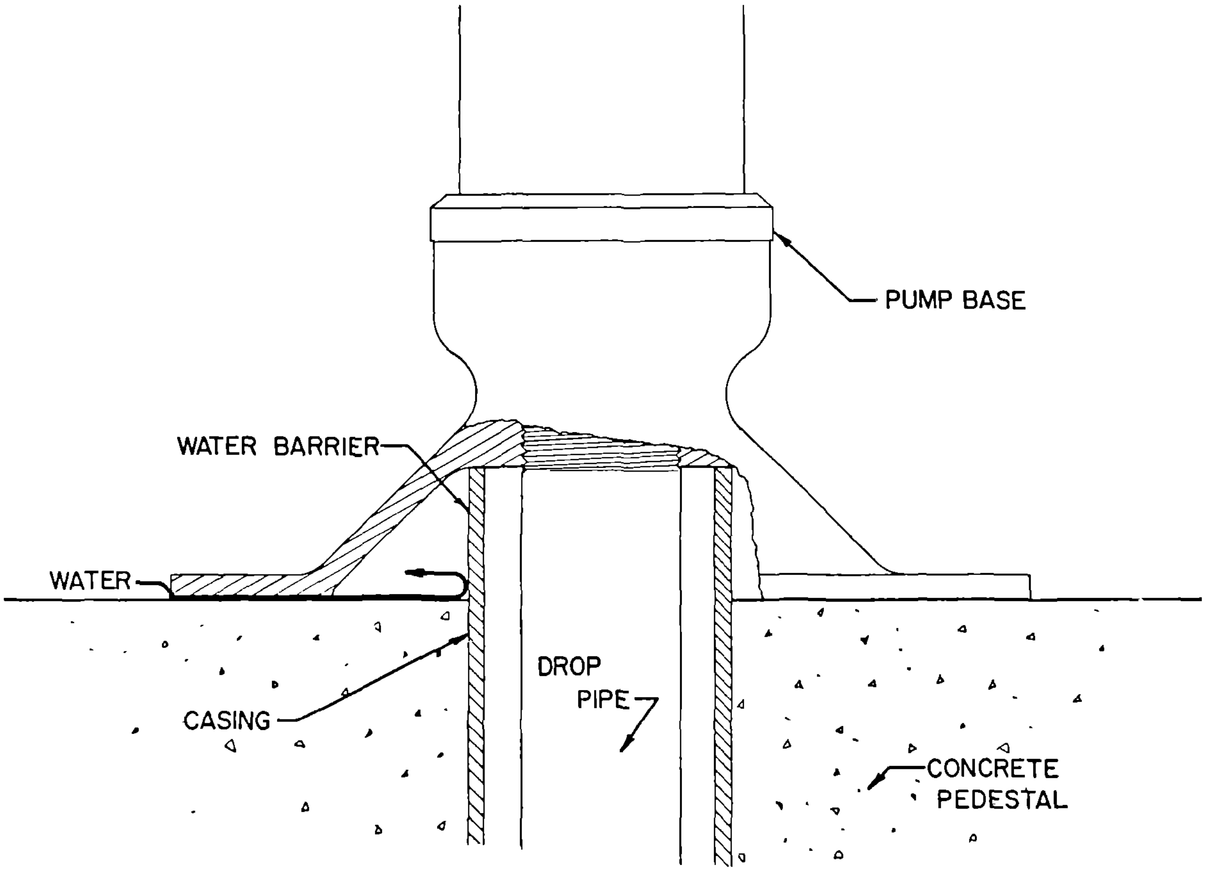


Figure 14. Casing as Water Barrier

Slowly fill the pedestal form with concrete to the bottom of the pump base, packing the concrete firmly between the anchor bolts. It is not necessary to fill the form to the top but only to the bottom of the pump base. Any cement that is splashed onto the bolt threads should be wiped off before it hardens. After the concrete has set, remove the pump base and the pedestal forms and plaster the pedestal with a one (1) cm thick 1:3 cement/fine sand rendering. Fill any voids left around the well casing as waste water may enter the well at this point.

Leaving space for the drain, construct a five (5) cm high by ten (10) cm wide water curb around the perimeter of the apron. Use the curb form (Handout 5-8, p. 13) as shown in Figure 15. After removing the apron and curb forms, plaster the curb with a 1:3 cement/fine sand rendering.

Allow the apron and pedestal to cure for at least one week before installing the pump so that the concrete can harden sufficiently (see Handout 5-9, Concrete Primer, for curing procedures).

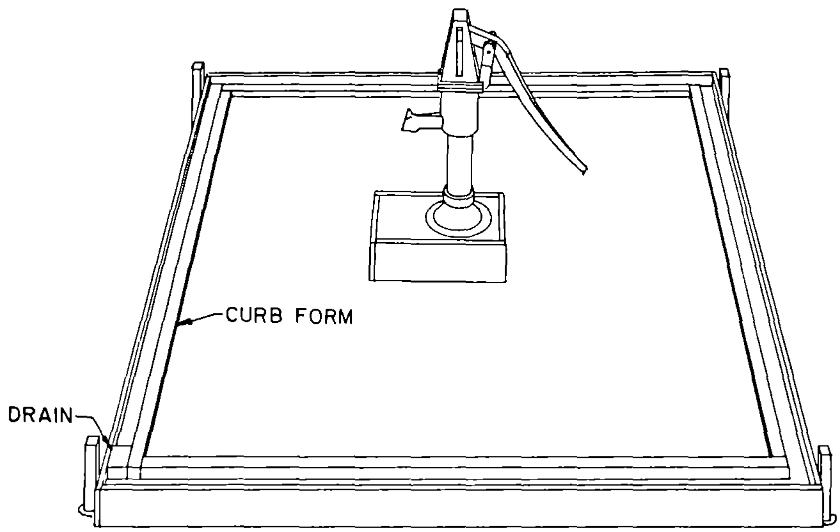


Figure 15. Constructing The Apron Curb

Form Work and Reinforcement

It has been found that the use of removable, reusable forms is more convenient and economical than other methods of concrete construction. This is particularly true of the deep-set pump column. The following section assumes the use of reusable forms. Form material is Tangili wood unless otherwise noted.

Apron Forms

Apron Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length:403 cm
No. of pieces:4

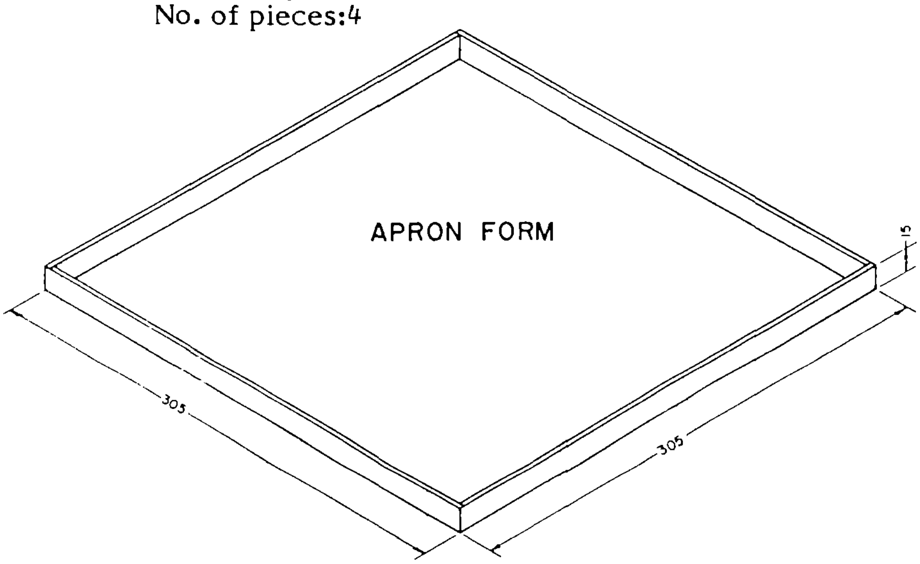


Figure 16.

Apron Curb Form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 377 cm
No. of pieces: 4

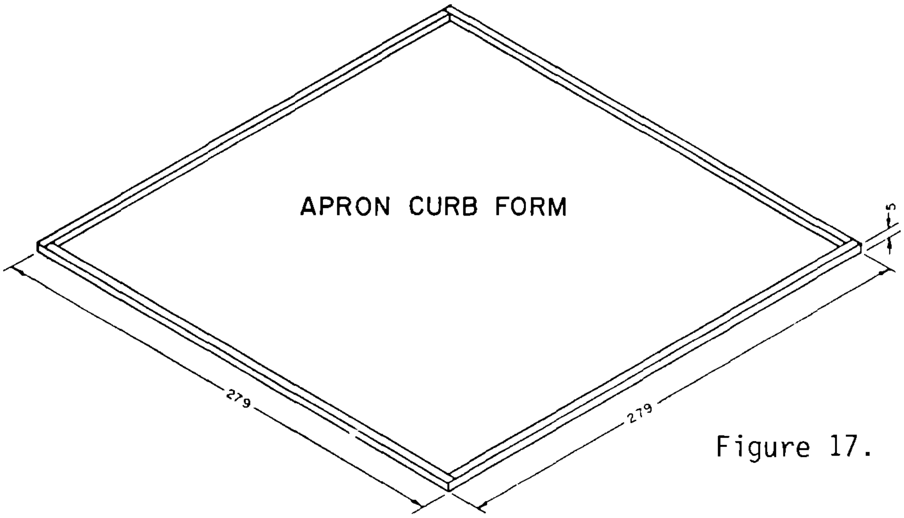
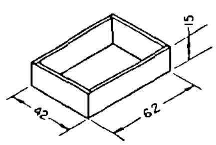


Figure 17.

Pedestal Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 60 cm No. of pieces: 2
Req'd length 40 cm No. of pieces: 2



PEDESTAL FORM

Figure 18.

Access Hatch Forms

Opening form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 48 cm
No. of pieces: 4

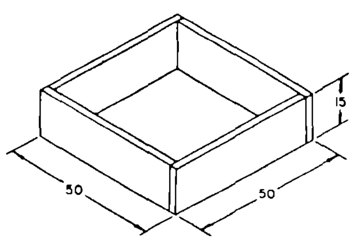


Figure 19. Opening Form

Opening curb form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 62 cm
No. of pieces: 4

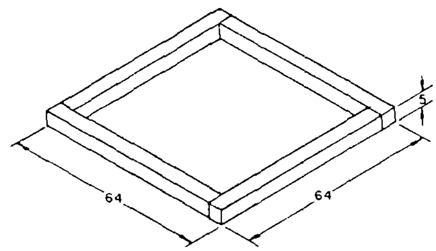


Figure 20. Opening Curb Form

Small Cover Form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 58 cm
No. of pieces: 4

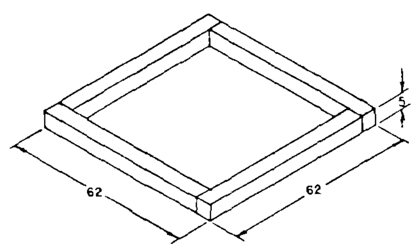


Figure 21. Small Cover Form

Large Cover Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 74 cm
No. of pieces: 4

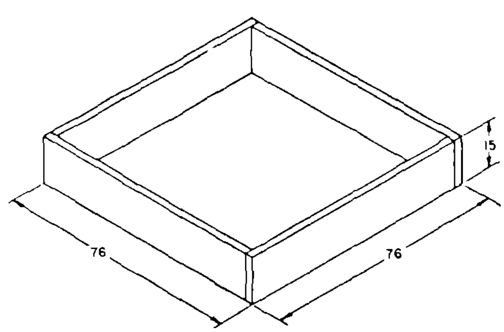


Figure 22. Large Cover Form

Assembly for above forms:

1. Cut the lumber to the required lengths as specified above.
2. Nail the boards together as shown in Figure 23. The dimensions given above are for this method of assembly. Assemble the forms on a flat area so that they won't have a warp.

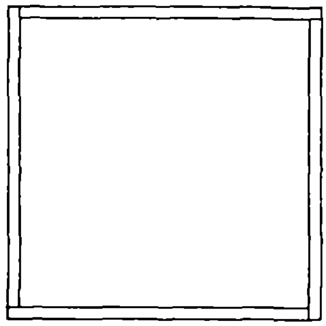
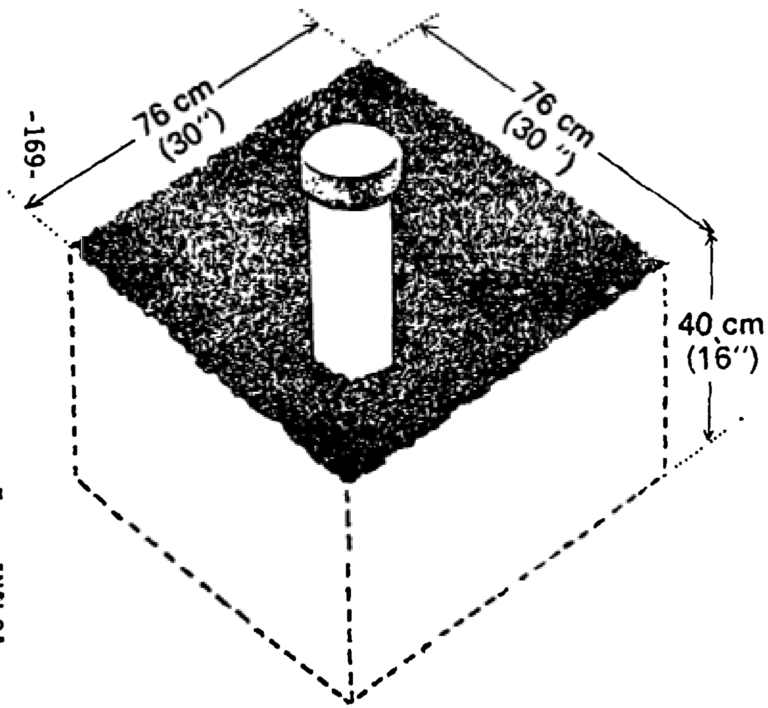


Figure 23. Recommended Assembly of Forms

1

(1) Cover casing pipe

(2) Dig a square pit around casing pipe 40 cm (16") deep



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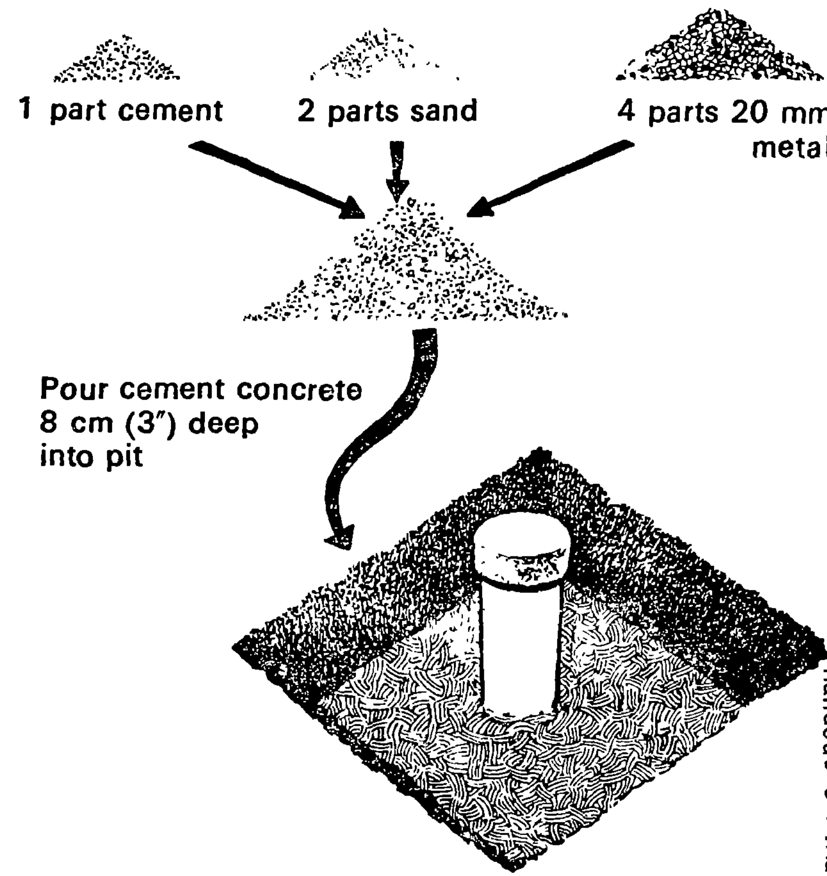
From INALSA

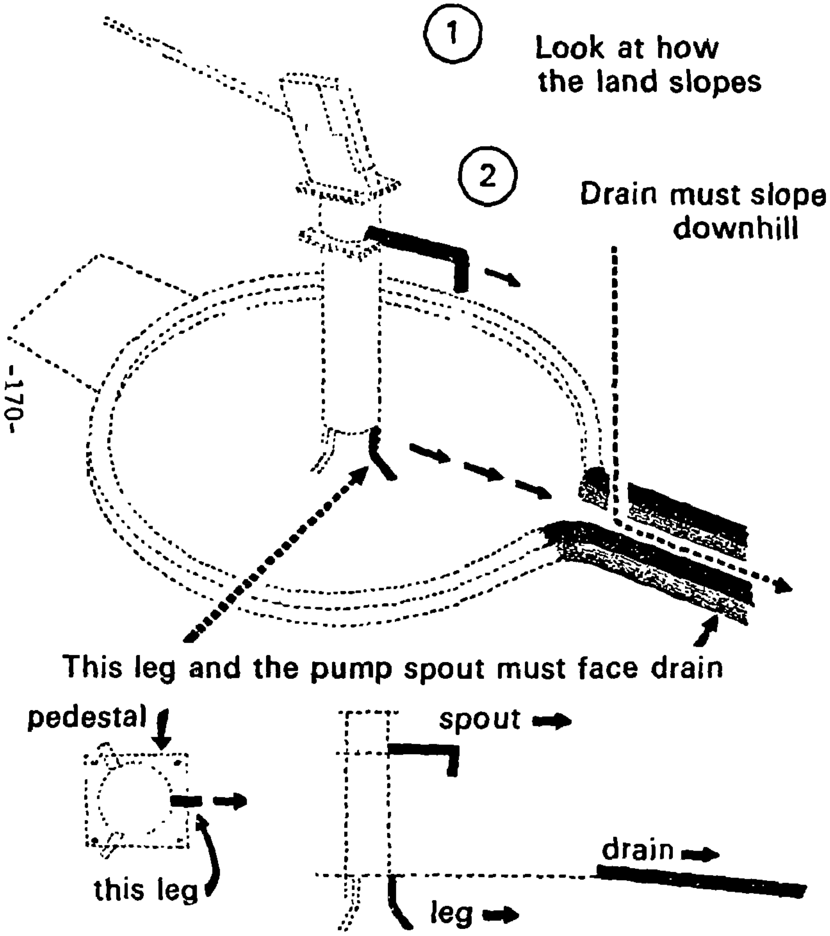
2

Prepare cement concrete mix

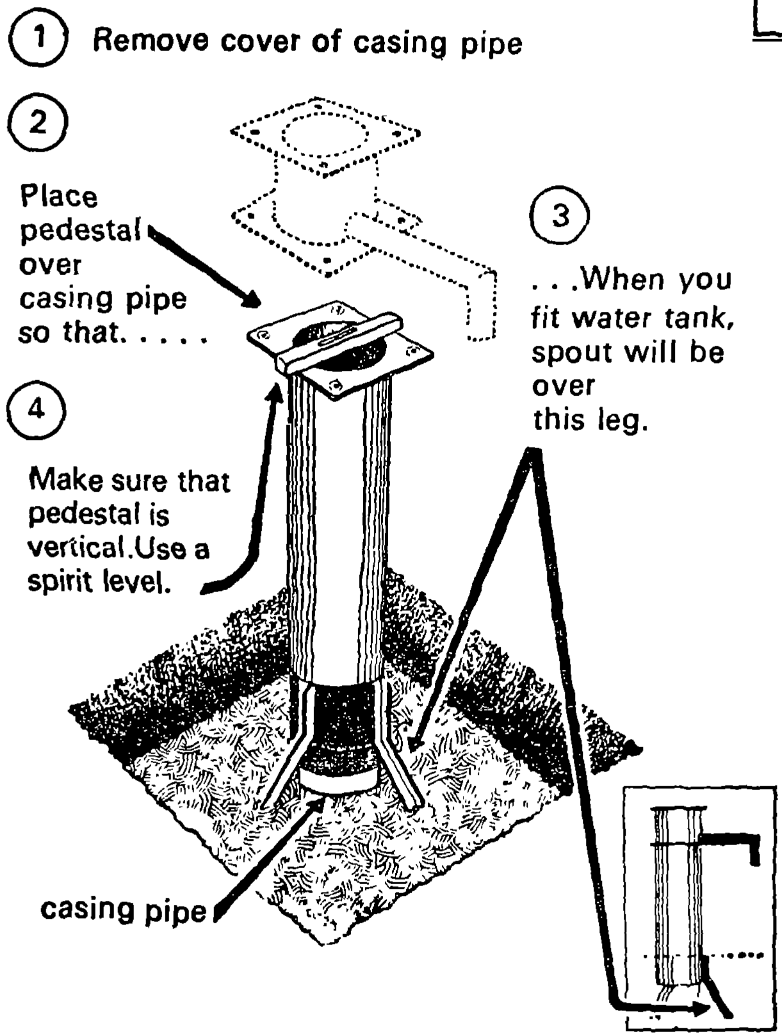


3

Decide now where you will make the drain



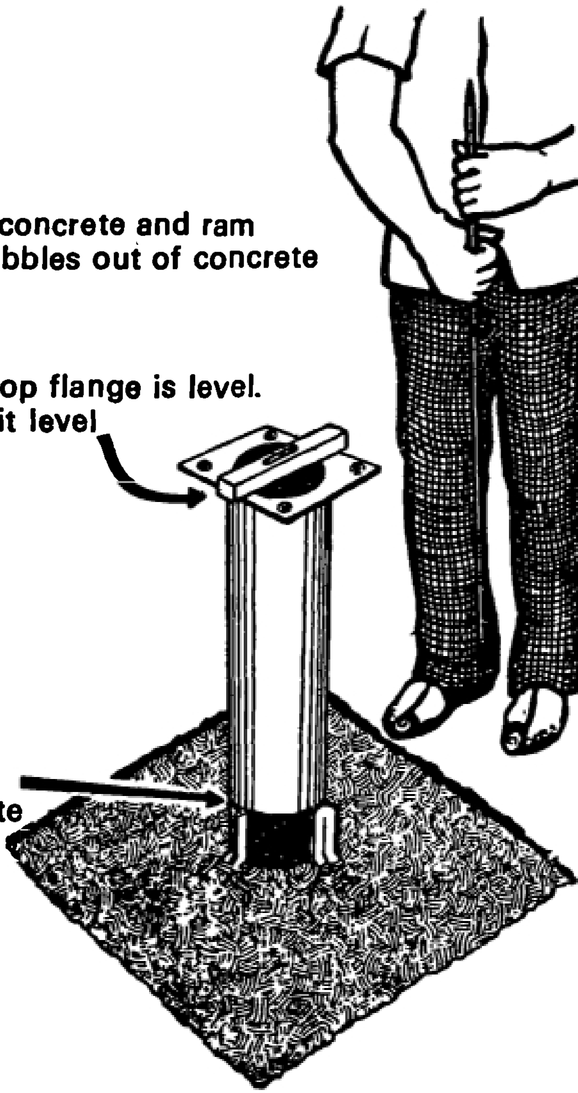
4



5

(1) Fill pit with concrete and ram to get air bubbles out of concrete

(2) Check that top flange is level. Use the spirit level

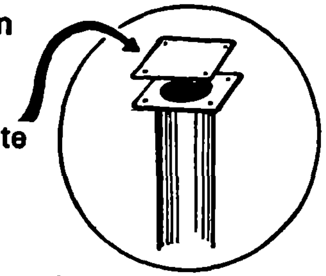


(3) Construct platform to top of leg while concrete is still wet

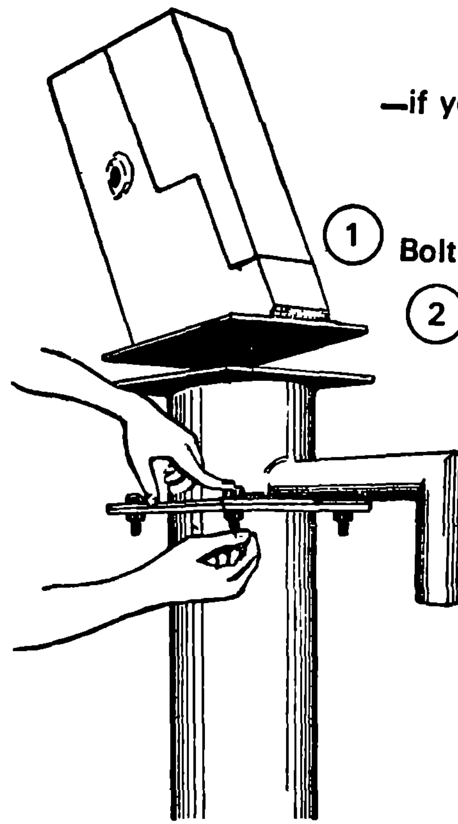
6

Cover pedestal so that children can't put stones in the well

— if you have a cover plate use it



—if you don't have a cover plate. . . .

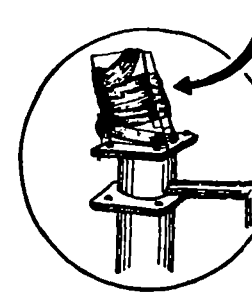


(1) Bolt on water tank

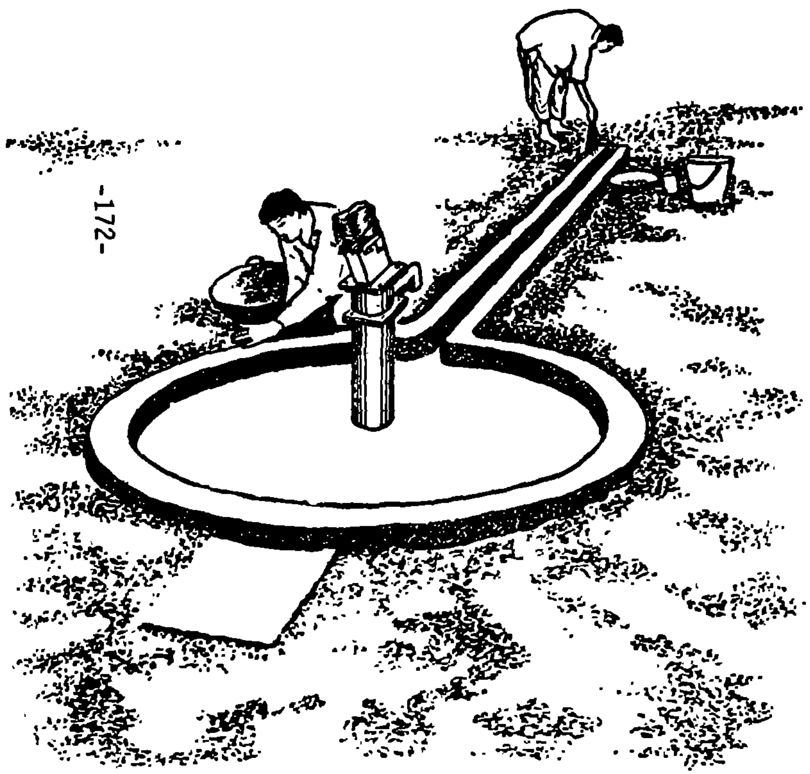
(2) Remove handle from head

(3) Bolt on head

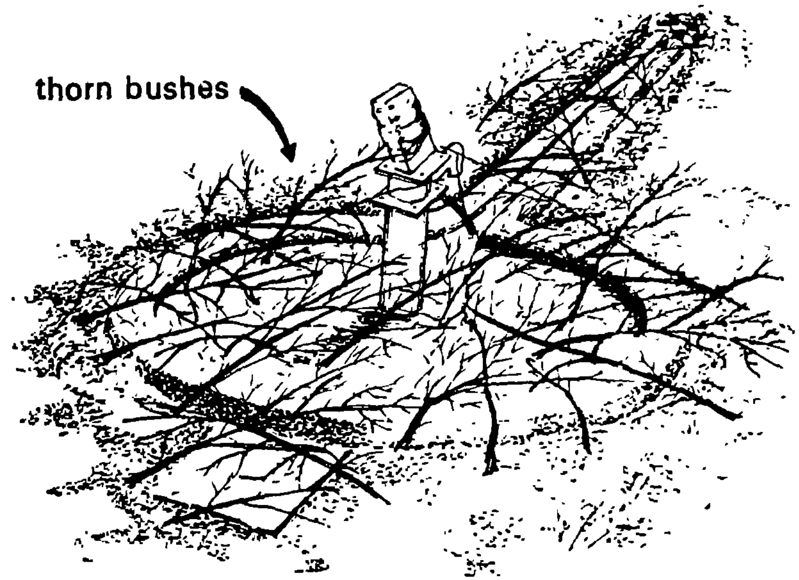
(4) Wrap cloth around head



Construct platform and drain.
Use plan on pages 8 and 9.



To cure concrete, block drain
and fill platform with water.
Ask villagers
to keep away
from installation.



ALLOW CONCRETE TO SET FOR 7 DAYS

CONCRETE PRIMER

A. Introduction to Cement

Cement is one of the most useful materials in well construction. It can easily be mixed with sand and water to make mortar or with gravel, sand and water to make concrete. Both mortar and concrete are among the strongest and most durable materials used for all types of construction around the world. Mortar is normally used as the bonding agent between bricks or rocks while concrete is normally reinforced with steel bars and molded to the desired size and shape.

For well work, mortar or concrete is usually the best material for the lining, headwall, platform and cover of dug wells, and the platform and seal around the top three meters of casing in drilled wells.

Cement is available in almost every country in the world. Sand and gravel are usually available locally. Occasionally it will be difficult to get cement for well construction either because there are other higher priority demands for the cement or because it is too expensive. It is impossible here to say how or even whether cement can be obtained in such a circumstance.

Of the two cement compounds, mortar and concrete, concrete is the stronger. This is because the rock that makes up the gravel itself is stronger than the concrete and so contributes to its strength. Sometimes the two can be used interchangeably where lack of materials or working conditions demand it. Remember that concrete is the stronger product and should be used where possible.

NOTE: The rest of the discussion in this appendix will deal specifically with concrete. The same procedures can and should be followed if mortar is used instead.

B. Ingredients of Concrete

Concrete is made from cement, sand, gravel and water. These ingredients are combined in certain proportions to achieve the desired strength. The amount of water used to mix these ingredients is by far the most important factor in determining the final strength of the concrete. Use the least amount of water that will still give you a workable mix. Sand and gravel, which are sometimes referred to as fine and coarse aggregate respectively, should be clean and properly graded. Cement and water form a paste which, when mixed, acts as a glue to bind the aggregates together in a strong hard mass.

1. Proportions:

- There are four major ingredients in concrete: cement, sand, gravel, and water.
- Dry ingredients are normally mixed in certain proportions and then water is added. Proportions are expressed as follows: 1:2:4, which means that

From WASH Field Report No. 54, Philippine Hand Pump Program, 8/82 to one part cement you add two parts sand and four parts gravel. A "part" usually refers to a unit of volume. Example: A 1:2:4 concrete mix could be obtained by mixing 1 bucket full of cement with 2 buckets of sand and 4 buckets of gravel.

- Proportions are almost always expressed as cement: sand: gravel, and they are usually labelled that way.

- There are many minor variations in the proportions used for mixing concrete. The most commonly used are 1:2:4, 1:2:3, 1:2.5:5. For purposes of well construction, all work equally well.

  NOTE: A 1:2:4 mix will go a little farther than the 1:2:3 mix and allows a little more room for using less than the best grade of sand or gravel than a 1:2.5:5 mix.

- Normal range for amount of water used to mix each 50 kg bag of cement is between 20 liters and 30 liters (94 lb. bag of cement is between 4.5 gal. and 7 gal.)

- The water-tightness of concrete depends primarily on the water/cement ratio and the length of moist curing. This is similar to concrete strength in that less water and longer moist-curing promote water-tightness.

2. Choice of Ingredients

- Cement: The descriptions and properties given in this appendix are specifically of Portland cement. This is the type most commonly used and hereafter will be referred to only as cement.

  When used, it should be dry, powdery and free of lumps. When storing cement, try to avoid all possible contact with moisture. Store it away from exterior walls, off damp floors, and stacked close together to reduce air circulation. If it could be kept completely dry it could be stored indefinitely. Even exposed to air it will gradually draw moisture, thus limiting even the covered storage time to between 6 months and 1 year depending on conditions.

- Water: In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement.

- Aggregates: Fine and coarse aggregates together occupy 60% to 80% of concrete volume.

  - Fine aggregate: Sand should range in size from less than .25 mm to 6.3 mm. Sand from sea shores, dunes or river banks is usually too fine for normal mixes. (You can sometimes scrape about 30 cm of fine surface sand off and find coarser, more suitable sand beneath it.)

  - Large Aggregate: Within the recommended size limits mentioned later, the larger the gravel you use the stronger and more economical the concrete will be.

- The larger the size of the gravel the less water and cement will be required to get the same strength concrete.

- The maximum gravel size should not exceed:

  - one-fifth the minimum dimension of the member;
  - three-fourths the clear space between reinforcing bars or between reinforcement and forms. (Optimum aggregate size in many situations is about 2.0 cm.)

The shape and surface texture of aggregates affect properties of freshly mixed concrete more than they affect hardened concrete. Rough textured or flat and elongated particles require more water to produce workable concrete than do rounded or cubical aggregates and more water reduces the final strength of the concrete.

It is extremely important to have the gravel and sand clean. Silt, clay, or bits of organic matter, even in low concentrations, will ruin concrete. A very simple test for cleanliness makes use of a clear widemouth jar. Fill the jar about half full of the sand and small aggregate to be tested, and cover with water. Shake the mixture vigorously, and then allow it to stand for three hours. In almost every case there will be a distinct line dividing the fine sand suitable for concrete and that which is too fine. If the very fine material amounts to more than 10% of the suitable material, then the concrete made from it will be weak.

This means that other fine material should be sought, or the available material should be washed to remove the material that is too fine. This can be done by putting the sand (and gravel if necessary) in some container such as a drum. Cover the aggregate with water, stir thoroughly, let stand for a minute, and pour off the liquid. One or two such treatments will remove most of the very fine material and organic matter.

Another point to consider in the selection of aggregate is its strength. About the only simple test is to break some of the stones with a hammer. If the effort required to break the majority of aggregate stones is greater than the effort required to break a similar sized piece of concrete, then the aggregate will make strong concrete. If the stones break easily, then you can expect that the concrete made of these stones will only be as strong as the stones themselves.

In very dry climates several precautions must be taken. If the sand is perfectly dry, it packs into a smaller space. If 20 buckets of dry sand are put in a pile and two buckets of water stirred in, you could carry away about 27 buckets of damp sand. If your sand is completely dry, add some water to it or else measure by weight instead of volume. The surface of the curing concrete should be kept damp. This is because water evaporating from the surface will remove some of the water needed to make concrete properly. Cover the concrete with building paper, burlap, straw, or anything that will hold moisture and keep the direct sun and wind from the concrete surface. Keep the concrete moist by sprinkling as often as necessary; this may be as often as three times per day. After the first week of curing, it is not necessary to keep the surface damp continuously (see "Curing Concrete" below).

3. Estimating Quantities of Materials Needed

1. Calculate the volume of concrete needed.

2. Multiply the volume of concrete needed by 3/2 (1.5) to get the total volume of dry loose material needed. The cement and sand do little to add to the volume of the concrete because they fill in the air spaces between the gravel.

3. Add 10% (1/10) for losses due to handling.

4. Add the numbers in the volumetric proportion that you will use to get a relative total. This will allow you later to compute fractions of the to[illegible] needed for each ingredient (1:2:3 = 6).

5. Determine the amount of cement needed by multiplying the volume of dry material needed (from step 2) by the proportional amount of the total mix (e.g., amount cement needed = 1/6 x volume dry materials).

6. Divide by the unit volume per bag, 33.2 liters per 50 kg bag cement or 1 cubic foot per 94 lb. bag cement. When figuring the number of cement bags round up to nearest whole number.

   NOTE: This calculation, even with the 10% addition for handling losses, rarely leaves any extra concrete, particularly for small jobs requiring less than 5 hand-mixed bags of cement.

C. Construction with Concrete

1. Outline of Concrete Work:

   - Build form (8C.5.2)
   - Place rebar (8C.5.3)
   - Mix concrete (8C.5.4)
   - Pour concrete (8C.5.4)
   - Remove forms (8C.5.4)
   - Finish surface (8C.5.4)
   - Cure concrete (8C.5.4)

2. Materials for Forms

   The following materials are used to construct interior forms:

   - Steel: forms made of steel are durable and strong but are heavy, awkward, and expensive.
   - Sheet metal: with a simple triangular interior support, forms made of sheet metal have proved to be successful. They are lighter and more maneuverable than steel forms but are not as strong and durable.
   - Wood: this material is commonly used because it is lightweight and strong. It must be carefully bent, waterproofed, and reinforced.

By using boards as wide as possible, form construction is easier and quicker. It also reduces the number of lines on the concrete surface that form at the junction of two boards. Plywood is excellent, especially if it has a special high density overlay surface. This allows for a smoother concrete finish, easier form removal and less wear on the forms.

If unsurfaced wood is used for forms, oil or grease the inside surface to make removal of the forms easier and to prevent the wood from drawing too much water from the concrete. Do not oil or grease the wood if the concrete surface will be painted or stuccoed.

- Earth: Any earth that can be dug into and still hold its shape can also be used as a form. Carefully dig out the desired shape and fill it with concrete. Once the concrete has set and cured it can be dug up and used where needed. A new form will have to be dug out for each piece of concrete poured.

- Other materials: Plastics and fiberglass are also occasionally used and continue to be experimented with as form materials. Fiberglass is much lighter than steel and, if handled carefully, lasts for a long time. Its cost and availability in developing nations seem to be the only factors limiting more widespread trials.

3. Concrete Reinforcement

Reinforcing concrete will allow much greater loads to be carried. Design of reinforced concrete structures that are large or must carry high loads can become too complicated for a person without special training.

Concrete alone has great compression strength but little tensile strength. Concrete is very difficult to squeeze (compression), but breaks relatively easily when stretched (put in tension). Reinforcing steel has exactly the opposite properties; it is strong in tension and weak in compression. Combining the two results in a material (reinforced concrete) which is strong in both compression and tension and therefore useful in a large number of situations.

Concrete is best reinforced with specially made steel rods which can be imbedded in the concrete. Bamboo has also been used to reinforce concrete with some success although it is liable to deteriorate with time.

- Reinforced concrete sections should be at least 7.5 cm thick although 10 cm is preferable.

- The reinforcing bar (rebar) usually comes in long sections of a given diameter.

- Exactly how much rebar is needed in a particular pour will depend on the load it will have to support. For most concrete work, including everything discussed in this manual, rebar should take up 0.5% to 1% of the cross-sectional area.

- Reinforcing bars should also have clean surfaces free of loose scale and rust. Bars in poor condition should be brushed thoroughly with a stiff wire brush.

- When placing rebar in a form before the concrete is poured it should be located:

  - at least 2.5 cm from the form everywhere.
  - in a plane approximately one-third of the way into the thickness of the pour from the bottom of the structure or slab.
  - in a grid so that there is never more than three times the final concrete thickness between adjacent bars.
  - no closer than 3 cm to a parallel bar.

- Rebar strength is approximately additive according to cross-sectional area. Four 4 mm rebars will be about as strong as one 8 mm rebar. The cross-sectional area of four 4 mm rebars equals the cross-sectional area of one 8 mm rebar.

- The rebars should be arranged in an evenly spaced grid-type pattern with more and/or thicker rebar along the longest dimension of the pour.

- All intersections where rebars cross should be tied with thin wire.

- When one rebar is tied onto another to increase the length of the rebars, the overlap should be 20 times the diameter of the rebar and be tied twice with wire.

Rebar Size	Overlap
6 mm	12 cm
8 mm	16 cm
10 mm	20 cm
12 mm	24 cm

- Larger sizes of rebar often have raised patterns on them which are designed to allow them to be held firmly in place by the concrete. Smaller sizes of rebar are generally smooth. When using smooth rebar always make a small hook at the end of each piece that will be in the concrete. Without the hook, temperature changes may eventually loosen the concrete from the rebar thereby destroying much of its reinforcing effect.

- Rebar should be carefully prepared so that the rebar is straight and square. Sloppy rebar work will result in weaker concrete and waste rebar.

- For particularly strong pieces or where small irregular shapes are being formed, the rebar can be put together in a cage-like arrangement. Use small rebar for the cross-sections and larger rebar for the length. This system is used to reinforce pieces like a cutting ring, with its irregular shape, or perhaps a well cover, which may have many people standing on it at one time.

- Where possible, it is usually best to assemble rebar inside the form so that it will fit exactly.

- The proper distance from the bottom of the pour in a slab can be achieved by setting the rebar on a few small stones before the concrete is poured or simply pulling the rebar grid a couple of centimeters up into the concrete after some concrete has been spread over the whole pour.

4. Mixing Concrete by Machine or by Hand

a. Mixing by Machine

Concrete must be thoroughly mixed to yield the strongest product. For machine mix, allow 5 or 6 minutes after all the materials are in the drum. First, put about 10% of the mixing water in the drum. Then add water uniformly with the dry materials, leaving another 10% to be added after the dry materials are in the drum.

b. Mixing by Hand

On many self-help projects, the amount of concrete needed may be small or it may be difficult to get a mechanical mixer. If a few precautions are taken, hand-mixed concrete can be as strong as concrete mixed in a machine.

The first requirement for mixing by hand is a mixing area which is both clean and watertight. This can be a wood and metal mixing trough (Fig. 8C-45) or simple round concrete floor (Fig. 8C-46).

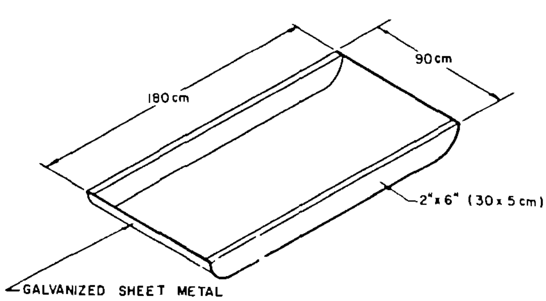


Figure 8C-47. Mixing Trough

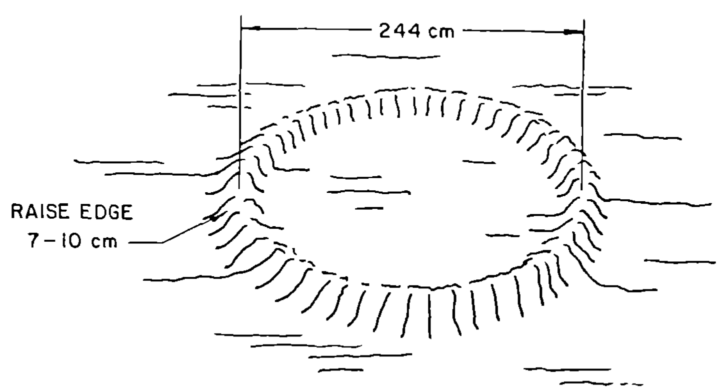


Figure 8C-48. Mixing Floor

Use the following procedure:

1. Spread the fine aggregate evenly over the mixing area.

2. Spread the cement evenly over the fine aggregate and mix these materials by turning them with a shovel until the color is uniform.

3. Spread this mixture out evenly, spread the coarse aggregate on it and mix thoroughly again. All dry materials should be thoroughly mixed before water is added.

A workable mix should be smooth and plastic -- neither so wet that it will run nor so stiff that it will crumble. If the mix is too wet, add small amounts of sand and gravel, <u>in the proper proportion</u>, until the mix is workable. If a concrete mix is too stiff, it will be difficult to place in the forms. If it is not stiff enough, the mix probably does not have enough aggregate, thus making it an uneconomical use of cement.

When work is finished for the day, be sure to rinse concrete from the mixing area and the tools to keep them from rusting and to prevent cement from caking on them. Smooth shiny tools and mixing boat surfaces make mixing surprisingly easier. The tools will also last much longer.

5. <u>Pouring Concrete Into Forms</u>

To make strong concrete structures, it is important to place fresh concrete in the forms correctly.

The wet concrete mix should not be handled roughly when it is being carried and put in the forms. It is very easy, through joggling or throwing, to separate the fine aggregate from the coarse aggregate. Do not let the concrete drop freely for a distance greater than 90 to 120 cm (3 to 4 feet). Concrete is strongest when the various sizes of aggregates and cement paste are well mixed.

Properly proportioned concrete will have to be worked into place in the form. Concrete that would on its own flow out to completely fill in a form would be too wet and therefore weak.

When pouring concrete structures that are over 120 cm high, leave holes in the forms at intervals of less than 120 cm through which concrete can be poured and which can later be covered to permit pouring above that level. Alternatively, a slide could be used through which concrete could flow down to the bottom of the form without separating. Any "U"-shaped trough wide enough to facilitate pouring concrete into it, narrow enough to fit inside the form, and long enough so that the concrete can slide down the chute without separating will work.

As the concrete is being placed it should be compacted so that no air holes, which would leave weak spots in the concrete, are left. This can be done by tamping the concrete with some long thin tools or vibrating the concrete. Tamping can be accomplished with a thin (2 cm) iron rod, a wooden pole or a shovel.

The concrete will be compacted to some extent as it is moved into its final position in the form. However, special attention must be paid to the edges of the pour to make sure that the concrete has completely filled in against the form. If the forms are strong enough they can be struck with a hammer on the outside to vibrate the concrete just enough to allow it to settle completely in against the forms. Too much vibration can force most of the large aggregate toward the bottom of the pour, thus reducing the overall strength of the concrete.

6. Finishing

Once the concrete is poured into the forms, its surface should be worked to an even finish. The smoothness of the finish will depend on what the surface will be used for. Where more concrete or mortar will later be placed on this pour, the area should be left relatively rough to facilitate bonding. Where the surface will later be walked on, as for example the cover of a well on which a pump will be mounted, it should be somewhat rough to prevent people from slipping on the concrete when its surface is wet. This somewhat rough texture can be achieved by finishing with a wooden float or by lightly brushing the surface to give it a texture. A very smooth finish can be made with a metal trowel. Over-finishing (repeated finishing) can lead to powdering and erosion of the surface.

7. Curing Concrete

After the forms are filled, the concrete must be cured until it reaches the required strength. Curing involves keeping the concrete damp so that the chemical reaction that causes the concrete to harden will continue for as long as is necessary to achieve the desired strength. Once the concrete is allowed to dry the chemical hardening action will gradually taper off and cease.

The early stage of curing is extremely critical. Special steps should be taken to keep the concrete wet. Once the concrete dries, it will stop hardening; after this happens it cannot be re-wetted in the field to re-start the hardening process.

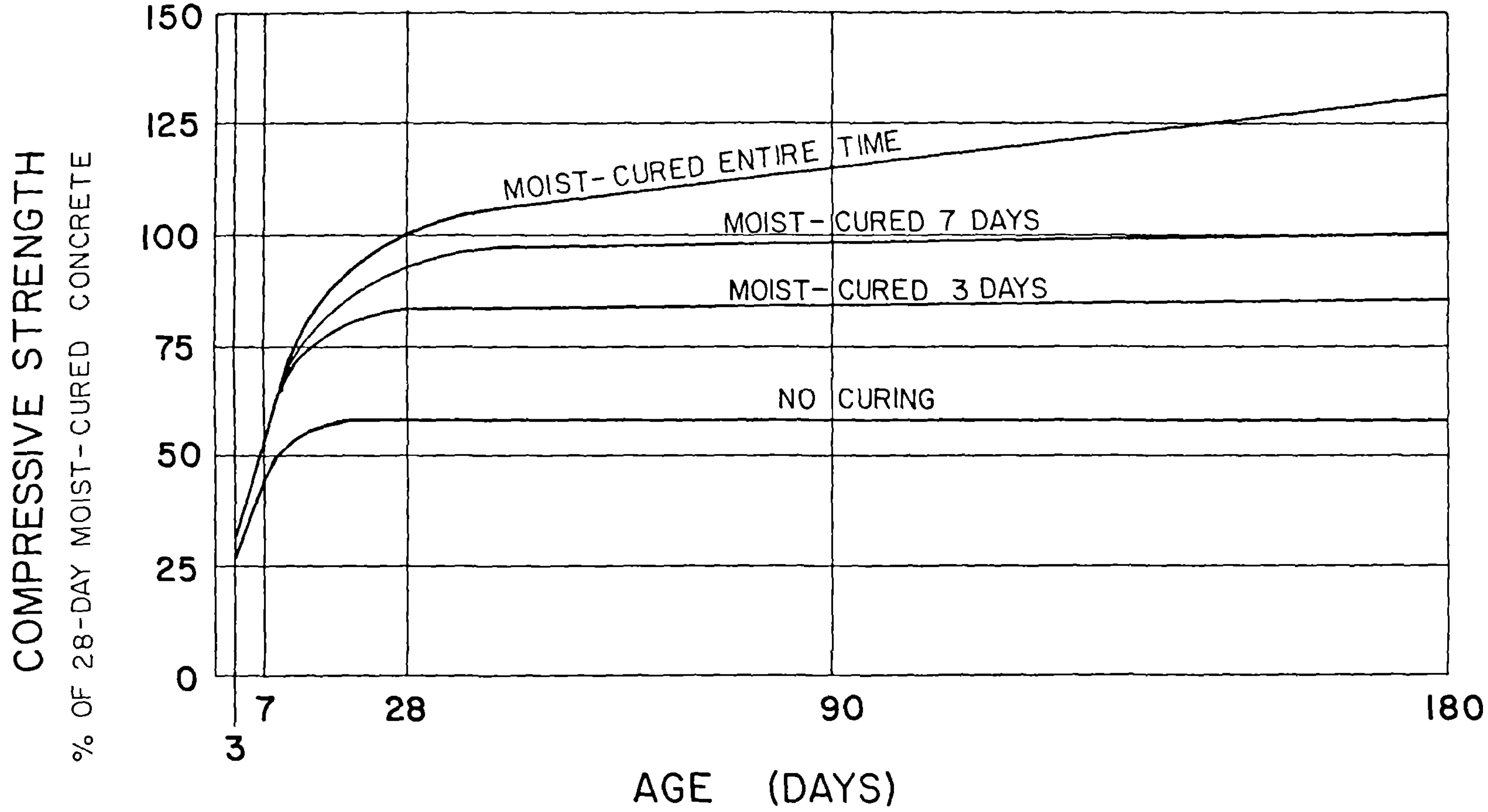
Covering the exposed concrete surfaces is usually easier than continuously sprinkling or frequently dousing the concrete with water which would otherwise be necessary to prevent the concrete surface from becoming dry. Protective covers often used include canvas, empty cement bags, burlap, plastic, palm leaves, straw and wet sand. The covering should also be kept wet so that it will not absorb water from the concrete.

Concrete is strong enough for light loads after 7 days. In most cases, forms can be removed from standing structures like bridges and walls after 4 or 5 days, but if they are left in place they will help to keep the concrete from drying out. Where concrete structures are being cast on the ground, the forms can be removed as soon as the concrete sets enough to hold its own shape (3 to 6 hours) if there is no load on the structure and measures are taken to ensure proper curing.

The concrete's final strength will result in part from how long it is moist cured. As can be seen from the Graph 8C-1, concrete will eventually reach about 60% of its design strength if not moist cured at all, 80% if moist cured for 3 days, and almost 100% if moist cured for 7 days. If concrete is kept moist, it will continue to harden indefinitely.

GRAPH 8C-1

Comprehensive Strength of Concrete



Instrument for Assessing Project Feasibility

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
Well Characteristics	• Yield of well					
	• State of disrepair of well					
	• Type of well and diameter					
Water Characteristics	• Chemical water quality					
	• Taste, odor and appearance of water					
Location of Well	• Distance from source of contamination					
	• Accessibility					
	Above known flood level					
	On small hill					

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
Community Interest and Support	Interest of village leadership and villagers in under taking project					
	Number of users					
	Potential for water committee or other responsible organization					
	Potential for village based maintenance capability.					
	Interest in supporting/promoting user education.					
Community Resources	• Available labor					
	• Available materials					
	• Ability to pay users fees, or other costs (if appropriate)					

SYNOPSIS OF SESSION 6: Preparing for Conducting Initial Village Assessment for Project Feasibility

Total Time: 5 Hours

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Part I				
Introduction	Trainer Presentation	30 Min.		Session Objectives
Lecturette: The Initial Village Assessment for Project Feasibility	Lecturette	15 Min.		
Discussing the Individual Work Assignment: Filling out the Assessment Instrument	Participants share and discuss responses	30 Min.	Assessment for Project Feasibility Instrument: Handout 5-10 given out in previous session	
Individual Work Assignment: Completing the Assessment Instrument	Instructions given	10 Min.		
Part II				
Introduction	Trainer Presentation	5 Min.		
Large Group Discussion: Completing the Assessment Instrument	Participants share and discuss responses	1 Hour		
Introduction to Task: Community Decision Making	Participants prepare a presentation	45 Min.		Task Instructions
Village Meeting Simulation	Group Presentations	50 Min.		

SYNOPSIS OF SESSION 6: Preparing for Conducting Initial Village Assessment for Project Feasibility (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Large Group Task: Identifying Problems in Gathering Information	List Problems	15 Min.		
Assigning Assessment Teams to Villages	Assignment and Briefing of Teams	10 Min.	Map of Region	Team Assignments Instructions for Assessment Task
Assessment Team Strategy Development	Team Planning	30 Min.		

Session 6: Preparing for Conducting Initial Village Assessment for Project Feasibility

Total Time: 5 hours
Part I: 1 hour 25 min.
Part II: 3 hours 35 min.

OBJECTIVES

By the end of this session, participants will be able to:

1. articulate the purpose of the assessment for project feasibility and its place in the project cycle

2. list what to look for and why when conducting an assessment

3. explain criteria useful in determining the feasibility of the handpump installation and in making decisions about how to proceed

4. explain to the village the assessment process, the benefits of a handpump project, and the role of the villagers, the extension workers, and others in the planning, implementation, and maintenance of a handpump project

5. consider strategies for conducting the assessment

OVERVIEW

In previous sessions, participants have worked to prepare the well site to receive a handpump. In reality, there are many activities which precede the actual construction work (as indicated in the project cycle model presented in Session 3.) In this session, the first phase of the project cycle (the pre-planning and assessment phase) is re-introduced with a primary focus on conducting a rapid assessment of a particular village and its current well sites to determine the feasibility of implementing a handpump project and to plan how to proceed. Because of the participants' early involvement in actual construction activities, it is important for them to understand how the sequence of activities will change in an actual field situation.

A particular gap in the planning capabilities of water and sanitation agencies is the ability of fieldworkers to systematically gather and use data on the capabilities of communities to organize efforts to install, maintain, and repair water facilities. Fieldworkers have neither access to useful data nor the means for bringing insights to bear on the practical problems they face--deciding on appropriate technical and organizational interventions in communities, for instance. There is a need to develop for fieldworkers the means both to assess the readiness of communities to participate in water improvements and to decide on the best technical and organizational approaches to take to these communities.

The feasibility assessment process has two major purposes:

1. to guide and direct project management decisions and technical design decisions that extension workers and villagers need to make

2. to "weed out" well sites that are technically inappropriate

Once the data from the assessment process have been gathered, a set of criteria must be applied to assist water agencies, extension workers, and villages to make well-informed decisions about whether and how to proceed. The criteria are based on what the experience of the technicians and extension workers has shown to be needed for a successful handpump project.

The degree of flexibility an extension worker has in making technical design decisions and project management decisions will vary from country to country depending upon how the national handpump programming effort has been structured and the number of pre-determined decisions.

Village participation should be considered during this initial phase of the project cycle. The assessment itself and, in particular, the discussions and planning meetings which follow are collaborative processes between extension workers and villagers whose views, perceptions, and interests must be elicited. This requires the extension worker to take on the role of consultant and resource person for the villagers.

During the information gathering part of the assessment process, the extension worker tries to make explicit what he or she is doing and explain to villagers what is being done and why. The extension worker can begin to clarify what the technical and program design options might be and the advantages and disadvantages.

Once the information is gathered and the criteria applied, village involvement in making decisions about whether and how to proceed becomes crucial. Decisions such as:

- How many technically acceptable well sites in a particular village should receive handpumps?

- Which of several technically acceptable sites should receive a handpump?

- Which handpump model would be most appropriate (when there is a choice)?

require full participation of villagers and sensitivity on the part of the extension worker. For example, a decision about site location should take into consideration convenience for women.

This session is immediately followed by fieldwork during which the participants actually conduct an assessment for project feasibility. The trainer must have made arrangements with villagers to conduct the assessment. See Trainer Note 1 at the end of this session for additional information.

In addition, the trainer needs to give participants information about the handpump project not previously known to them before they begin the village assessment. The trainer should have information about

cost of well
resources that need to be available
procedures that will be undertaken to implement project

PROCEDURE Part I: Total Time: 1 hour 25 min.

1. Introduction Time: 30 min.

Give the objectives of the session and major activities.

Develop an introduction from the information contained in the overview. Emphasize that the construction activities over the last few days were out of sequence with the activities of the first two stages of the project cycle. Refer to the project cycle chart posted in the training room and point out the pre-planning and assessment phase and its activities.

Ask participants to quickly review the steps that should have occurred before arrival at the workshop for the handpump project on which we are now working.

Ask the following questions:

- What evidence do we have that they occurred?
- What should have been looked for in order to determine project feasibility?
- If there were no training program being conducted here, would you have chosen this site? Why? Why not?

2. Lecturette: The Initial Village Assessment for Project Feasibility

Time: 15 min.

Make the following points:

- The approach an extension worker takes in conducting an assessment survey can affect the success of the project over time. Knowledge gained through participation in the assessment process leads village members to define problems and formulate plans for solving them. If men and women gather information it can bring to light important points that may otherwise be overlooked. For example:

  - In many developing countries pumps installed to provide pure, accessible water break down. Investigations show that the pump handles were designed for men when, in fact, women and children were the main users. Because women and children need a lower pump handle position, they used the pumps inefficiently causing damage and breakdown.

- In several Central American and African villages, surveys reveal that some domestic water supply projects fail to capture community interest. Because pure and accessible water was a problem in these rural areas, however, a follow-up study was conducted and it was learned that earlier surveys were directed toward village leaders who were men. The men felt water was needed for agriculture, irrigation, cattle breeding, and industry. Few of them mentioned drinking water or domestic use of water. When women were asked, lack of water for family use came up immediately.

o Extension workers should share their technical experience with villagers about what does and does not work so that villagers understand and are able to use that experience to make decisions. Extension workers should be careful about making promises they are not prepared to carry out.

3. <u>Discussing the Individual Work Assignment; Filling Out the Assessment Instrument</u> Time: 30 min.

A) During the previous session participants were given the assessment instrument and asked to decide why each item listed is important and what criteria could be used to analyze the information gathered (columns C and D). Ask participants what they decided for each item, and after a short discussion, try to reach general agreement and then post the responses on flipchart paper. Use the model instrument (<u>Handout 5-10</u>) as a guide (see Trainer Note 2).

B) Ask the following questions:

- Was there any general area (column A) or item (column B) that you felt was left out? Which? Why? (If agreement can be reached by the group, add to the instrument.)

- Are there any questions about why it is important to assess these items or about the criteria to use?

- Which criteria seemed most appropriate?

4. <u>Individual Work Assignment: Completing the Assessment Instrument</u> Time: 10 min.

A) Tell participants that the next activity is to decide how to obtain information for each assessment item and whether each item has an impact on:

<u>whether</u> to proceed or <u>how</u> to proceed.

B) To further clarify the task, take an item from the model assessment chart at the end of the previous session as an example.

C) Tell participants that between now and the next session (Session 6, Part II) they should fill in the information needed in columns E (how to get the information) and F (impact).

PROCEDURE Part II: Total Time: 3 hours 35 min.

5. Introduction Time: 5 min.

Participants have been asked to fill in columns E and F of the assessment for project feasibility instrument. Tell them that we will now continue our work on the instrument and then prepare to conduct an assessment in villages.

6. Large Group Discussion: Completing the Assessment Instrument

Time: 1 hour

Go over each item listed on the assessment for project feasibility instrument and ask participants how they filled in columns E and F. Allow enough time for discussion and to arrive at an agreement as to the information that should be included. If needed, refer to the model chart to help clarify.

7. Introduction to Task: Community Decision Making Time: 45 min.

A) State the following in your own words:

"If a village is to decide whether it wants to commit itself to a handpump project it needs to have information. Some of the information has to do with how villagers feel about undertaking the project. Other information needs to come from the extension worker based on his/her experience in working with other villages and his/her technical expertise and knowledge of resources. In anticipation of this need the extension worker must decide how best to communicate the information. The following exercise should prepare you for the meeting that you will hold in the village you will visit. Think of this exercise as part of your entry strategy."

B) Divide participants into two groups and give the following instructions:

- Design a presentation for a village group that communicates all of the information the group needs to know about the assessment process and the next necessary steps.
- Help the villagers make a decision about a handpump project. Hypothesize that:
  - You have heard that this village has indicated interest in a handpump project and has at least one or more wells. This will be your first visit to this village. What are the kinds of things you will want to talk about?
- Consider village responsibilities in planning, implementing, and maintaining resource contributions and any information gathered from the previous exercise.

- Be prepared to present this information in a village meeting simulation.

  Note: The participants should use visual aids where appropriate. This presentation format may develop into a model for future use after the workshop.

8. Village Meeting Simulation Time: 50 min.

Ask one group and then the other to make its presentation. Allow 10 minutes for presentation and 15 minutes for discussion. The group not making a presentation should actt as the "villagers." After each presentation ask:

- What did you like about this presentation? Why?
- What would you have done differently? Why?

9. Large Group Task: Identifying Problems in Gathering Information

Time: 15 min.

Tell participants it is important to identify typical problems fieldworkers have in gathering information before they begin to plan how they will conduct the assessment. Ask participants to think about a situation in which they have tried to gather some information on the job or in their personal life. Ask for examples of problems and list them on a flipchart or a blackboard. The list should include items such as:

- initially people may not trust you
- people may tell you what they think you want to hear
- you may be asking the wrong question
- you may be asking the wrong people
- you may be asking questions at the wrong time and place
- people may have difficulty telling you about things that are second nature to them

10. Assigning Assessment Teams to Villages Time: 10 min.

Use a map of the region. Locate the villages with which previous arrangements have been made to conduct an assessment. Assign assessment teams to villages (see Trainer Note 3). Ask participants what they know about these villages. Brief them about what has occurred in the village in relation to the potential handpump project, if anything, and what follow-up they can expect after their visit. Also provide information to the participants about how much a handpump project in this area is likely to cost and what resources are available.

11. Assessment Team Strategy Development   Time: 30 min.

Tell participants that this part of the session is a time for them to plan a strategy for entering the village where they will conduct an assessment using the assessment instrument.

A) Suggest that they keep in mind the problems they may have in gathering information. Teams should then use the assessment instrument and what was learned from the simulated community meeting and take 20 minutes to prepare themselves to enter the village (see Trainer Note 4). Give them the following instructions:

- You have 20 minutes to plan your survey and up until ____________ (time) to conduct a survey of your village. (Give logistical information here.)

- Decide among your team members how you will work together; who will conduct the meeting; who will collect what information; how you will involve the villagers in the assessment.

- After conducting the assessment, prepare a 10-minute presentation for the rest of the group including:

  - a general account of what happened and the difficulties encountered

  - survey activities and information gathered for each general area and item on the assessment instrument (with the exception of the assessment item "yield of well")

  - the team's impression of the feasibility of the site after applying the criteria

  - next steps recommended

B) Participants should spend 20 minutes working together to develop their plan. At the end of the time, teams should be ready to travel to their assigned village.

MATERIALS

1. Map of region

2. Flipchart paper

3. Marker pens

4. Tape

5. Flipcharts prepared for:
   - session objectives
   - instructions for community decision-making task (step 7B)
   - participant assignments to assessment teams (step 10)
   - instructions for assessment team strategy development task (step 11A)

TRAINER NOTES

1. Prior to the beginning of this session, the trainer must have made arrangements for villages to be surveyed. The villages selected need to be close enough to the training site to enable participants to spend approximately two to three hours there. When selecting the villages, care must be taken to clearly communicate the reasons for the visit and to not raise unrealistic expectations. It may be possible to select villages where participants will actually be able to follow up after the training program. If this is not the case, the assessment teams need to consider how best to make the assessment process a learning experience for the villagers. Information of the sort gathered through the assessment process could be useful to villagers if they consider water and other projects. When possible, several villages should be selected so that survey teams can be composed of three to six people each (depending on the size of the total participant group). The trainer should be prepared to brief each village visited and give approximate information about how much a handpump project would cost that village and what resources are available.

2. The "model" assessment for the project feasibility instrument provided at the end of the previous session should serve only to assist the trainer to explain the task and to guide the participants. Some information in the instrument will vary depending upon standards and criteria set at a national level. Emphasis should be on using the assessment process as a way of determining strategy and approach.

3. Assign participants to survey teams before this session. Take into consideration the following:

   - whether participant(s) is currently responsible for area in which village is located (for possible follow-up after workshop)

   - whether participants are familiar with village

   - whether familiar with the local language (if applicable)

   - whether familiar with village men or women (if applicable)

   - participants' areas of expertise and job roles (if applicable).

4. Participants will need at least two to three hours to conduct the assessment. This does not include travel time.

SYNOPSIS OF SESSION 7: Conducting the Assessment and Analyzing Assessment Results

Total Time: 7 Hours 15 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Part I				
Conducting the Assessment for Project Feasibility	Teams conduct assessment in villages	4 Hours		
Part II				
Introduction	Trainer Presentation	10 Min.		Session Objectives
Final Preparation of Reports	Teams prepare reports	30 Min.		
Assessment Teams Presentation of Reports	Teams report	1 Hour 30 Min.		
Processing the Assessment Task	Questions and Discussion	30 Min.		
Generalizing from the Assessment Task	Participants list learnings	20 Min.		
Application	Participants identify what they will do differently next time	10 Min.		
Closure	Trainer Presentation	5 Min.		

Session 7: Conducting the Assessment and Analyzing Assessment Results

Total Time: Approximately 7 hrs. 15 min.
Part 1: Approximately 4 hrs.
Part 2: 3 hrs. 15 min.

OBJECTIVES

At the end of the session, participants will have:

1. carried out an assessment for project feasibility
2. articulated their most important findings
3. discussed the potential of the village and sites for a handpump project

OVERVIEW

This session includes an actual assessment which would take a full morning or afternoon (approximately 4 hours) including transportation time. In the suggested workshop schedule, the village field trips to conduct the assessment activity (Part I) occur in the afternoon and the analysis of assessment results (Part II) takes place the next day. After completing the assessment, teams are asked to present their findings in respect to the potential of the village and site(s) for a handpump project.

PROCEDURE Part I: Total Time: Approximately 4 hours

1. Conducting the Assessment for Project Feasibility — Time: 4 hours

The participants will travel to nearby villages and conduct the project feasibility assessment.

PROCEDURE Part II: Total Time: 3 hours 15 min.

2. Introduction — Time: 10 min.

State objectives and sequence of events. Tell group they will have one half hour to make final preparations for reports. As mentioned in the previous session, reports should include:

- a general account of what happened, including difficulties encountered
- survey activities and information gathered
- impressions of site feasibility
- next steps

Ten minutes will be allowed for each presentation and five minutes for questions.

3. Final Preparation for Reports — Time: 30 min.

4. Assessment Teams Presentation of Reports — Time: Approx. 1 hour 30 min. Depending on total number of participants

After each survey team has made its presentation, allow five minutes for questions. Ask:

- Do you agree or disagree with the team's assessment of feasibility. Why/Why not?
- Do you agree or disagree with its analysis of the next steps? Why/Why not?
- Are there other possible approaches?

5. Processing the Assessment Task — Time: 30 min.

Ask some of the following questions:

- How did the assessment instrument work? What changes would you make?
- Did you hear examples of village participation in the assessment activities? Which?
- How easy or difficult was it to gather the information? Why?
- With whom did you talk? Were certain groups not approached? Why?
- What surprises if any did your assessment team encounter?

6. Generalizing from the Assessment Task — Time: 20 min.

Ask participants to individually jot down the three most important things they learned about conducting village assessments. Ask for examples and develop a list on flipchart paper or a blackboard.

7. Application — Time: 10 min.

Ask participants to look over the list and decide what they will try to do differently the next time. Get four or five responses from the group.

8. Closure Time: 5 min.

Refer back to the objectives for Sessions 6 and 7 and ask participants if they have been met.

MATERIALS

1. Flipchart paper

2. Marker pens

3. Tape

4. Flipcharts prepared for:
   - session objectives

ESSION 8

SYNOPSIS OF SESSION 8: Working with the Village Community

Total Time: 4 Hours
5 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	10 Min.		Session Objectives Project Cycle
Large Group Discussion: The Water Committee	Discussion	20 Min.		
Small Group Task: Helping to Establish Village Water Committee	Small groups prepare reports	45 Min.		Task Instructions
Small Group Reports	Small groups give reports	20 Min.		
Processing	Trainer asks questions and leads discussion	15 Min.		
Introduction to Small Group Task	Trainer gives instructions	5 Min.		
Small Group Task: Analyzing the Situation	Small groups solve community participation problems	30 Min.	Handout 8-1: Situations for Problem Solving	Task Instructions
Processing the Situations	Small groups present analysis of the situation and large group discusses	1 Hour 15 Min.		
Generalizing	Participants list conclusions	10 Min.		
Application	Sentence completion	10 Min.		
Closure	Reviewing session objectives	5 Min.		

Session 8: Working with the Village Community

Total Time: 4 hours 5 min.

OBJECTIVES

By the end of the session, participants will be able to:

1. articulate the major tasks and decisions in which a village committee could be involved

2. suggest the possible forms a water committee might assume and identify approaches for getting it organized

3. identify problems relating to village involvement at each phase of the project cycle and develop strategies to overcome the problems

OVERVIEW

Once the village assessment has been conducted and the decision to go ahead with the project has been made, the planning and design phase of the project cycle has been reached. This session requires participants to think about the water committee, its function, and role and the extension worker's responsibility to it. It also raises the issue of village involvement in decision making and implementation. The session ends with a series of problem-solving situations fieldworkers may experience during the planning, implementing, or monitoring of a handpump project. Participants are asked to consider each situation and develop a strategy to solve the problem.

Frequently an improved water supply fails to improve health or even is not used at all because of a poor understanding between the responsible agency and the community. Technical staff sometimes appear to think their job is limited to the provision of water which meets certain specifications and not to the long-term use of the system.

It is likely that the system will best meet the needs of its users if it is discussed with them. Experience gained in similar communities will be a valuable guide, but each community must also be considered on its own merit.

At the earliest possible stage it is important that the agency make clear to the village the extent of its commitment and leave no doubt about the cost which will fall upon the community. Community participation in planning implies that the community will be required to make a substantial financial contribution. They should be presented with alternatives and enabled to choose the one which does not impose too big a burden.

The next question to be decided is the responsible organization, within the community, which will be the focus of consultations and community action. Many types of councils and committees exist in rural areas which have various degrees of power and responsibility.

Regardless of which organization is approached initially--and this should be particularly clear with traditional authorities--there will often be the need to establish a second committee or informal group to discuss details. Formed with the support of the more senior organization in order not to appear to compete with it, such a group should ideally include representatives of each of the social groups in the community (e.g. both sexes and various age groups as well as any other sub-groups), persons with relevant knowledge whether modern or indigeneous (e.g., a school teacher, a plumber or mechanic, a well-digger), and active younger people.

A committee will not always have enthusiastic and articulate members, but the more representative and the more active a committee is, the less difficulty there will be in ensuring that the needs of all members of the community are met. Where it is not possible to gather a representative group, it will be very important for the extension worker to sound out views and opinions through informal conversations.

PROCEDURE:

1. Introduction — Time: 10 min.

Give the objectives of the session and its major activities. Develop an introduction from the information contained in the overview. Present the planning and design phase of the project cycle to the participants and go over the activities involved.

2. Large Group Discussion: The Water Committee — Time: 20 min.

Begin the discussion by stating that a village organization needs to be established to take responsibility for planning and managing the project. The extension worker then becomes a consultant to this group. There can be many variations in form, membership, size, and areas of responsibility in this group based on individual village characteristics, resources provided by the government, and criteria set by the implementing agency.

Ask participants the following questions:

- From *your* perspective, what should the function and role of the village committee be?

- Does this function and role maximize community involvement?

- Think back to the village where you conducted an assessment. From *your* perspective, what kind of village committee would work best? Describe it. What other options are there?

- What do you think your responsibility and role should be in regard to:

  formation of the committee
  technical assistance
  orientation and training

3. Small Group Task: Helping to Establish the Village Water Committee

Time: 45 min.

Introduce the task by stating that when implementing a handpump project in a village, an extension worker should interact with the village committee and play a role in supporting it. This may mean raising issues and helping the committee to plan.

Give participants the following instructions:

Break into small groups of three or four and

- describe a role for a village water committee
- list the topics that should be put before the committee for decision making or action
- decide on a strategy for ensuring that the committee has all the necessary information

4. Small Group Reports

Time: 20 min.

Ask each group to present its work (five minutes each) holding questions until all presentations have been made.

5. Processing

Time: 15 min.

Ask the following questions:

- What were the major differences in the presentations? The similarities?
- Who should decide what the village committee should look like? Why?
- What is the role of the extension worker in working with the committee?
- What could be done to provide additional opportunities for committee and village involvement and decision making?

6. Introduction to Small Group Task: Problem Solving in Regard to Community Participation

Time: 5 min.

Tell the group the following:

"In a few minutes you will read about a situation which is a typical experience for most fieldworkers. We will ask you to identify what you see as the major issues/concerns raised in the situation and to think about what you might do if you were the extension worker. The situations are open-ended, that is, there are no right answers. They may have several possible explanations and solutions."

7. Small Group Task: Analyzing the Situations   Time: 30 min.

Break the large group into three small groups. Pass out Handout 8-1: Situations for Problem Solving to each group and assign each a different problem. Give the following instructions:

Discuss the following in your group and prepare to share your analysis of the situation:

- Do you see any problems in the situation described?
- What is the role of the extension worker?
- What possible strategies could be used here?

Note: There are five problem situations described in Handout 8-1. Choose the three that are most applicable to your experience or create three of your own.

8. Processing the Situations   Time: 1 hour 15 min.

Ask each group to present an analysis of the situation it was assigned. Before each group begins its presentation pass out to the other participants the description of the situation being analyzed, and give them five minutes to read it and think about how they would answer the above questions. After each groups presentation, allow 15 minutes for discussion. Ask some of the following questions:

- What is your reaction to the analysis presented?
- What other problems could be identified?
- What additional information would you need in order to clarify the problems?
- Are there other roles the extension worker might take?
- Are other strategies possible here?

Following are the times for each activity. Include a 15 minute break after completing the discussion about the second situation.

- Participants read situation: 5 minutes
- Small group presents analysis: 5 minutes
- Large group discussion: 15 minutes

9. Generalizing   Time: 10 min.

Ask participants the following questions:

- What are the most important things we can conclude about community involvement in a handpump project? (list)
- What is the primary role of the extension worker in respect to community involvement?

10. Application Time: 10 min.

Post the following sentence, ask individuals to think about it for a moment, and then ask for individual responses.

The most important thing I learned today that I can use in my work is:______.

11. Closure Time: 5 min.

Go back to original objectives of the session and check with participants to see if they were met.

MATERIALS

1. Handout 8-1: Situations for Problem Solving
2. Flipchart paper
3. Marker pens
4. Tape
5. Note Books
6. Prepared flipcharts for:
   - session objectives
   - instructions for small group task (step 3)
   - instructions for small group task (step 7)

Situations for Problem Solving

Situation #1:

Ali is an extension worker with the Ministry of Natural Resources. After attending a training workshop on handpumps, Ali surveyed the village of Potiskum and, from a technical stand point, decided it was ready to receive a handpump. There are three wells in the village, one of which meets all of the criteria for a good site. It needs a minimum of relining, it is at least 15 meters from a cattle pen, so that contaminiation from animal waste should not be a problem, and has it adequate drainage. Ali has determined that this village should be the first of the villages in his circuit to receive a handpump. Several days after his visit, Ali met the village school teacher in a nearby town. The school teacher told Ali that the villagers are talking about his visit and that the village is split between two factions-- one faction, made up mostly of women is saying that a handpump project should not be allowed to come to the village. They say that while Ali was in the village, he poisoned one of the wells; that is why he left the village so quickly after dropping something down into the wells.

Another faction is saying, "Let the handpump come. In the village of Gadaka, a team came in and installed the pump only two weeks after the visit of the extension worker. They completed all the work in three days and then left. The villagers had to do nothing."

Situation #2:

Central government authorities have been running a media campaign to convince villagers to use clean water. In addition, mobile units have brought movies and talks about clean water into villages. The central government has publicaly announced that 500 handpumps will be installed over the next month. For Mushi, an extension worker in the Kunhan District of Si Sa Ket, this means responsibility for preparing 20 villages in four weeks to receive handpumps.

Mushi feels that handpump projects are an important way to improve the health of rural people as well as a means to encourage villagers to participate in planning and designing a village project.

Situation #3:

Villagers were not coming to work at the well site as they had been scheduled. Help was needed for the work. Finally, the extension worker, Jose, visited each person house to house the day before their appointed work day and asked them why they were not coming. He tried to find out what the problems were and stressed the importance of the handpump for creating a source of clean water for the village. Every man he visited came to work, but he had to continue visiting them and make a personal appeal to each one before they would come.

Situation #4:

The handpump in the village of Fika has been laying idle for three months. There has been disagreement in the village about how much money should be collected every month by the water committee and how this fund should be used. In the beginning ______ was being collected from every family. Now, however, there are complaints that it is too much, especially since there has been an outbreak of pests and all the villagers are forced to spend money to buy pesticides. Most families have refused to give money to the water committee treasurer for the last two months. The pump needs a foot valve in order to work again. The village caretaker has estimated this would cost ______.

Situation #5:

Women in the Bahr El Ghazil Province of Sudan spend many hours fetching and carrying water long distances. Often this water is contaminated and causes illness and death.

A water supply project was started in response to the need for clean water and to provide the women with a more accessible water source. Handpumps were installed and villagers were trained in their use and maintenance. Health education was also given to stress the importance of using the new water source.

When the women used the handpumps they found that the time spent for fetching water was lessened and there was a decrease in water-related illnesses. Nevertheless, they did not use this water source consistently. When questioned, they gave the following reasons:

1. The water tastes bad and can lessen appetite when used in food.

2. The water changes color when boiled for tea or exposed to air.

3. Too many people use the pump and there is a long wait. This often causes fights among the villagers

4. The pump is often broken.

SESSION 9

SYNOPSIS OF SESSION 9: Mid-Point Workshop Evaluation and Review

Total Time: 1 Hour 10 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Large Group Review	Trainer reviews workshop activities to date	15 Min.		Session Objectives from Sessions 1-8
Individual Task: Mid-Point Evaluation Form	Individuals fill out form	15 Min.	Handout 9-1: Mid-Point Evaluation Form	
Large Group Discussion: Evaluation Results	Trainer solicits responses and posts them	30 Min.		Chart for Recording Responses
Closure	Trainer Presentation	5 Min.		

Session 9: Mid-Point Workshop Evaluation and Review

Total Time: 1 hour
10 minutes

OBJECTIVES

By the end of this session, the participants will have:

1. reviewed the session objectives from the first eight sessions

2. filled out the mid-point workshop evaluation

3. discussed problems encountered during the first half of the workshop and made suggestions on how they can be resolved

OVERVIEW

The mid-point evaluation has two purposes. The first is to give participants an opportunity to review what they have learned to date in the workshop. The second is to give trainers information about how the participants are reacting to the workshop. The questionnaire, which participants fill out anonymously, should indicate if any modifications need to be made by the trainers during the second half of the workshop. For example, if a sufficient number of participants feel uncertain about topics or skills covered in a specific session, an evening review session could be planned.

Individuals should be encouraged to approach the trainers about any area of confusion.

PROCEDURE

1. Introduction — Time: 5 min.

Introduce the mid-point evaluation by explaining to participants that this is an opportunity to review what they have accomplished in the workshop so far, to identify any information that needs to be clarified or skills that need further practice, and to find out in general how participants feel about the workshop.

2. Large Group Review — Time: 15 min.

Post the session objectives from all past sessions and briefly review for participants the major activities covered in each session. Make reference to the project cycle chart and where each session fits.

3. <u>Individual Task: Mid-Point Evaluation Form</u> Time: 15 min.

Pass out Handout 9-1: Mid-point Evaluation Form to each participant and ask them to fill it out. Encourage honest responses. Tell them not to write their names on the form. Give them 15 minutes to complete it.

4. <u>Large Group Discussion: Evaluation Results</u> Time: 30 min.

A) Post the following chart on flipchart paper and ask participants to give their responses. Record their responses on the chart.

Objectives Sessions Problem	Things Learned	General Workshop Problems	Ideas for Resolution

B) Go over the compilation of the evaluation responses with the participants clarifying the responses when necessary. Make some gen 1 observations about the responses, i.e., "It seems like most of you found Session 7 to be particularly useful and at least half of you did not see Session 4 as applicable to your work." Lead a discussion by asking the following questions:

- What do the evaluation responses say about how we should proceed?
- Who agrees/disagrees with the ideas for resolution of workshop problems? Why? What alternatives do we have?

The discussion should end with agreements between trainers and participants about any modifications that need to be made in the next half of the workshop. Ask participants to hand in their evaluation sheets.

5. <u>Closure</u> Time: 5 min.

Encourage participants to continue to voice their ideas and reactions to the workshop. Invite individuals who feel a need for clarification of a particular topic or for a follow up session to see the trainers.

MATERIALS

1. Handout 9-1: Mid-Point Evaluation Form

2. Flipchart paper

3. Marker pens

4. Tape

5. Prepared flipcharts for:
   - Session objectives
   - Compiling the evaluation results (step 4)

Mid-Point Evaluation

1. Do you feel capable of accomplishing all of the session objectives covered so far? If not, which ones present the most problems (specify session and objectives)?

2. What are the things you have learned from the first half of the workshop? Place a check next to the items which are most useful to you in your work.

3. In general, what are the problems you encountered during the first half of the workshop? What do you think should be done to resolve them?

SESSION 10

SYNOPSIS OF SESSION 10: Finishing the Site

Total Time: Dug Well: 3 Hours 5 Min. Drilled Well 2 Hours 35 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Lecturette/Discussion: Finishing the Site	Discussion of work completed and next steps	15 Min.		
Preparation for Field Work	Teams plan their work	20 Min.	Handout 10-1: Dug Well, Team Work Plan Guide Handout 10-1: Drilled Well, Mark II Pump, Team Work Plan Guide	Team Work Plan Guide (Dug or Drilled Well)
Field Work: Finishing the Site	Teams remove forms, plaster apron sides and construct a drainage system	Dug Well: 2 Hours Drilled Well: 1 Hour 30 Min.	Materials and tools needed to finish the site (see materials and tools list)	
Discussing Field Work Activities	Participants state what they learned	10 Min.		
Application	Pairs share how they will apply what they learned	10 Min.		Construction Line Chart
Closure	Review of session objectives	5 Min.	Handout 10-2: Finishing the Site	

Session 10: Finishing the Site

Total Time: Dug well: 3 hours 5 min
Drilled Well: 2 hours 35 min

OBJECTIVES

By the end of this session the participants will be able to:

1. complete the apron construction

2. provide adequate site drainage

OVERVIEW

To complete the handpump site one must remove forms, plaster the apron sides, and construct a simple drainage system for the apron. The construction of the drainage system is important because water spilled around the apron will filter through the soil and may enter and contaminate the well. In addition, standing water around the well site will soon make the area a mud hole and a breeding spot for mosquitos and other insects.

Completing the site can also be a vehicle by which the village can develop pride in the well and pump. Some villages have used the run-off water to water a garden; others have built benches or an ornamental fence around the site. In some countries competitions are staged between neighboring villages for the most attractive well site.

This session is a continuation of the construction begun in Session 5. At least three days must be allowed for the concrete apron constructed in Session 5 to cure before the forms can be removed. This is the last construction session in which cement mixtures are used.

After a brief introduction, the session begins with a lecturette/discussion about what tasks remain. The participants then decide how they will organize the work. Following the fieldwork the participants talk about what they did and suggest how they could make improvements the next time they do these tasks.

Because this session addresses both dug wells and drilled wells, and because there is more than one method of apron construction for both types of wells, information which pertains to a certain design or construction method is separated from the session procedures and is included in a section called "Trainer Reference Sheets." The trainer reference sheets give the construction team work plan and special trainer guidelines for supervising the construction for both a dug well and a drilled well apron design. When apron designs and construction methods other than the two included are used, the trainer reference sheets can be used as models for developing material to suit the design and methods. The modification of the trainer reference sheets will not affect the procedure of the session, which should remain the same for any type or method of apron construction.

To use the trainer reference sheets, select either the dug well or drilled well sections found at the end of the session (or develop sheets for the construction method you will be using) and insert them in the text after the page in which they are referenced.

The labor, tool, and material requirements of this session are much the same as the previous construction session. Because of a three-day gap between the construction sessions, however, it will be necessary to make special arrangements for the workmen and any tools borrowed from the village to be available again. This session uses workmen for repetitive labor when the participants have had sufficient time to learn the task.

The construction tasks of this session are more involved for a dug well than a drilled well and may require more time to complete. A sump will be needed only on flat land or when an existing drainage trench is not nearby. The number of participants will also influence the time needed to complete the session.

PROCEDURE

1. Introduction — Time: 5 min.

Develop an introduction from the material in the overview covering the following points:

- session objectives
- why finishing the site is an important step in apron construction
- how the session relates to the project cycle

Tell the participants that for this session, as in the previous construction session, Session 5: "Constructing the Apron," they will also work in teams.

2. Lecturette/Discussion: Finishing the Site — Time: 15 min.

A. Quickly summarize the construction steps that have been completed so far. Then ask the participants the following questions and have them write their answers on flipchart paper or a blackboard:

- What needs to be done in order to finish each of the well sites?
- What input from the users might be needed at this time?
- What could be done to make the site both attractive and more convenient to users?

B. Review the list of tasks volunteered by the participants and add any other tasks from the trainer reference sheets for Step 2 to create a list of tasks that need to be completed in this session. It may be helpful to reorganize the tasks in chronological or topical order.

C. Give participants details of the design based on local standards and interest that they will be using to finish the site. For example:

- length and depth of the ditch and sump
- plans to use run off water for a garden

3. <u>Preparation for Fieldwork</u> Time: 20 min.

A. Explain that the two teams will be working at their well sites again to complete the tasks listed in the trainer reference sheets for step #3. Suggest that the teams use the plan layed out in the trainer reference sheets to accomplish the tasks (put plan on flipchart paper). Include any other tasks on the flipchart that were generated earlier by the participants but not included on the trainer reference sheet.

Note: Insert Trainer Reference Sheets for Step 3 after this page.

B. Remind participants that upon arrival at the well sites they should take a few minutes to:

- choose a new team leader
- designate a team member to be responsible for tools
- plan who will do which tasks

C. Pass out <u>Handout 10-1: Team Work Plan Guide</u> and <u>Handout 10-2: Finishing the Site</u>

4. <u>Fieldwork: Finishing the Site</u> Time: Dug Well: 2 hrs
Drilled Well: 1 hr 30 min

The trainer(s) should move between the two well sites while participants are working on the tasks. The role of the trainer is to:

- Act as a resource person if there are steps of which the participants are unsure

- Pose questions to participants instead of telling them how to do a step:

  - If you continue doing it that way, what do you think will happen?
  - Is there a more efficient way to do that task?

- Closely observe the work being done. Spot problem areas or lack of understanding.

In particular, the trainers should watch out for:

- safety considerations, especially when removing the planking for dug wells

- whether drain slopes sufficiently toward the sump

5. Discussing Fieldwork Activities Time: 10 min.

Ask what the participants learned during the session. In what areas did they have difficulty? In what areas do they think they need more practice?

6. Application Time: 10 min.

Ask the participants to think over the activities of all the construction sessions. Post the flipcharts with the construction session steps or Handout 2-1: Construction Line Chart to help them recall. Ask the participants to jot down how they will be using what they learned in the construction sessions after the workshop is over. After several minutes, have the participants in pairs exchange their thoughts.

7. Closure Time: 5 min.

Review the session objectives. Ask the participants if each one was met. If they don't think it was, ask them to explain what was omitted.

MATERIALS

1. The materials and tools needed in this session are listed in "Materials and Tools" following Trainer Notes.

2. Handout 10-1: Dug Well: Team Work Plan Guide

   Handout 10-1: Drilled Well and Mark II Pump: Team Work Plan Guide

3. Handout 10-2: Finishing the Site

4. Flipchart paper

5. Marker pens

6. Tape

7. Flipcharts prepared for:
   - session objectives
   - team work plan guide

TRAINER NOTES

For the field activity the tools and materials need to be brought to the site before the session begins. A participant from each team should be made responsible for bringing the tools from the storeroom and returning them when the session is over.

Materials and Tools

Materials	Quantity*	Tools	Quantity**
cement		hammer	2
sand		key hole saw	1
gravel		trowel	3
hollow blocks or brick		shovel	4
clay		bucket	4
		pick/maddox	2

*Quantities will vary depending on the size of the apron and length of the drain. Refer to Session 8 to determine material quantities.

**Quantities listed are per work site. If there are more than one work site, the quantities should be increased proportionately.

Trainer Reference Sheet for Step #2

(Drilled Well-Ground Level Apron Design and Mark II Pump)

A) Remove forms from apron:

- Why? - no longer needed, concrete can be finished now
- Key points to remember:
  - tap forms with hammer to loosen them
  - do not chip concrete

B) Plaster the newly exposed apron surfaces:

- Why? - to make it look good
- Key points to remember:
  - wet surfaces before plastering

C) Dig ditch and sump:

- Why? - to drain water from well site
- Key points to remember:
  - sump needed when well is not near a drainage ditch or on flat land

D) Lay drain:

- Why? - to keep water from seeping back into ground near the site by channeling the water to a ditch, sump, garden, etc.
- Key points to remember:
  - use string to lay drain in straight line

E) Fill sump with gravel and cover with clay:

- Why? - no standing pool of water for children to play in or insects to breed in

F) Grade area around apron, drain low spots:

- Why? - to drain any standing water
- Key points to remember:
  - splash water around apron to find low spots

G) Spread gravel around apron:

- Why? - to provide an area around apron that will not become muddy and to make the site attractive

Trainer Reference Sheets for Step #2

(Dug Well-Ground Level Apron Design)

A) Remove forms from apron:

- Why? - no longer needed, concrete can be finished now
- Key points to remember:
  - tap forms with hammer to loosen them
  - do not chip concrete

B) Cut hole in wooden platform for access hatch and place access hatch (dug well only):

- Why? - provide protected access to well for maintenance and repair and to get water from the well in event that the pump breaks down
- Key points to remember:
  - remove as much planking as possible. The planking that remains will eventually rot and fall into the well
  - keep planking from falling in well. Remove from water all pieces of planking so that they won't clog the pump when it is installed

C) Plaster the newly exposed apron surfaces:

- Why? - to make it look good
- Key points to remember:
  - wet surfaces before plastering

D) Dig ditch and sump:

- Why? - to drain water away from well site
- Key points to remember:
  - sump needed when well is not near a drainage ditch and on flat land

E) Lay drain:

- Why? - to keep water from seeping back into ground near the site by channeling the water to a ditch, sump, garden, etc.
- Key points to remember:
  - use string to lay drain in straight line

F) Fill sump with gravel and cover with clay:

- Why? - no standing pool of water for children to play in or insects to breed in

G) Grade area around apron, drain low spots:

- Why? - to drain away any standing water
- Key points to remember:
  - splash water around apron to find low spots

H) Spread gravel around apron:

- Why? - to provide an area around apron that will not become muddy and to make the site attractive

Trainer Reference Sheets for Step #3

(Drilled Well-Ground Level Apron Design and Mark II Pump)

Suggest the following plan for each team to accomplish the tasks for finishing the well.

Group	Task	Approximate Time
Group A	. remove form . plaster exposed surface	10 minutes 60 minutes
Group B	. dig sump . fill sump with gravel and cover with clay . grade area around site	20 minutes 20 minutes 30 minutes
Group C	. dig drain . place drain, mortar in place	20 minutes 45 minutes

Trainer Reference Sheets for Step #3

(Dug Well-Ground Level Apron Design)

Suggest the following plan for each team to accomplish the tasks for finishing the well.

Group	Task	Approximate Time
Group A	. remove planking . place hatch cover	1 hour 10 minutes
Group B	. remove forms . plaster exposed surfaces	20 minutes 45 minutes
Group C	. dig sump . fill sump with gravel and cover . grade area around sump	20 minutes 30 minutes 30 minutes
Group D	. dig drain . place drain, mortar in place	20 minutes 45 minutes

Note: Depending on the size of the work team, these tasks may take longer to complete than indicated above. Groups B and D should designate two or three people to mix the plaster and mortar for both groups to further conserve time and manpower.

Team Work Plan Guide

Group	Task	Approximate Time
Group A	• remove planking • place hatch cover	1 hour 10 minutes
Group B	• remove forms • plaster exposed surfaces	20 minutes 45 minutes
Group C	• dig sump • fill sump with gravel and cover • grade area around sump	20 minutes 30 minutes 30 minutes
Group D	• dig drain • place drain, mortar in place	20 minutes 45 minutes

Team Work Plan Guide

Group	Task	Approximate Time
Group A	. remove form . plaster exposed surface	10 minutes 1 hour
Group B	. dig sump . fill sump with gravel and cover with clay . grade area around site	20 minutes 20 minutes 30 minutes
Group C	. dig drain . place drain, mortar in place	20 minutes 45 minutes

Finishing the Site

Concrete Drain and Area Around the Apron

Excavate a drainage trench from the drain space in the apron to a sump or an existing drainage ditch. Slope the bottom of the trench so water from around the apron will drain into it as shown in Figure 1 . Fill the trench with at least five (5) cm of small gravel. Using hollow blocks, construct a concrete drain over the gravel in the trench for a distance of at least five (5) meters. The floor of the drain should be five (5) cm thick and ten (10) cm wide. The concrete drain removes water from the apron while the sublayer of gravel allows water from around the apron to be drained away.

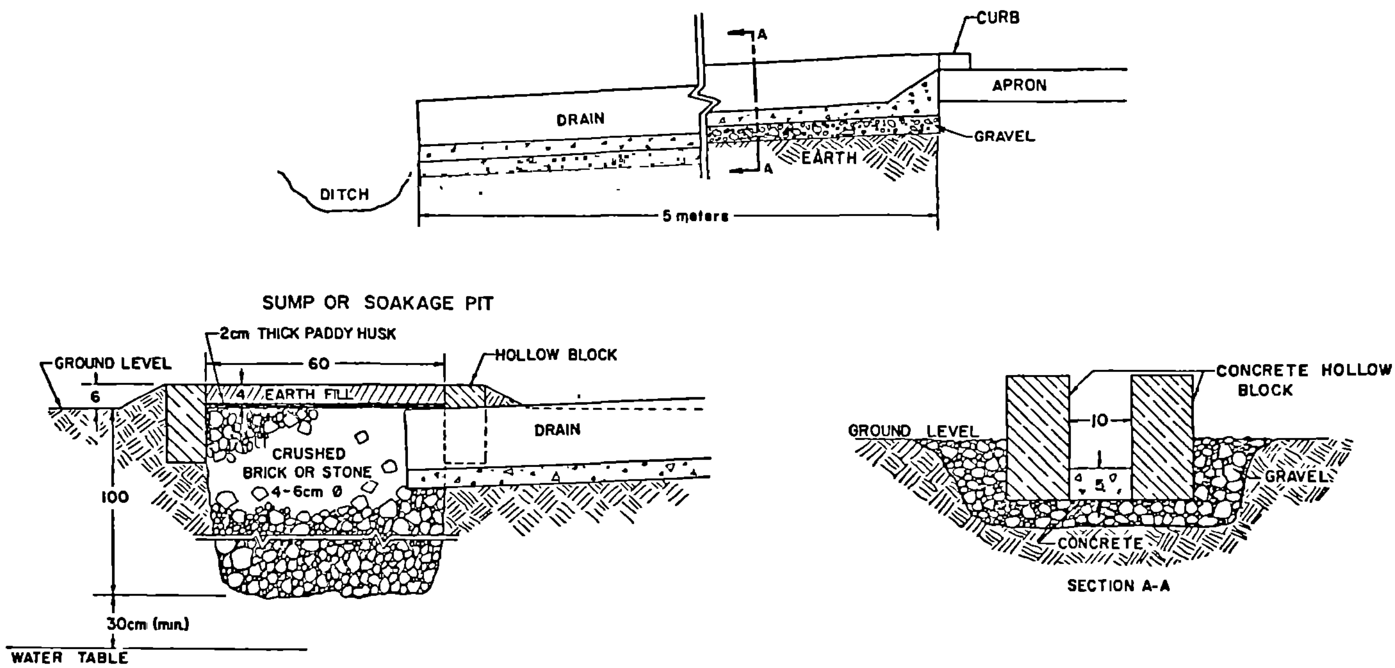


Figure 1. Apron Drain

Clear a one and one-half (1½) meter area around the apron. The area should be sloped so that waste water is drained away from the apron and toward the drain. This procedure is recommended because standing water may contaminate the well. Splash water on the cleared area to locate low spots as in Figure 2. When the low spots have been drained, cover the area with 10 to 15 centimeters of small gravel. The gravel provides a non-slip and neat surface especially during the rainy season. Sites on soft soil will require more gravel than those on hard soil.

The following figures depict completed sites and some innovative ideas for making the site more attractive or functional.

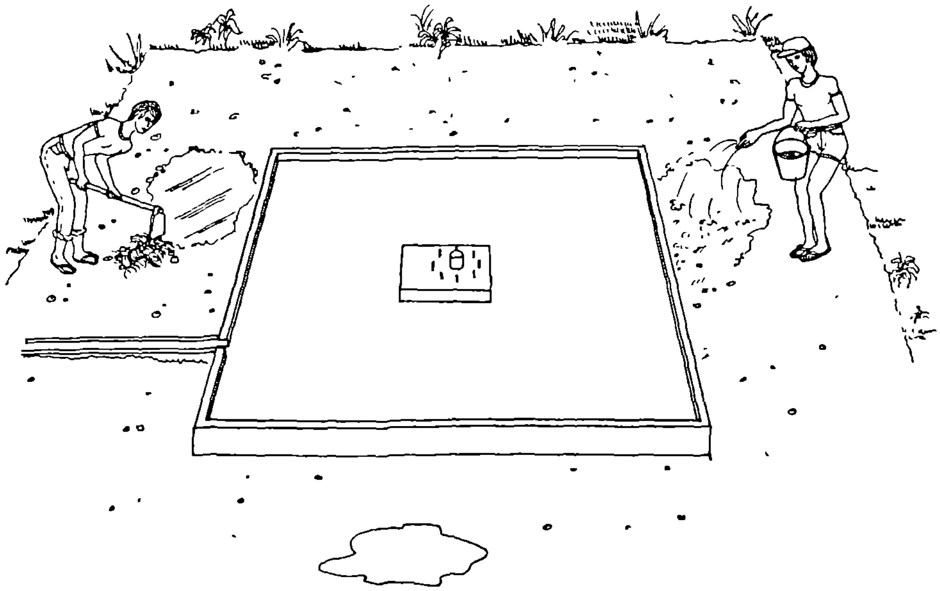


Figure 2. Drainage of Area Around Apron

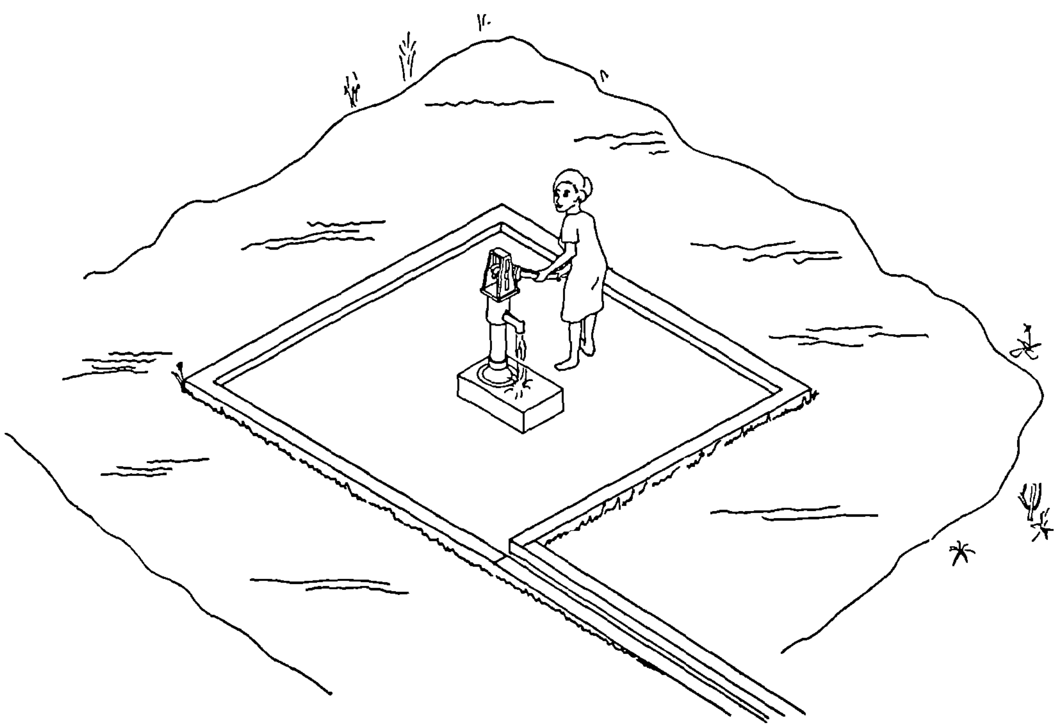
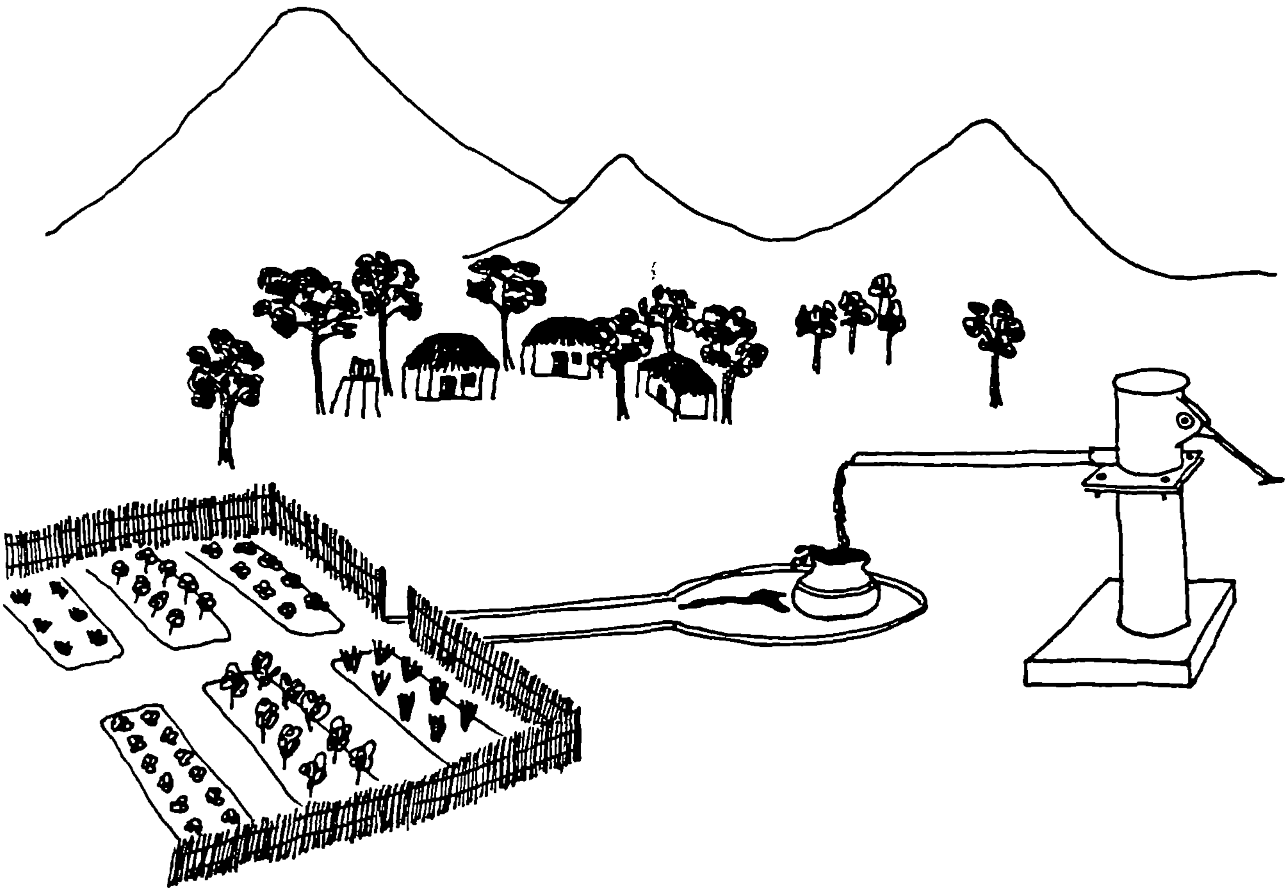


Figure 3. The Finished Site



Konzani ngalande kuti madzi wotaika pa chitsime adzeremo polowa padimbo.

Channel drain water into a garden

SESSION 11

SYNOPSIS OF SESSION 11: Installing the Handpump and Disinfecting the Well

Total Time: Shallow Well Pump Only:
5 Hours
50 Min.
Deep Well Pump Only:
7 Hours
35 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Part I				
Introduction	Trainer Presentation	20 Min.		Session Objectives
Lecturette/Discussion: Rules-of-Thumb for Installation Depths	Trainer Presentation	10 Min.		
Problem Session: Rules-of-Thumb for Installation Depths	Individuals solve sample problems	10 Min.	Handout 11-1: Estimating Rules for Pump Installation Depths Handout 11-2: Problems for Determining Installation Depth	
Discussing the Problem Session	Participants share answers and discuss	10 Min.	Handout 11-3: Answers to the Problems for Determining Installation Depths	
Lecturette: Pump Installation Steps		15 Min.		Steps for Pump Installation (Shallow Well or Deep Well Pump)
Preparation for Field Work	Trainer presents tools needed for installation, maintenance and repair and gives instructions for field work.	20 Min.	Handout 11-4: Steps for Installing an AID Shallow Well Pump Handout 11-4: Steps for Installing an AID Deep Well Pump	

SYNOPSIS OF SESSION 11: Installing the Handpump and Disinfecting the Well (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Field Work: Practice on Barrels	Participants install pumps on barrels	Shallow Well Pump: 45 Min. Deep Well Pump: 1 Hour 30 Min.	See Section 1.8 of the Introduction and tools and materials list	
Discussion of Practice Session	Questions and Answers	10 Min.		
Part II				
Group Planning for Installing the Pump on the Well	Trainer gives instructions for field work	15 Min.		Field Work Instructions
Field Work: Installing the Pumps on the Wells	Teams install pump on well	Shallow Well Pump: 1 Hour Deep Well Pump: 2 Hours	See tools and materials list	

SYNOPSIS OF SESSION 11: Installing the Handpump and Disinfecting the Well (cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Field Preparation for Well Disinfection	Trainer presentation on well disinfection and team calculation of amount of disinfection	30 Min.	See materials and supplies-disinfection Handout 11-5: Steps for Disinfecting Wells Handout 11-6: Water for the World: Disinfecting Wells	
Field Work: Disinfecting the Well	Teams disinfect wells	45 Min.	See materials and supplies-disinfection	
Field Discussion: Who is Responsible for Disinfection and Overcoming User Resistance	Discussion	30 Min.		
Generalizing and Applying	Trainer poses questions for discussion	15 Min.		
Closure	Trainer summarizes and refers back to session objectives	5 Min.		

Session 11: Installing the Handpump and Disinfecting the Well

Total Time: Shallow well pump only: 5 hrs 50 min.
Deep well pump only: 7 hrs 35 min.

Part I: Shallow well pump: 2 hrs 30 min.
Deep Well pump: 3 hrs 15 min.

Part II: Shallow well pump: 3 hrs 20 min.
Deep well pump: 4 hrs 20 min.

OBJECTIVES

By the end of this session, the participants will be able to:

1. perform the pre-installation steps for a shallow well and a deep well pump
2. install a shallow well and a deep well pump
3. determine the amount of disinfectant needed to disinfect a well
4. disinfect a well
5. safely handle and use disinfectants for wells
6. discuss techniques to overcome user objections to well disinfection

OVERVIEW

The installation of the pump is the last step to sanitarily seal a well. Improper installation may result in damage to the pump and insufficient or undesirable water for the users. The problems associated with improper installation and their solutions are addressed in the session.

Every time a well is opened for pump repair or to remove water, there is a high probability, almost a certainty, that harmful contaminants will be introduced into the well. Essentially, opening a well can allow contaminants into the well that the well lining or casing, the apron and the handpump were meant to keep out. For this reason, it is important to disinfect the well when the pump is installed and every time the well is opened thereafter.

Often in actual practice the well is disinfected for the first time immediately before the pump is installed or just before installation is completed. During this session disinfection is done as the last step of the installation but the procedures can easily be rearranged as noted in step 11. The procedures of disinfection are usually taught to the caretakers when the pump is installed.

Contaminants can also enter the well from the aquifer if the aquifer is near sources of contamination. The technical assessment of the site is an attempt to screen out wells with contaminated aquifers (as was pointed out in the Session 6: "Preparing for Conducting Initial Village Assessment for Project Feasibility".)

During this session the participants will learn to install a deep well and/or shallow well pump.

To give participants adequate practical experience they should be divided into three groups and practice installing a pump on a barrel. After the practice sessions, the participants will install a pump on the actual well.

Because of a wide range of pumps available this session uses trainer reference sheets to separate trainer procedures from the specific steps to install a particular pump. Trainer reference sheets are included at the end of the session for an AID shallow well pump and an AID deep well pump. When other pumps are included in the session, the trainer reference sheets can be used as models for developing installation guides for the other pumps. Modification or replacement of the trainer reference sheets will not affect the session procedures.

Use the trainer reference sheets at the end of this session and select either the AID shallow well or deep well pump sections (or develop sheets for the pumps you will be installing) and insert them in the text after the page in which they are referenced.

For more than one type of pump, the installation procedures (Steps 5 through 8) should be repeated for each pump. Each additional shallow well pump will add up to 1-1/2 hours to the session length and each additional deep well pump up to 2 hours and 15 minutes, depending on how different the tools and procedures are.

This session requires many materials, tools, and supplies which must be procured and set up in advance. Refer to the materials and tools list at the end of this session and to Section 1.8 in the Introduction.

Disinfection of the well must be discussed with the users of the pump several days prior to disinfection. If there is user resistance the trainer or local extension or health worker should develop a strategy to overcome it. This strategy (and the discussion) can be shared later with the participants in Step 13.

The type and form of disinfectant used in this session will vary with the country. Provided for this session is a quantities chart (Handout 11-6, Table 1) to obtain a given concentration in the well water for chlorine in concentrated solid, unconcentrated solid, and unconcentrated liquid forms. If other disinfectants are used, quantities charts will have to be procured by the user of this guide.

Set up for the demonstrations in this session beforehand:

- Set the barrels on which to install the pumps in a circle or in rows at the work site.
- Number each barrel.
- Set out a shallow well pump and/or a deep well pump beside each barrel.
- Set out a set of suction pipe, drop pipe and plunger rod pieces with connectors and any other accessories in each barrel.

PROCEDURE Part I: Time: Shallow well pump: 2 hrs 30 min.
Deep well pump: 3 hrs 15 min.

1. Introduction Time: 20 min.

A) Welcome the participants to the session. Give the participants:

- session objectives
- relationship of this session to the project cycle and the workshop schedule
- main steps of the session

B) Make the following key points about improper installation:

Shallow well pumps and deep well pumps

- When the cylinder or end of the suction pipe is installed at too great a depth, the pump will raise sand and mud with the water. The users will not find sandy or muddy water palatable and may go to other, perhaps contaminated, sources. Sand and mud will also abrade the cups and cylinder and can cause the foot valve to stick.
- When the cylinder or end of the suction pipe is installed at too shallow a depth, the water level may drop below the bottom of the cylinder or suction pipe so that water can't be pumped.
- Pre-installation steps also affect the performance of the pump. When the pump connections and pipe sections are not tightened sufficiently they may leak or unscrew. A leak in the suction pipe of a shallow well pump can cause the pump to stop pumping water. Connections that become unscrewed can also cause the pump not to function.

Deep well pumps only

- Installing the cylinder at a greater depth than necessary increases material costs and makes the whole drop pipe assembly heavier.

- If the plunger rod is cut too short or too long on the deep well pump, the plunger assembly will strike the ends of the cylinder. Under those conditions the plunger assembly will eventually break.

2. <u>Lecturette/Discussion: Rules of Thumb for Installation Depths</u>

Time: 10 min.

A) Make the following points:

The factors which influence the depth at which the cylinder or suction pipe should be installed are:

- A dug well has a greater storage capacity per vertical foot than the drilled well and usually a faster recharge rate because of the larger surface area of the walls through which water enters the well. The water level lowers much more slowly in a dug well than a drilled well being pumped at the same rate. The cylinder or suction pipe should be installed deeper in a drilled well than in a dug well.

- A new well has more silt and loose sand in it than an older well (say, several months old). This material may be pumped up causing damage to the cups and making the water cloudy. The cylinder or suction pipe should be a further distance from the bottom of a new well than an older well.

- The slower the recharge rate, the deeper in the well the cylinder or suction pipe should be installed.

- The proximity of heavily-used wells necessitates installing the cylinder or suction pipe deeper. Nearby motorized irrigation pumps can lower the water table by several meters.

B) Discuss what can be done if the depth is mismeasured:

- If mud and sand are being pumped, shorten the pipe.

- If the cylinder or suction pipe is out of the water, add an extra length of pipe at the bottom. Remember that water can only be lifted a maximum of about eight meters from below the plunger assembly of the pump. For severe mismeasurements a shallow well pump may have to be replaced by a deep well pump or, for a deep well pump installation, an extra length of drop pipe and rod may have to be added above the cylinder.

3. Problem Session: Rules-of-Thumb for Installation Depths Time: 20 min.

A) Pass out Handout 11-1: Problems of Determining Installation Depth and Handout 11-2: Rules of Thumb for Pump Installation Depth.

Note: The problems cover both drilled and dug wells and both deep and shallow well pumps. When one or more of these wells and pumps are not included in the workshop the problems should be changed to reflect this difference.

B) Give the participants the following instructions:

These problems can be solved by using the rules-of-thumb for the depth to install the cylinder or suction pipe. Work on the problems individually for the next 15 minutes. At that time we will discuss the answers to the problems. Begin now.

4. Discussing the Problem Session Time: 10 min.

Read the problem aloud. Discuss the answers for each problem. Distribute Handout 11-3: Answers to the Problems at the end of the discussion.

5. Lecturette: Pump Installation Steps Time: 15 min.

A) Post the steps for pump installation of flipchart paper or a chalk board. Use the steps in the trainer reference sheets for step 5. These steps can be used as a model to develop installation guides for other pumps.

TRAINER NOTE: Insert Trainer Reference Sheets for step 5 following this page

6. Preparation for Fieldwork Time: 20 min.

A) Make the following points about the tools used for installation, maintenance, and repair. Make additions as needed.

- Pipe wrench
  - adjust wrench so that pipe fits fully in mouth of wrench but does not slip
  - hold pipe with wrench close to joint being tightened or loosened
  - best mechanical advantage is obtained when the handles of both wrenches are on the same side of pipe (forces cancel each other and pipe is not put in a bind)
  - the pipe can be held vertically in the well by a pipe wrench, but a more secure method is to use two pipe wrenches facing opposite directions
  - two pipe wrenches facing opposite directions can be used in place of a vice or clamp when cutting threads

- Adjustable wrench

  - adjust the wrench each time it is placed on a nut or bolt to prevent rounding off the corners of the nut or bolt

- Pliers

  - used to pull cotter pins
  - do not use as punch to drive out bearing pins

- Hacksaw

  - hold the piece being cut securely
  - use with full, even, straight, and unforced strokes
  - always file off rough edges left by a hacksaw

- Hammer

  - use to hammer instead of other tools
  - do not hammer the pins to remove them because it will flatten the head of the pin making it impossible to remove, use a piece of wood or a slender object between the pin and the hammer

- Screwdriver

  - use to remove foot valve (flapper type) and to unscrew plunger cage (insert through plunger cage)
  - do not use to remove pins because this will flatten the head of the screw driver

- Pipe Threader

  - before beginning to use the threader, wipe the pipe clean of dirt or other foreign matter
  - apply cutting oil or lard to the pipe to enhance cutting (but not motor oil because it is a lubricant)
  - cut the threads by rotating the pipe cutter 1/2 to 3/4 turn and then backing off 1/4 turn to allow cuttings to fall away
  - wipe all loose cuttings off newly-cut threads before connecting with another pipe

- General

  - use a tool for its intended purpose: e.g. do not use wrenches as hammers
  - do not stand on, drop or throw tools: put them in a place where they can be easily reached but are not in the way.
  - oil tools periodically to keep them operating smoothly and free of rust

B) Explain that two teams will first practice installing a pump on barrels filled with water and then actually install a pump on each of the well sites. In order to insure hands-on experience with installation, use the barrels first.

C) Pass out the appropriate sections of Handout 11-4: Steps for Installing a Pump for the pump(s) being used in the workshop.

Give participants a few minutes to read and ask for questions.

D) Explain that the teams will divide themselves into three groups, one group per barrel, and that everyone will practice all the installation steps up to disinfecting the well.

Disinfection will be covered later.

E) Caution the participants on safety hazards (jabbing self with sharp objects, dropping parts of a pump on oneself, scraping knuckles, pinching fingers between handle and pump).

7. Fieldwork: Practice on Barrels — Time: Shallow well pump: 45 min. Deep well pump: 1 hr. 30 min.

A) Set up the work site beforehand:

- Make sure all the supplies and materials are at the work site (Trainer Note 1).
- Fill the barrels with water.

B) During the practice, the trainer(s) should also watch for the following:

- tools being used correctly and for their intended purpose
- participants referring to their handouts when they need help, not depending on a more experienced group member or the trainer
- participants with less experience heavily involved in the practice activity

8. Discussion of Practice Session — Time: 10 min.

Gather the participants and ask what they learned or what "tips" they would like to exchange with the group. Ask if there are questions before going on to the next activity.

Note: The next activity may be a lecturette on the installation (on the barrel) of another type of pump or it may be going to the actual site to install the pump on the recently constructed apron. Steps 5 through 8 should be repeated for each pump type.

PROCEDURE Part II: Time: Shallow well pump: 3 hrs 20 min.
Deep well pump: 4 hrs 20 min.

9. Group Planning for Installing the Pump on the Well Time: 15 min.

Explain that a pump will be installed on each well on which the participants have been working. The same teams which worked together to construct the apron will work together to install the pump. The steps for pump installation on the well are the same as on the barrel. Participants do all the steps except the last, well disinfection.

The groups are to do the following in preparation for the fieldwork (post on flipchart paper or blackboard):

A) Pick one member to be the team leader for the day. The job of the team leader is to:

- see that everyone is involved
- delegate work in such a manner that the participants gain experience doing unfamiliar tasks
- participants both learn and get the work done

B) Using the handout for the pump to be installed, divide the tasks.

C) Pick one team member to be responsible for gathering and returning the tools.

Ask if there are questions. Then have participants go to their work sites and spend 10 to 15 minutes planning how they will go about installing the pump.

10. Fieldwork: Installing the Pumps on the Wells

Time: Shallow well pump: 1 hr.
Deep well pump: 2 hrs.

A) The trainer(s) should move between the two well sites while participants work on the tasks. The role of the trainer(s) is to:

- act as resource person(s)
- pose questions, not solve problems for participants. Ask:
  - If you continue doing it that way, what do you think will happen?
  - Is there another way of doing that task which is more efficient?
  - What resources or assistance will you need to finish the task in the allotted time? How will you get to where you want to be?
- closely observe the work being done and spot problem areas or lack of understanding

B) In particular, the trainer(s) should watch out for the following:

- the proper use of tools (especially the pipe threader)
- that the drop pipe is securely held all during installation
- that all rods and pipe are firmly connected

11. Field Preparation for Well Disinfection Time: 30 min.

Note: For drilled wells the trainer may choose to disinfect the well before installing the pump. In this case, steps 11 and 12 can be done in the field before step 10.

A) Once the pumps have been installed on each of the two well sites, gather participants at one site and make the following points about well disinfection:

- lack of contamination--pure water--is the goal of the whole handpump project
- a well located a sufficient distance from sources of contamination is a safer source of water than a stream or pond, but it may become contaminated by dirty buckets or other objects falling into the well
- a handpump is used to raise water from a well when the well has been sealed against surface contamination
- even when a well is properly sealed, protected and equipped with a handpump contaminants may enter when the pump is removed; contaminants may be introduced if the repair team handles the pump with dirty hands, if dirt sticks to the outside of the pump, if debris falls into the well and if dirty buckets are used to remove water while the pump is not functioning.
- all this makes disinfection necessary before the well is resealed for use

B) Show participants the materials they will use to disinfect the wells:

- chlorine (or other disinfectant used locally)
- plastic bucket
- measuring cup
- broom

Tell participants that chlorine should be stored in a dry, dark place. Chlorine solutions weaken with age so it is better to use powdered chlorine (like HTH) and mix a solution only when it is needed.

C) Pass out Handout 11-5: Steps for Disinfecting Wells and Handout 11-6: Water for the World: Disinfecting Wells, and ask participants to read the steps listed under "Finding the Amount of Disinfectant" in Handout 11-5. Remind participants that they already know the number of meters of water in each well. Ask if there are questions about calculating the amount of disinfectant needed.

D) Ask each team to calculate the amount of disinfectant for its well and to report back to the trainer(s) once the calculation is completed. The trainer(s) should check each calculation for accuracy.

E) Gather participants together once more and review the steps in Handout 11-5 in the section "Disinfecting the Well". Ask for questions.

F) Explain that each team will now disinfect its well by performing the following steps:

pump the well
dissolve powdered disinfectant
pour disinfectant into well
mix disinfectant into well water
force disinfectant into aquifer
disinfect exterior of pump
operate the pump

Suggest to the teams that they may want to follow this plan to complete the above tasks:

- have several volunteers pump the well
- divide into groups of two or three with each group mixing a bucket of disinfectant. (This step will give hands-on experience to most members of the team.)
- divide the remaining steps between the groups

12. Fieldwork: Disinfecting the Well — Time: 45 min.

While the participants disinfect the well the trainer(s) should move between the two well sites.

The role of the trainer(s) is to:

- act as a resource person
- pose questions such as:
  - If you continue to do it in this way, what will happen?
  - Is there another more efficient and safer way of doing that task?
- closely observe the work being done and spot problems or lack of understanding

In particular, the trainer(s) should watch for the following:

- safe handling of the disinfectant

- that all participants get hands-on experience

When the disinfection steps have been completed (through "pumping the pump" until "the disinfectant can be smelled") have the participants put away the tools and wash the disinfectant from their skin.

13. Field Discussion: Who is Responsible for Disinfection and Overcoming User Resistance — Time: 30 min.

A) Identify who is responsible for disinfection. Both the caretakers and participants may have some responsibility. Define roles. Remind participants that if caretakers have responsibility for disinfection, they may have to be trained.

B) Identify who has to pay for the disinfectant. If it is the community, explore ways to communicate the importance of disinfection.

C) Ask "What comments about disinfecting a well have you heard, or might you expect to hear from the well users?" (It may be helpful to let the participants taste a glass of water with a faint but noticeable trace of chlorine in it. However, taste is only one possible source of user objections. They may also object on philosophical, cultural, or religious grounds or from fear of drinking chemicals or something not pure or natural.)

D) Ask the participants to suggest strategies to overcome user resistance. Then explain how the discussion on disinfection with the users at these wells was carried out and how any user resistance was overcome.

E) Remind participants of the last two steps on ~~Handout 11-5: Steps for~~ Disinfecting Wells (see Trainer Note 2 at the end of this session).

- Allow time for disinfection to work.
- Pump out odor of disinfectant.
- Tell participants when these two steps will be complete.

14. Generalizing and Applying — Time: 15 min.

Ask participants the following questions about the day's session (see Trainer Note 3):

- What do you think of today's field activities?
- What problems did you encounter?
- How did you solve the problems?
- What would happen if the disinfectants were not pumped out before the users of the well began to draw water?

- When you anticipate doing these activities on you own, what concerns you the most?

15. Closure Time: 5 min.

Summarize the session briefly, refer to the objectives, and link the current session to workshop.

MATERIALS

1. The tools and materials required to install a shallow well pump and a deep well pump and to disinfect the well are given in the list "Tools and Materials" following Trainer Notes.

2. Some of the activities of the session will involve the use of pumps, barrels and their accessories. A list of these can be found in section 1.8 of the main introduction.

3. Handout 11-1: Estimating Rules for Pump Installation Depth

4. Handout 11-2: Problems for Determining Installation Depth

5. Handout 11-3: Answers to Problems for Determining Installation Depth

6. Handout 11-4: Shallow Well: Steps for Installing an AID Shallow Well

   Handout 11-4: Deep Well: Steps for Installing an AID Deep Well Pump

7. Handout 11-5: Steps for Disinfecting Wells

8. Handout 11-6: Water for the World: Disinfecting Wells

9. Flipchart paper

10. Marker pens

11. Tape

12. Prepared flipcharts for:
    - session objectives
    - pump installation steps (step 5)
    - group planning (step 9)

TRAINERS NOTES

1. The supplies needed to set up fieldwork: practice on barrel is included in section 1.8 of the Introduction.

   Before the session begins, the barrels, materials, and supplies should be set in an open area where there is plenty of work space. Fill the barrels with water. The tools should be checked out of the storeroom by the group member assigned to this task.

2. Upon completing disinfection, make provisions for someone to pump out the chlorine the following day. The trainer(s) may want to bring all the participants back to the site to help with the pumping.

3. Steps 14 and 15 can be done in the field or in the classroom.

Tools, Materials and Supplies

The following tools, materials and supplies are required to install an AID shallow well pump using PVC pipe as the suction pipe. For galvanized suction pipe, substitute GI pipe and connectors in place of the PVC pipe and accessories.

Item	Quantity
adjustable wrench	2
pipe wrench (5 cm grip)	1
pliers	1
hacksaw (or pipe cutter)	1
tape measure (or tape measure and string to measure depth of well	1
rags	1
sandpaper	-
grease	-
hammer	1
punch (or pointed object to insert and remove pins)	1
PVC pipe (1-1/4" diameter)	Determined by well depth
PVC male threaded adapter (1-1/4" diameter)	1
PVC connector (1-1/4" diameter)	As needed
PVC solvent cement	-
teflon tape	
stiff wire brush (to clean threads in pump base)	-
chlorine	Determine by volume of water in well
plastic bucket (6 liters or more)	1
measuring cup (1/2 liter)	1
bucket (emergency eye wash)	1

The groups will install the shallow well pumps on barrels. Each group should have one set of tools and the materials listed above. See section 1.8 in the main introduction for the accessories that need to go with the pumps and barrels.

The following tools, materials and supplies are required to install an AID deep well pump:

Item	Quantity
1/2" die set	1
1-1/4" NPT pipe threader	1
tripod and pulley	1
heavy rope	1
pipe wrench (7-9 cm grip)	2
adjustable wrench	2
tape measure (or tape measure and string to measure the depth of well)	1
pipe clamp	1
hacksaw	1
rags	
stiff wire brush (to clean pipe threads)	
hammer	1
punch (or pointed object to insert and remove pins)	1
grease	-
1-1/4 inch GI Pipe	determined from well depth
1-1/4 inch GI pipe connectors	1 per pipe length
teflon tape or pipe joint compound	-
1/2 inch rod	determined from well depth
1/2 inch rod connectors	1 per pipe length
chlorine	determined by volume of water in well
plastic bucket (6 liters or more)	1
measuring cup (1/2 liter)	1
bucket (emergency eye wash)	1

The groups will install a deep well pump on barrels and later on the wells. Each group should have one set of the tools, materials and supplies above except for the pipe threaders and the tripod, pulley and rope. There should be at least one 1/2" die set for every three groups. One 1/2" die set, one 1 1/4" pipe threader and a tripod pully and rope, are needed for each well site where a deep well pump is to be installed. See section 1.8 in the main introduction for a list of the accessories that need to be included for each pump and barrel.

Trainer Reference Sheets for Step #5

(Installing an AID Shallow Well Pump)

1. Soak cups: The cups need soaking so they will expand and form a tight seal with the sides of the cylinder. This makes priming uncecessary. Priming may introduce dirty water into the pump.

   - unbolt pump cap from body
   - disconnect plunger assembly from cap
   - put plunger assembly in bucket of water

2. Tighten all connections: If all connections are not tight, they may loosen and eventually separate causing the pump to be inoperable.

   - tighten plunger assembly
   - tighten plunger rod lock nuts
   - tighten foot valve connections
   - tighten bolts and nuts holding cap on body
   - tighten body/base joint

3. Cut suction pipe to length: Using the estimating rules from the lecturette, measure and cut the suction pipe to the desired length. (Do this calculation with the participants or ask them to calculate. Give them all relevant information.

4. Glue adaptor to end: Solvent weld the 53 mm PVC suction pipe sections together following the directions on the can of solvent. Weld a male threaded coupling on the upper end. Attach the well strainer, if used. Allow several minutes for the solvent weld to set.

5. Place suction pipe in well: Lower the suction pipe assembly into the well.

6. Attach suction pipe to pump: Screw the male threaded coupling into the pump base. This task is much easier if the pump base is unscrewed from the pump body.

7. Bolt pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-gallon) can in 18-22 strokes, which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky footvalve or leaky joints. This situation is intolerable in shallow well pump installations since the pump may require regular priming which can introduce contaminants into the well. The pump should be removed and the cause of the leak determined and corrected before re-installation.

9. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the sider block tracks. Reassemble the pump.

10. Disinfect the Well: See Handout 11-5: Steps for Disinfecting Wells. For drilled wells it is usually easier to disinfect the well before installing the pump.

Trainer Reference Sheets for Step #5

(Installing an AID Deep Well Pump)

1. Tighten connections: The connections in the cylinder need to be tightened before the pump is installed.

2. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. Allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe. Follow the procedure below:

   - wipe the loose cuttings and dirt from the end of the pipe
   - thread the die on the pipe until the teeth begin to bite into the metal
   - apply cutting oil or animal lard liberally to the end of the pipe
   - cut the threads by turning the die clockwise 1/2 turn and then counter-clockwise 1/4 turn to allow the cuttings to fall away
   - continue in this manner until approximately 1 1/2 to 2 inches of threads have been cut
   - carefully remove the die without damaging the threads
   - wipe any loose cuttings off the pipe with a rag

3. Install cylinder, drop pipe and plunger rod to desired depth: Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the threads to make future disassembly easier, attach a length of plunger rod to the plunger rod section in the cylinder. Tighten firmly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly. If used, attach a strainer to the bottom of the cylinder.

   Lower this portion of the drop pipe assembly into the well.

   Put a section of plunger rod inside an equal length section of drop pipe. Raise these sections over the already-lowered portion of drop pipe assembly, connect the plunger rod first (being sure it is very tight). Apply Teflon tape or pipe joint compound to the drop pipe threads and then connect and tighten the drop pipe. (A pipe clamp and tripod will be required to perform this step and those following.) Again, always wipe the threads clean before applying Teflon tape or a pipe joint compound and joining sections of pipe together.

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

4. Attach drop pipe to base: Unbolt the pump cap from the pump body. Attach the pump body and base to the drop pipe.

5. Cut rod to length and thread rod: Push the plunger rod down to the lowest position (until it cannot be pushed down any more, refer to handout). Mark the rod 1 inch above the top of the pump body. Cut and thread the

plunger rod. Follow the same threading procedure for the drop pipe. This step ensures that the plunger assembly will be well centered within the cylinder.

6. Attach cap to rod and body: Hold the pump cap over the pump body. Join the plunger rod sections. Rebolt the pump cap to the pump body. Check all exposed nuts and bolts for tightness.

7. Bolt down pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-gallon) container in 18-22 strokes which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky foot valve or leaky joints. This situation is inconvenient to the users since they may have to operate this pump a long time before it delivers water. The pump should be removed and the cause of the leak determined and corrected before re-installation.

9. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the slider block tracks. Reassemble the pump.

10. Disinfect the Well: See Handout 11-5: Steps for Disinfecting Wells. For drilled wells it is usually easier to disinfect the well before installing the pump.

Trainer Reference Sheets for Step #5

(Installing a Mark II Deep Well Pump)

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

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

3. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. Allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe. Follow the procedure below:

   - wipe loose cuttings and dirt from the end of the pipe
   - thread the die on the pipe until the teeth begin to bite into the metal
   - apply cutting oil or animal lard liberally to the end of the pipe
   - cut the threads by turning the die clockwise 1/2 turn and then counter clockwise 1/4 turn to allow cuttings to fall away
   - continue in this manner unitl approximately 1 1/2 to 2 inches of threads have been cut
   - carefully remove the die without damaging the threads
   - wipe any loose cuttings off the pipe with a rag

4. Install cylinder, drop pipe and plunger rod in desired depth:

   Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the rod threads to make future disassembly easier, attach a length of plunger rod to the rod section in the cylinder. Tighten the connection and lock nut tightly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound n the pipe threads and tighten firmly. If used, attach a strainer to the bottom of the cylinder.

   Lower this portion of drop pipe assembly into the well. Secure it with a pipe clamp or tripod.

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

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

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

6. Cut plunger rod to desired depth and thread: Push the plunger rod down to the lowest position (until it cannot be pushed down any further). Mark the rod level with the top of the water tank with a hacksaw or scribing tool. Raise the rod up as far as possible. Place a rag into the water tank to keep rod cuttings from falling into the well. Clamp the rod with a rise or clamp. Cut and thread the plunger rod following the same procedure as for the drop pipe. Remove the rag. This step ensures that the piston assembly will be centered in the cylinder.

7. Attach plunger rod to head assembly: Remove the inspection cover from the head and lower the head onto the water tank. Screw the chain section onto the rod. Tighten the connection and the lock nut firmly. Using a bar, lift the head off of the tank and remove the rod clamp. Then bolt the head of the tank.

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

8. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The standard cylinder (2 1/2" ID) of the Mark II pump should fill a 19-liter (5 gal.) container in 30-34 strokes which is about 2/3 liter per stroke.

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

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

10. Disinfect the well: See Handout 11-5: Steps for Disinfecting Wells. For drilled wells it is usually easier to disinfect the well before installing the pump.

Estimating Rules for Pump Installation Depth

Rule I

Wherever possible the bottom of the cylinder or bottom of the suction pipe should be installed at the following depths:

Rule I A: Shallow well pumps	- 8-9	meters below pump
Rule I B: Deep well pumps on dug wells	- 3-5	meters below the dry season static water level
Rule I C: Deep well pumps on drilled wells	- 10-12	meters below the dry season static water level

Rule II

When the well is so shallow that the pump cannot be installed as deep as ROT I recommends, the minimum distance that the bottom of the cylinder or suction pipe should be from the bottom of the well is:

Rule II A: New dug well	- 30 cm
Rule II B: Older dug well	- 10-15 cm
Rule II C: New drilled well	- 2 meters
Rule II D: Older drilled well	- 1 meter

Rule III

The recharge rate of the well influences the depth at which the cylinder or end of the suction pipe should be installed:

Rule III A: Recharge rate low	- Install deeper than Rule I or 1/2 Rule II
Rule III B: Recharge rate medium or high	- Follow Rules

Key to recharge rates:

insufficient:	recharge rate less than 8 l/min.
minimal:	recharge rate of 9-13 l/min.
adequate:	recharge rate grater than 14 l/min.

Rule IV

When the recharge rate is low a deep well pump should be used when the static water level is the following distance below the surface:

Rule IV A: Dug well - 7 meters
Rule IV B: Drilled well - 4 meters

Rule V

When in doubt, always install deeper than the Estimating Rules. When the cylinder or end of the suction pipe is not installed deep enough, or installed too deeply, do the following:

- Shorten the pipe if mud and sand are being pumped.
- Add an extra length of pipe if the bottom of the cylinder or suction pipe is out of the water. Up to 8 meters of suction pipe can be added below a deep well cylinder before additional drop pipe and plunger rod must be added.

Problems for Determining Installation Depth

Problem #1

A drilled well with a broken pump cannot be repaired and will receive a new pump. The well is 100 meters deep with the current dry season water level 38 meters. How deep should the cylinder be installed?

Problem #2

A 1.5 meter diameter dug well is 30 meters deep. It was dug down to rock many years ago by a tribal leader. The recharge rate was measured at about 10 liters/min. There is 2 meters of water in the well. How deep should the cylinder or suction pipe be?

Problem #3

A 60-meter deep well was recently drilled. The water in the well rose to within 46 meters of the surface. Its recharge rate was measured at 5 liters/min. Where should the cylinder be installed?

Problem #4

A new drilled well has a water table 14 meters below the surface. The well is 19 meters deep. During the recharge rate test, the test crew noted that the water level returned to its original level within the first minute after test-pumping stopped. How deep should the installation crew install the cylinder?

Problem #5

A 26-meter deep well was just dug by the villagers. It is the dry season and 3 meters of water are currently standing in the well. The workers couldn't dig any deeper even with others helping to bail the well. How deep should the pump cylinder be installed?

Answers to the Problems for Determining Installation Depth

Problem #1

The well is an older drilled well. According to the estimating rules the cylinder should be 10-12 meters below the static water level but not closer than 1 meter from the bottom of the well. Following rule 1, the pump cylinder should be 48-50 meters below the surface. Since the well is 100 meters deep there is not a problem with installing the cylinder too close to the bottom of the well.

Problem #2

This is an older dug well with a medium recharge rate. Because there is only 2 meters of water in the well the estimating rule recommendation of installing the cylinder 3-5 meters below the static water level doesn't apply. When the pump is installed the bottom of the cylinder should be 10-15 centimeters from the bottom of the well.

Problem #3

The well is a newly drilled deep well. The recharge rate is low. Therefore, the cylinder should be installed as deep as possible which is 2 meters from the bottom of the well according to the estimating rules.

Problem #4

The estimating rule is that the cylinder be installed 10-12 meters from the bottom of the well. Because the water level returned to its original level very quickly during the recharge rate test the well's water level won't vary much during regular use. Therefore, an installed depth of 17 meters should be acceptable even though there will be only 3 meters of water above the cylinder.

Problem #5

The well is recently dug and has a very high recharge rate as evidenced by the incoming water impeding the work. Following the estimating rules, the bottom of the cylinder should be 30 centimeters from the bottom of the well.

Steps for Installing an AID Shallow Well Pump

1. Remove cups for soaking the day before installation:

   - unbolt pump cap from body
   - disconnect plunger assembly from cap
   - put plunger assembly in bucket of water

2. Tighten pump connections:

   - tighten plunger assembly
   - tighten plunger rod lock nuts
   - tighten bolts and nuts holding cap on body
   - tighten body/base joint

3. Cut suction pipe to length: Using the estimating rules for the depth at which to locate the suction pipe, measure and cut the suction pipe to the desired length.

4. Glue adaptor to end: Solvent weld the 53 mm PVC suction pipe sections together following the directions on the can of solvent. Weld a male threaded coupling on the upper end. Attach the well strainer, if used. Allow several minutes for the solvent weld to set. Avoid getting solvent on yourself.

5. Place suction pipe in well: Lower the suction pipe assembly into the well.

6. Attach suction pipe to pump: Screw the male threaded coupling into the pump base. This task is much easier if the pump base is unscrewed from the pump body.

7. Bolt down pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the slider block tracks. Reassemble the pump.

9. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-Gallon) can in 18-22 strokes which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky footvalve or leaky joints. This situation is intolerable in shallow well pump installations since the pump may require regular priming which can introduce contaminants into the well. The pump should be removed and the cause of the leak determined and corrected before re-installation.

NOTE: The pump may require priming if the cups were not soaked overnight. Pour a bucket of clean drinking water into the plunger rod hole in the pump cap. Repeat with pumping if water cannot be raised after the first priming.

10. Disinfect the Well: Follow the steps of Handout 11-5: Steps for Disinfecting Wells to disinfect the well.

Steps for Installing an AID Deep Well Pump

1. Tighten connections: The connections in the cylinder need to be tightened before the pump is installed.

2. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. In the measurement allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe following the procedure below:

   - Wipe the loose cuttings and dirt from the end of the pipe.
   - Thread the die on the pipe until the teeth begin to bite into the metal.
   - Cut the threads by turning the die clockwise 1/2 turn and then counter-clockwise 1/4 turn to allow the cuttings to fall away.
   - Continue in this manner until approximately 1 1/2 to 2 inches of threads have been cut.
   - Carefully remove the die without damaging the threads.
   - Wipe any loose cuttings off the pipe with a rag.

3. Install cylinder, drop pipe and plunger rod to desired depth: Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the threads to make future disassembly easier, attach a length of plunger rod to the plunger rod section in the cylinder. Tighten firmly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly. If used, attached a strainer to the bottom of the cylinder.

   Lower this portion of the drop pipe assembly into the well.

   Put a section of plunger rod inside an equal length section of drop pipe. Raise these sections over the already-lowered portion of drop pipe assembly, connect the plunger rod first (being sure it is very tight), apply Teflon tape or pipe joint compound to the drop pipe threads and then connect and tighten the drop pipe. A pipe clamp and tripod will be required to perform this step and those following. Again, always wipe the threads clean before applying Teflon tape or a pipe joint compound and joining sections of pipe together.

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

4. Attach drop pipe to base: Unbolt the pump cap from the pump body. Attach the pump body and base to the drop pipe.

5. Cut rod to length and thread rod: Push the plunger rod down to the lowest position (until it cannot be pushed any more, refer to handout). Mark the rod 1 inch above the top of the pump body. Cut and thread the plunger rod. Follow the same threading procedure as for the drop pipe. This step ensures that the plunger assembly will be well centered within the cylinder.

6. Attach cap to rod and body: Holding the pump cap over the pump body, join the plunger rod sections. Rebolt the pump cap to the pump body. Check all exposed nuts and bolts for tightness.

7. Bolt down pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the slider block tracks. Reassemble the pump.

9. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-gallon) can in 18-22 strokes which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky footvalve or leaky joints. This situation is very inconvenient to the users since they may have to pump a long time to get water in the morning. The pump should be removed and the cause of the leak determined and corrected before re-installation.

10. Disinfect the Well: Follow the steps given in Handout 11-5: Steps for Disinfecting Wells, to disinfect the wells.

INSTALLING THE PUMP

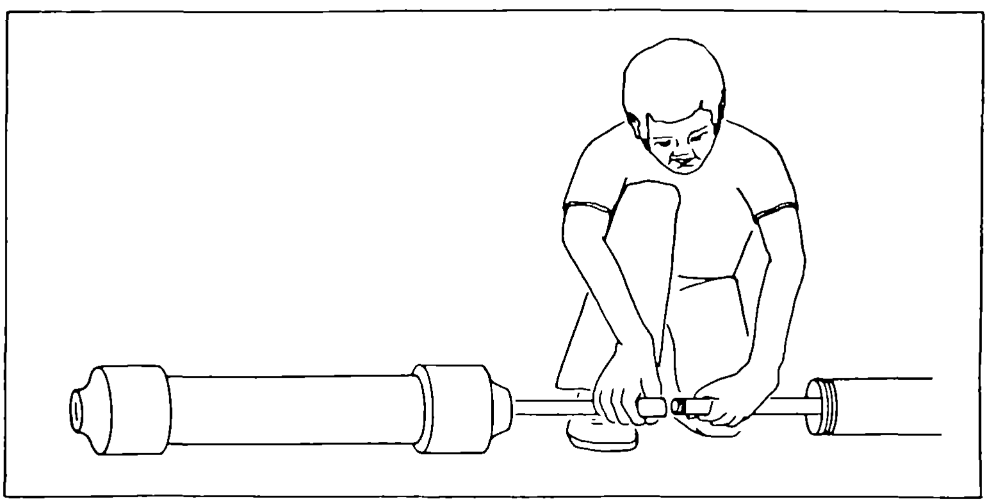
1 Determine how much drop pipe you need. Use the Rules of Thumb below Then cut and thread the drop pipe

RULES OF THUMB FOR DETERMINING CYLINDER DEPTH FOR DEEP WELL PUMPS

IF the well is	AND IF it is	THEN the cylinder should be
Dug	New	3 - 5 meters below the static water level BUT No closer than 30 cm from the bottom of the well
	Old	3 - 5 meters below the static water level BUT No closer than 10 - 15 cm from the bottom of the well
Drilled	New	10 - 12 meters below the static water level BUT No closer than 2 meters from the bottom of the well
	Old	10 - 12 meters below the static water level BUT No closer than 1 meter from the bottom of the well

2 Put the cylinder in the well

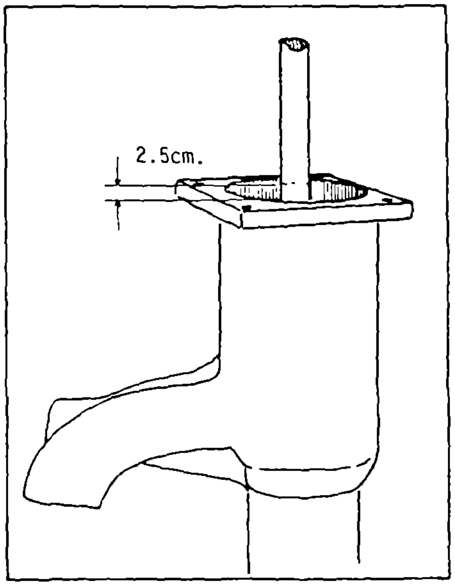
a Attach the plunger rod to the rod in the cylinder



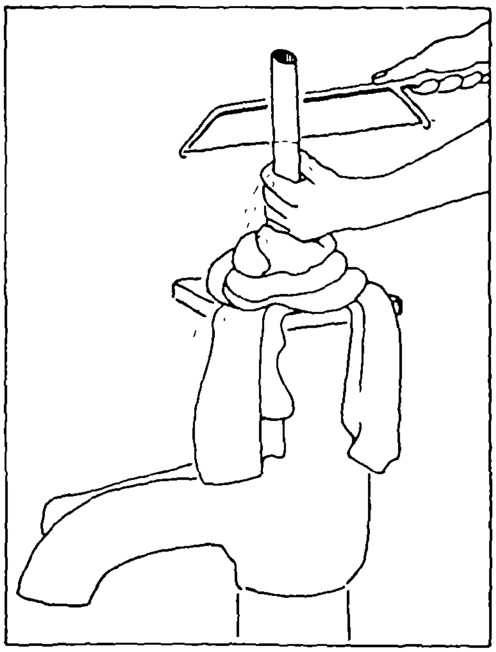
b Attach the drop pipe to the cylinder
c Continue adding sections of rod and pipe until desired depth is reached.

INSTALLING THE PUMP (PAGE 2)

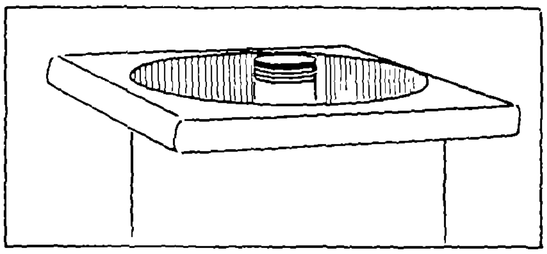
3 Cut the plunger rod to length and thread it:
a. Push the plunger rod to full "down position"
b. Mark the plunger rod at 2.5cm. above the body of the pump.



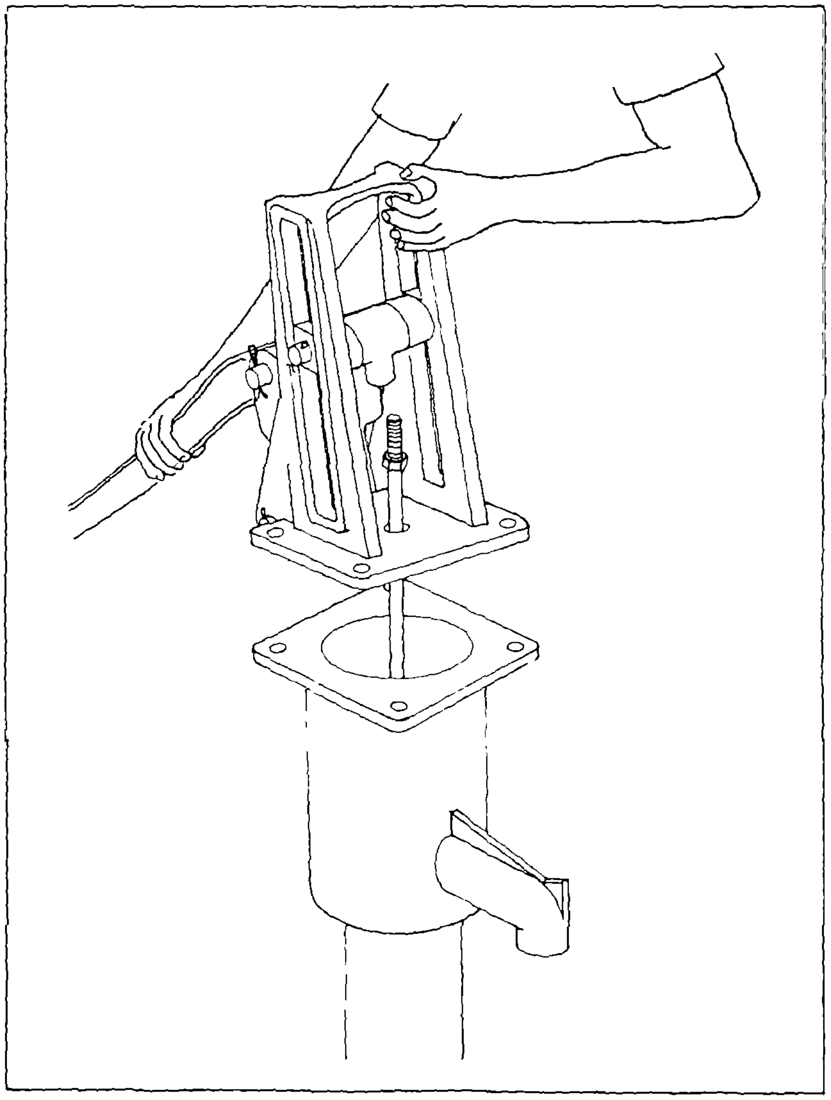
c. Wrap a rag around the rod to cover the pump opening
Then cut the excess rod away



d. Thread the plunger rod.



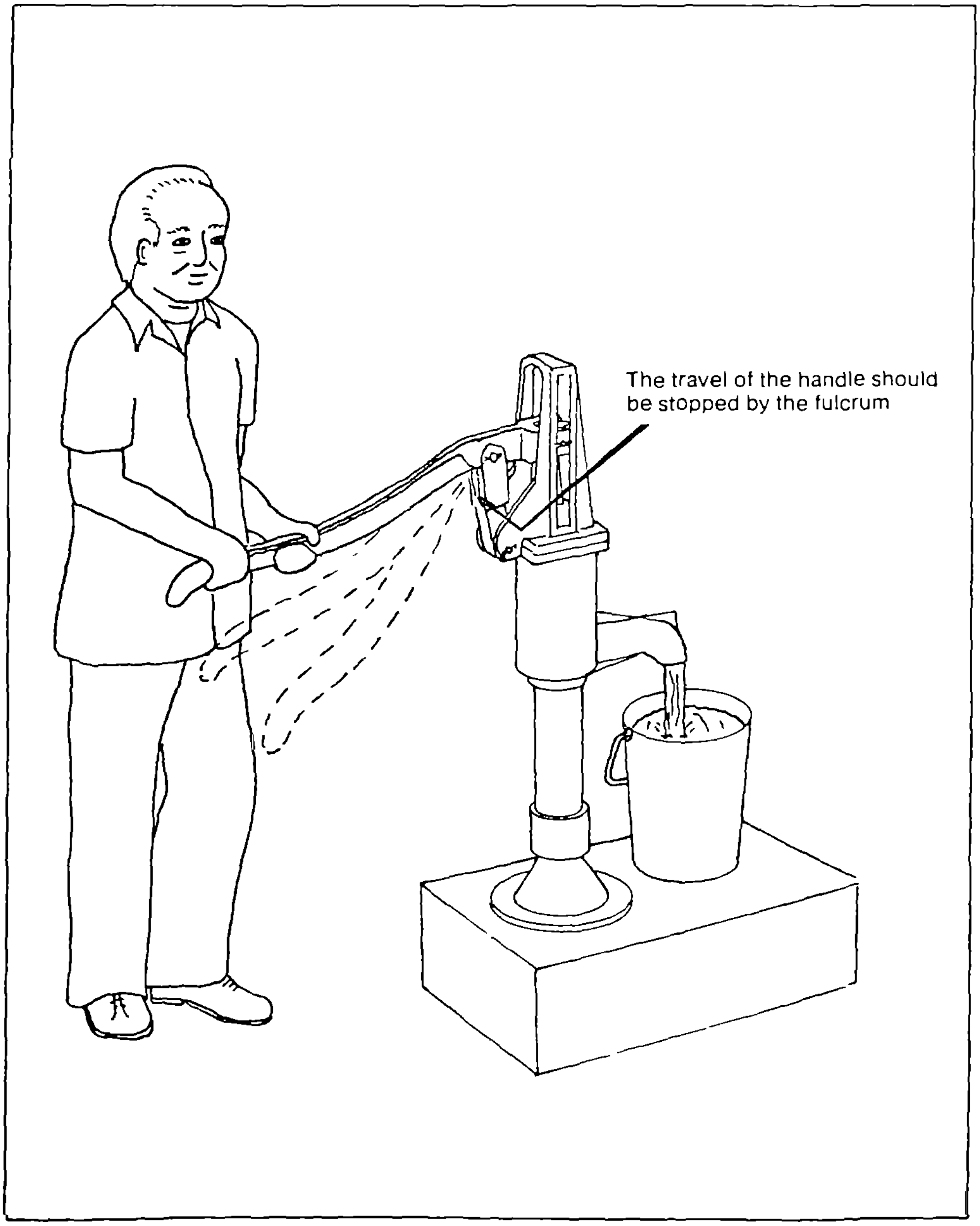
4 Put the cap on the pump, and attach the plunger rod to the handle.



TESTING THE PUMP

Check these.

- The handle should move fully, as shown in this picture
- Check the flow rate You should be able to fill a 12 liter container in about 12 full strokes.
- Check the leak rate Leave the pump alone for about 15 minutes, then start pumping again You should have water after 2 or 3 strokes



Steps for Installing a Mark II Deep Well Pump

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

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

3. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. Allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe. Follow the procedure below:

   - wipe loose cuttings and dirt from the end of the pipe
   - thread the die on the pipe until the teeth begin to bite into the metal
   - apply cutting oil or animal lard liberally to the end of the pipe
   - cut the threads by turning the die clockwise 1/2 turn and then counter clockwise 1/4 turn to allow cuttings to fall away
   - continue in this manner until approximately 1 1/2 to 2 inches of threads have been cut
   - carefully remove the die without damaging the threads
   - wipe any loose cuttings off the pipe with a rag

4. Install cylinder, drop pipe and plunger rod to desired depth: Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the rod thread to make future disassembly easier, attach a length of plunger rod to the rod section in the cylinder. Tighten the connection and lock nut tightly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly. If used, attach a strainer to the bottom of the cylinder.

   Lower this portion of drop pipe assembly into the well. Secure it with a pipe clamp or tripod.

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

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

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

6. Cut plunger rod to desired depth and thread: Push the plunger rod down to the lowest position (until it cannot be pushed down any further). Mark the rod lever with the top of the water tank with a hacksaw or scribing tool. Raise the rod up as far as possible. Place a rag into the water tank to keep rod cuttings from falling into the well. Clamp the rod with a rise or clamp. Cut and thread the plunger rod following the same procedure as for the drop pipe. Remove the rag. This step ensures that the piston assembly will be centered in the cylinder.

7. Attach plunger rod to head assembly: Remove the inspection cover from the head and lower the head onto the water tank. Screw the chain section onto the rod. Tighten the connection and the lock nut firmly. Using a bar, lift the head off to the tank and remove the rod clamp. Then bolt the head to the tank.

   Next, insert the handle through the head and bolt the chain firmly to the handle. Insert the axle through the handle and tighten retaining nuts on axle.

8. Test the pump: Perform the following tests on the pump:

   • Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The standard cylinder (2 1/2" ID) of the Mark II pump should fill a 19-liter (5 gal.) container in 30-34 strokes which is about 2/3 liter per stroke.

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

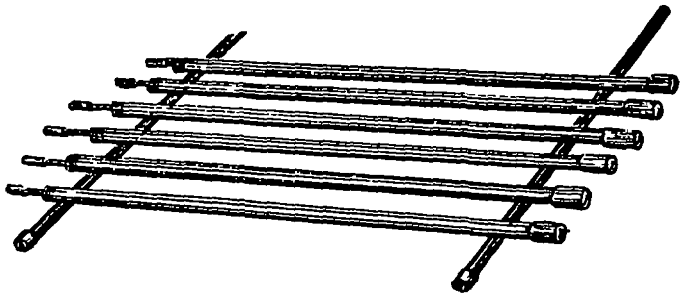
9. Lubricate the pump: Apply grease to the chain. The handle bearings are sealed and do not need lubrication.

10. Disinfect the well: See Handout 11-5: Steps for Disinfecting Wells for disinfecting the well. For drilled wells it is usually easier to disinfect the well before installing the pump.

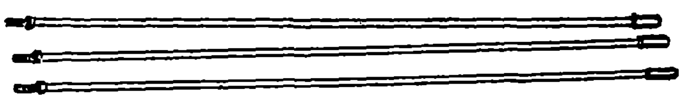
9

SEVEN DAYS LATER

(1) Lay out pipes and connecting rods.
Check that pipes and rods are threaded 40 mm.
Check that all threads are good and clean.



(2) Check rods are fitted with check nuts and couplings

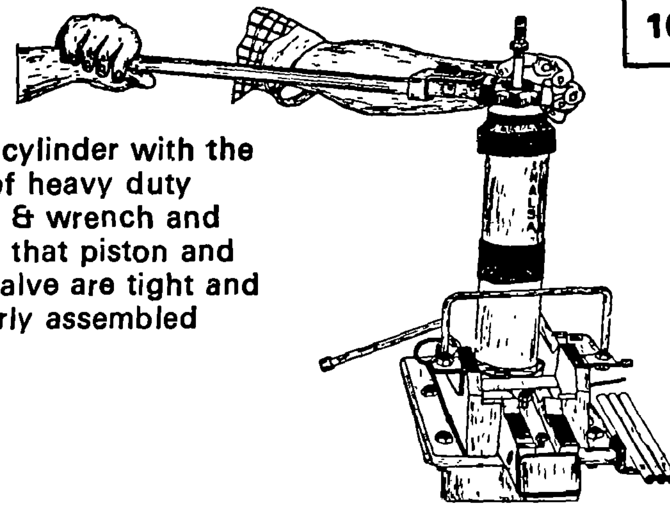


(3) If rods have couplings welded at one end, fit check nuts at the other end

(4) Make sure you have spare check nuts

From INALSA

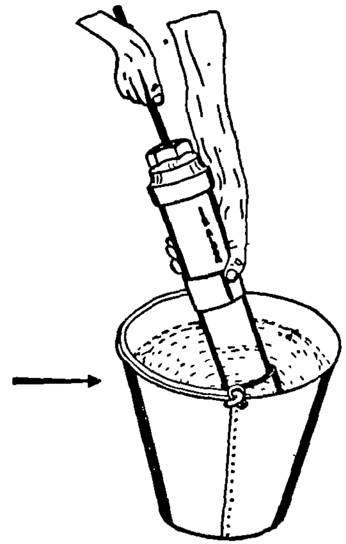
10



(1) Open cylinder with the help of heavy duty clamp & wrench and check that piston and foot-valve are tight and properly assembled

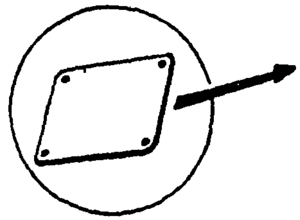
(2) Re-assemble cylinder

(3) Test cylinder in a bucket of water.
If foot-valve leaks replace it.

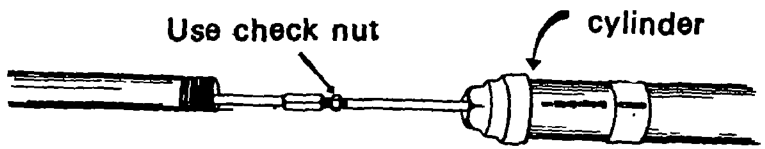


11

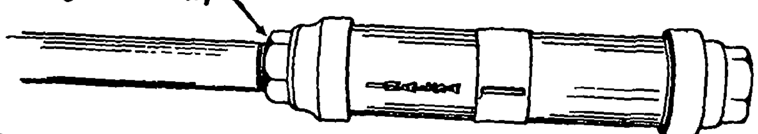
(1) Remove cover of pedestal



(2) Join first connecting rod to cylinder rod



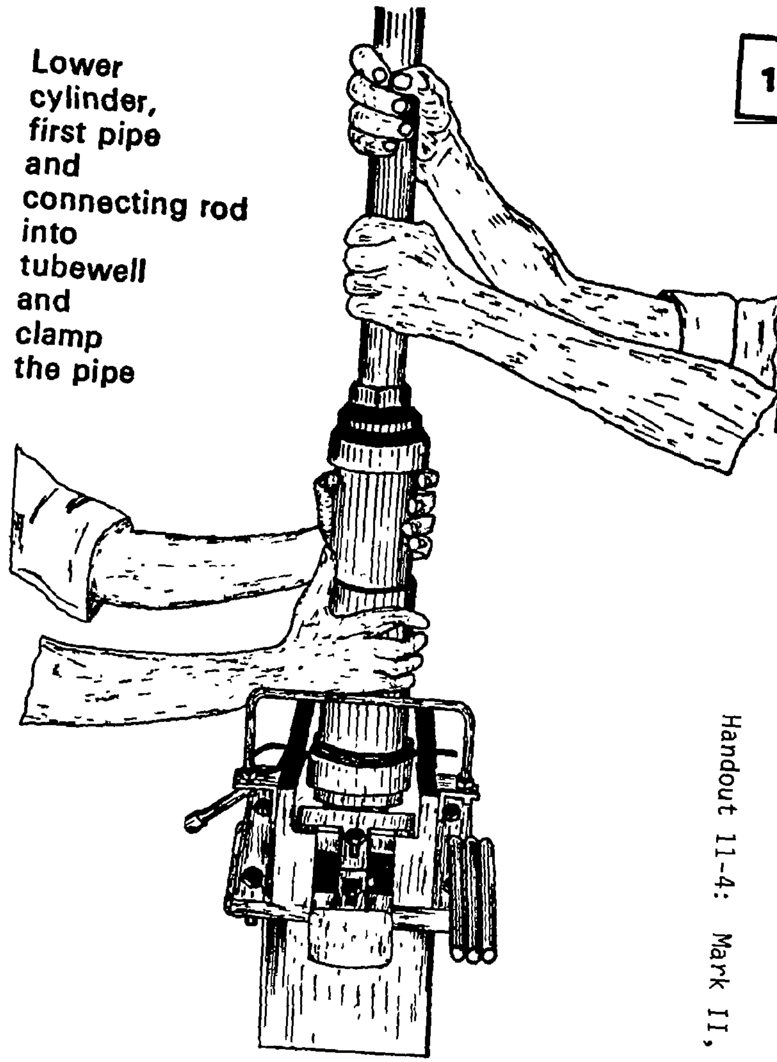
(3) Screw first pipe into cylinder.
Use jointing compound.
Tighten fully



(4) Wipe off excess jointing compound

12

Lower cylinder, first pipe and connecting rod into tubewell and clamp the pipe



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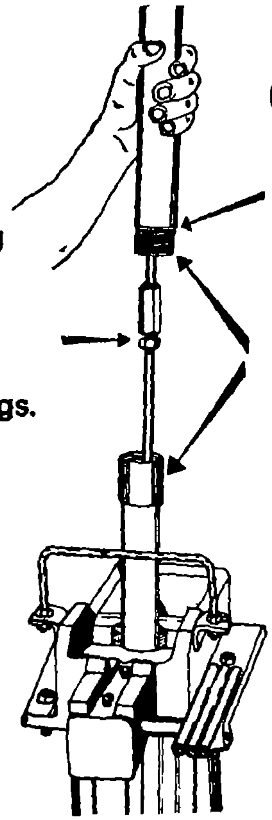

(1) Join connecting rods together. Use check nut at every joint. Tighten fully against couplings.

(2) Put jointing compound on pipe threads

(3) Join pipes together. Tighten fully.

(4) Wipe off excess jointing compound or it will spoil the water in the tubewell

(5) Lower cylinder, pipe and connecting rod into tubewell and clamp. Continue to last pipe. For this, use heavy duty clamp as shown.

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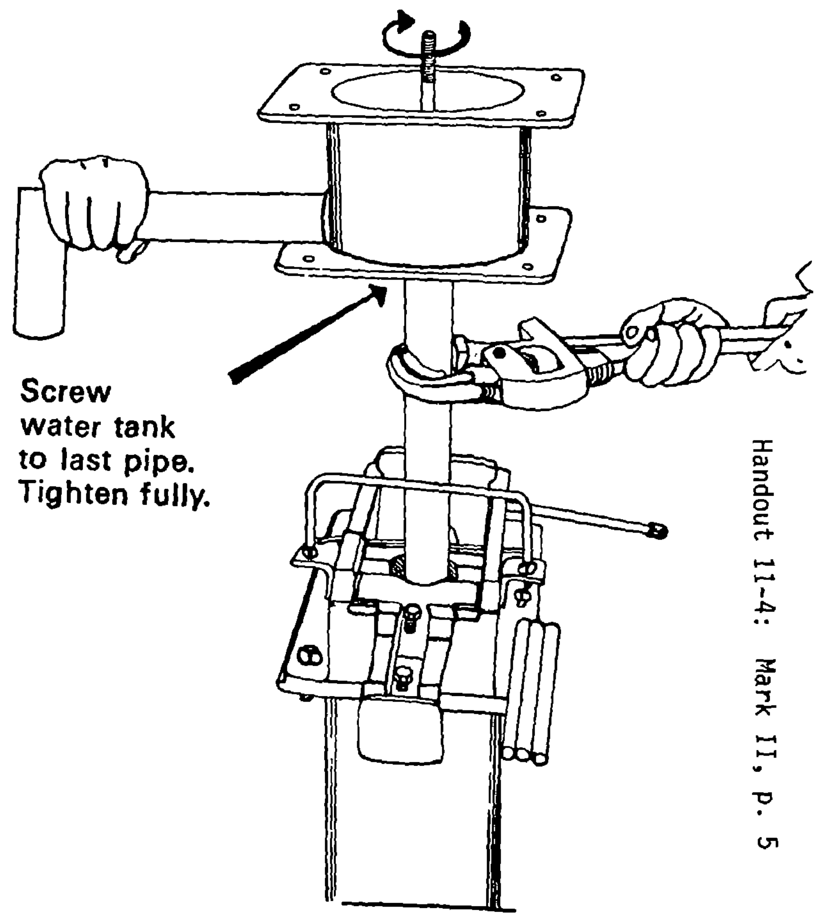
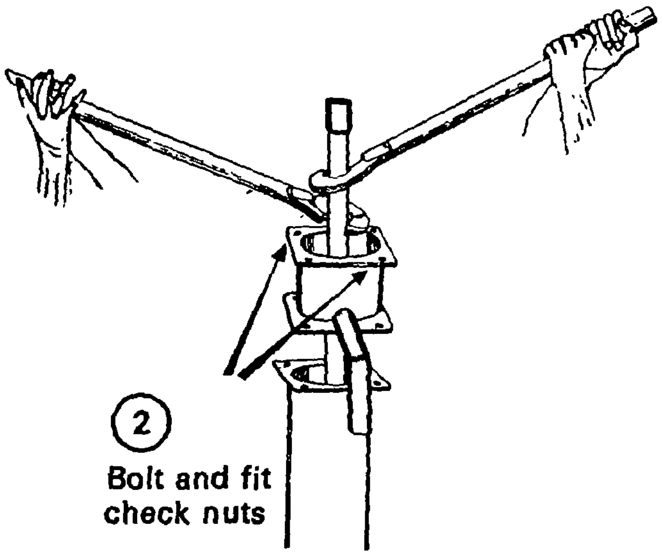
Cylinder should be installed at a minimum depth of 24 metres (80′) for maximum efficiency



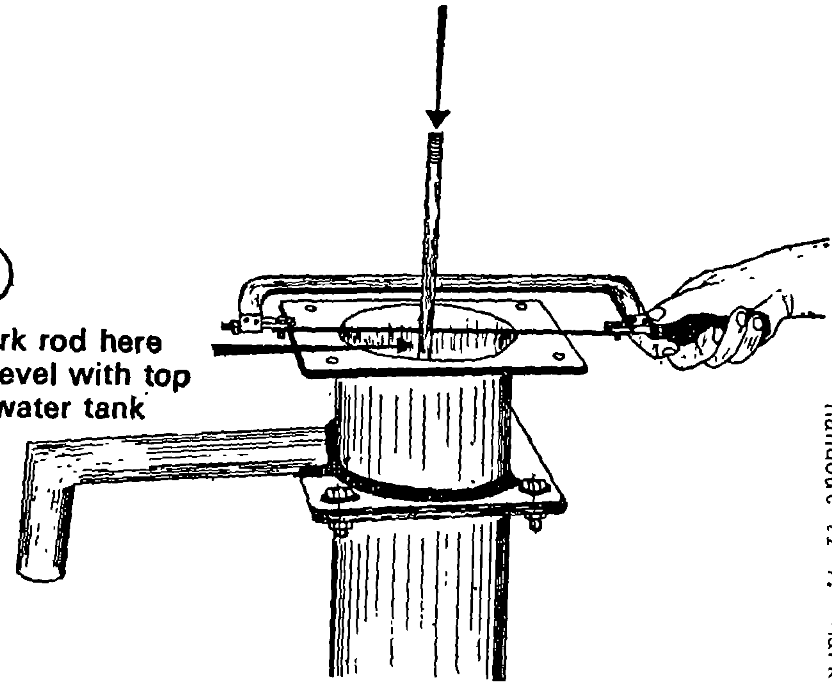
Screw water tank to last pipe. Tighten fully.

1 Carefully lower water tank on to pedestal with the help of lifter pipe and lifting spanners. Spout must face drain.



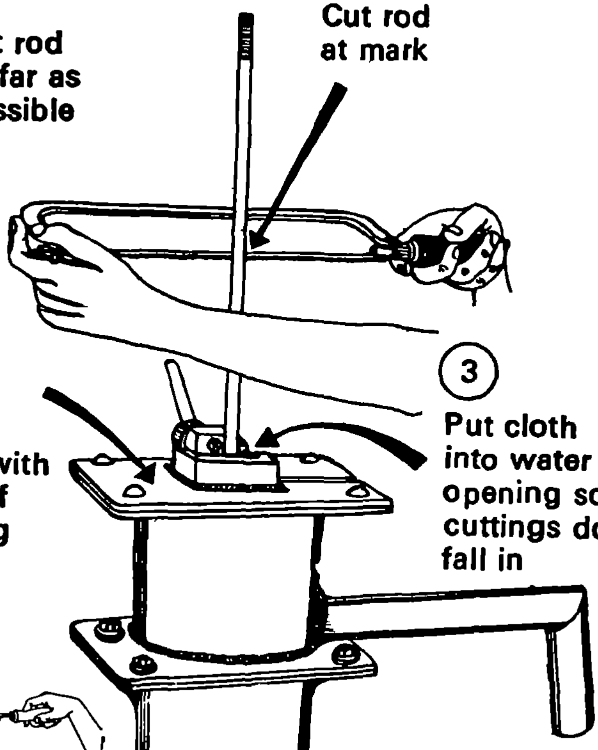
2 Bolt and fit check nuts

1 Push rod down as far as possible



2 Mark rod here — level with top of water tank

17

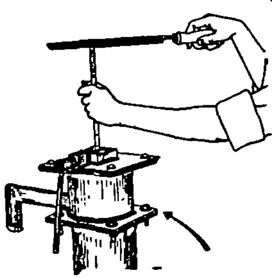


(1) Lift rod as far as possible

(2) Clamp rod here with the help of connecting rod vice

(3) Put cloth into water tank opening so that cuttings don't fall in

(4) Cut rod at mark



(5) File top of rod smooth

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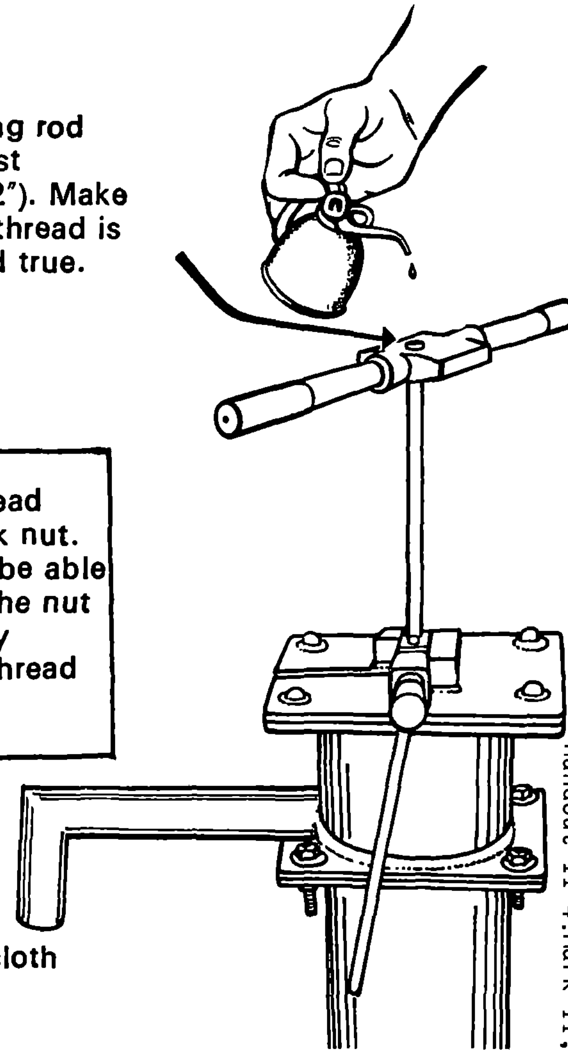
Leave cloth in water tank



(1) Thread connecting rod for at least 50 mm (2"). Make sure the thread is clean and true.

Check thread with check nut. You must be able to screw the nut all the way down the thread by hand.

(2) Now remove cloth

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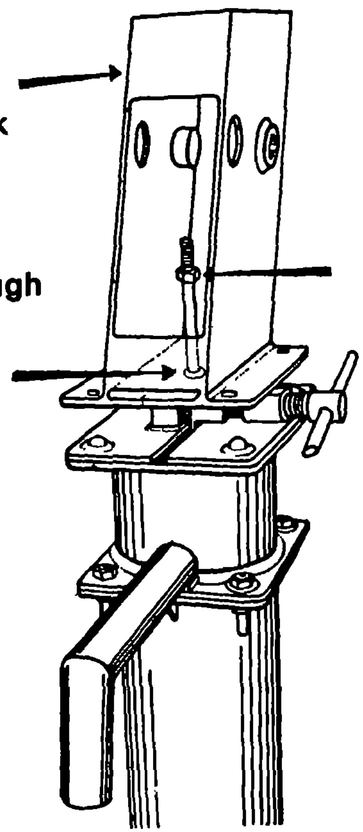
① Remove inspection cover of head

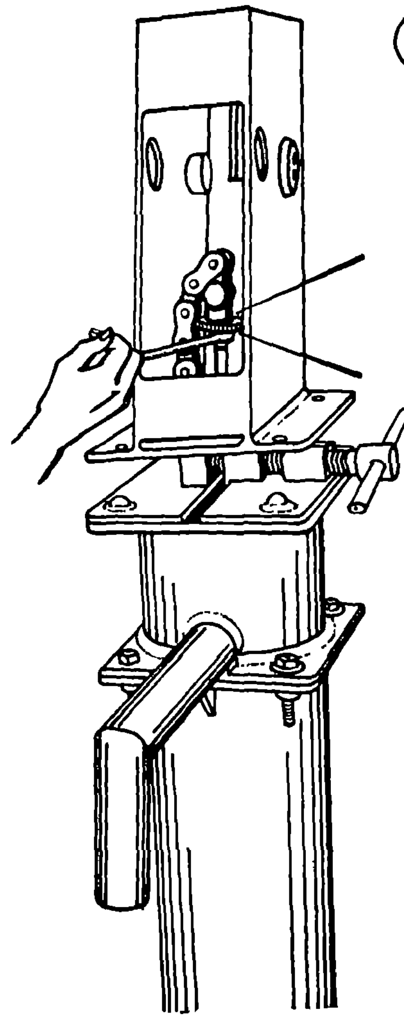
② Lower head onto water tank

③ Rod goes through guide bush



④ Fit check nut here

20



① Screw chain onto rod. Tighten rod fully into chain coupling

② Use two spanners— tighten check nut fully against chain coupling

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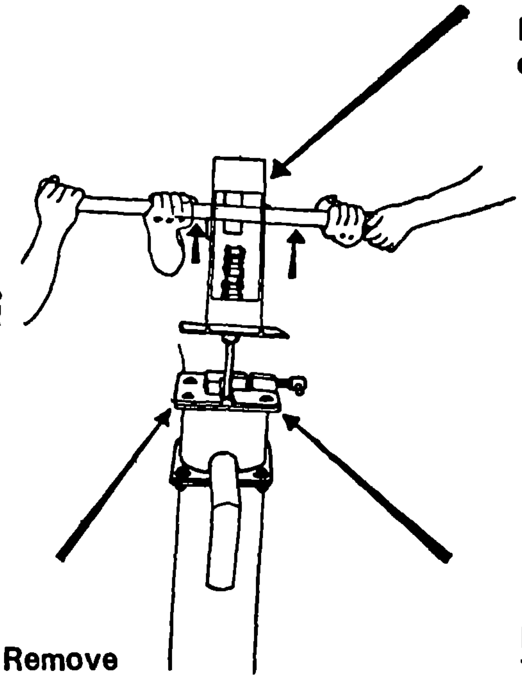

(1) Lift evenly
(3) Lower head onto water tank
(2) Remove rod clamp
(4) Bolt here. Fit check nuts. Tighten fully.

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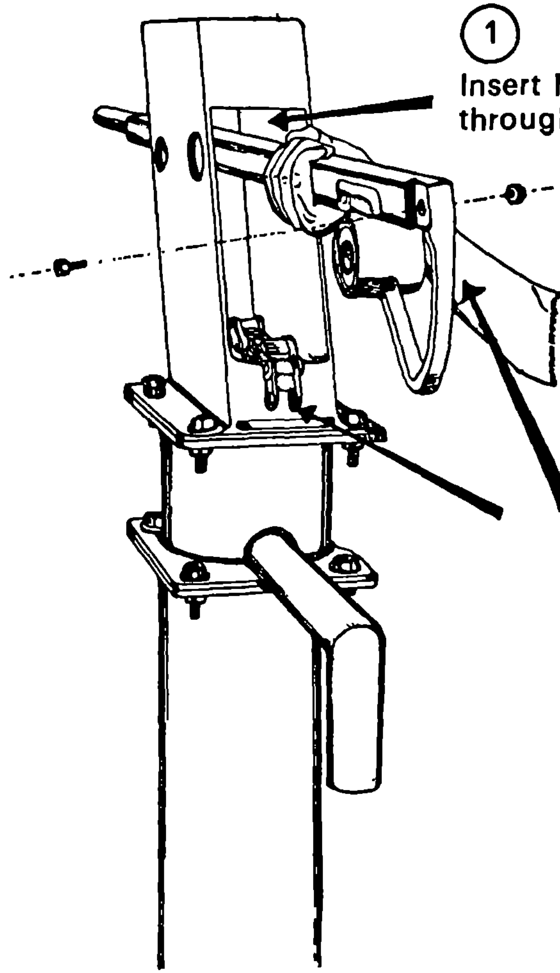
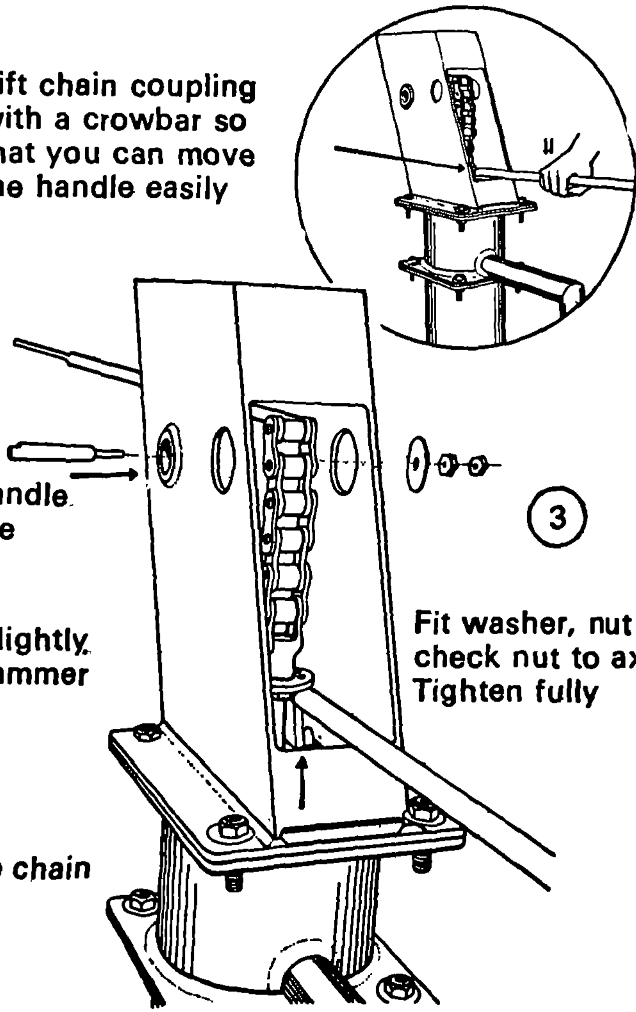


(1) Insert handle here through head
(2) Bolt chain to handle. Use self locking nut. Tighten fully– use two spanners.

23



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Now make sure that . . . . . .

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

Now fit inspection cover.
Tighten cover bolt fully.

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

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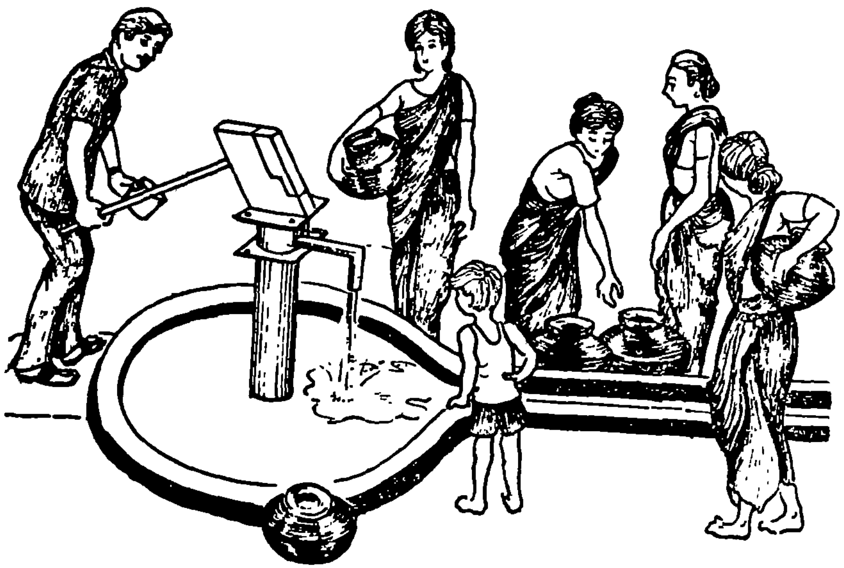
Pump one hundred times
to get clean water.



Check the water. Is it clear of
oil, jointing compound, dirt ?
If water is not clean, pump another 100 times.

The water may taste strange to the villagers.
Explain to them that it is good, safe water.
They will soon get used to it.

FINAL CHECK LIST

Before you leave, have you . . .

- ▫ talked to the villagers about the importance of the handpump for their health ?
- ▫ purged the tubewell ?
- ▫ checked the quality and taste of the water ?
- ▫ explained to the villagers that the water from the handpump may taste different, or strange? You must explain that they should still drink it, because this water is safe. They will get accustomed to the new taste soon.
- ▫ given the villagers the address of your office, so that they can inform you if the pump breaks down ?
- ▫ made a note of any problems with the tubewell or the handpump, so that you can report them to the District Executive Engineer ?

Steps for Disinfecting Wells

Finding the Correct Amount of Disinfectant

A) Measure the well diameter and the number of meters of water in the well.

B) Calculate the volume of water in the well in cubic meters (see Worksheets in Handout 11-6: Water for the World, Disinfecting Wells).

C) Find the volume of water on the disinfectant table and read off the required amount of disinfectant. (See Table 1 in Handout 11-6).

Disinfecting the Well

A) Pump the well: Pump the well until the water is relatively clear and as free from cloudiness (turbidity) as possible. If there are no other sources of water nearby to use in step E below, save 25 to 40 liters of water. Remove the pump after this step if the well does not have an access hatch.

B) Dissolve powdered disinfectant: Dissolve the powdered chlorine compound in a bucket before adding it to the well. It is important that the solution be prepared in a clean container and mixed with clean utensils. Dirt, grease, oil and organic matter will reduce the strength of the chlorine solution. Avoid the use of metal containers because the strong chlorine solution will cause them to rust. Instead, use plastic, ceramic, glass, or rubber-lined containers. This step can be deleted if only liquid disinfectants are used.

C) Pour disinfectant into well: Slowly pour the required amount of chlorine solution, as determined above, into the well. Allow the solution to wash down the sides of the well. Use a brush to distribute the disinfectant on the walls of dug wells.

D) Mix disinfectant into well water: Mix the chlorine solution with the water in the well. This can be done by tying a rope around a large, clean rock and moving it up and down in the water in the well. In the case of deep wells with a high water table, special steps should be taken to ensure that the chlorine is thoroughly mixed with the well water. If a concentrated solid form of the disinfectant is available (like HTH), place it in a burlap (or similar) bag with a rock. Tie a rope tightly around the top of the bag and lower it into the well. Alternately raise and lower the bag in the water to distribute the disinfectant. If only liquid forms of the disinfectant are available, a plastic bottle with perforations near the top will allow well water to mix with the disinfectant without disinfectant being spilled before it is lowered into the well. Alternately raise and lower the bottle, as with the bag.

E) Force disinfectant into aquifer: Add 25 to 40 liters (5 to 10 gallons) of clean, chlorinated water to the well to force the solution into the aquifer.

F) Disinfect exterior of pump: Wash the exterior surface of the pump cylinder and drop pipe (or suction pipe). If the well does not have an access hatch, wash the exterior surface of the pump cylinder and drop pipe as they are being reinstalled in well.

G) Operate the pump: After waiting 20 minutes operate the pump until you can smell chlorine.

H) Allow time for disinfectant to work: Stop pumping and allow the chlorine solution to remain in the well for at least 12 hours, but preferably 24 hours. It must be stressed that this strong chlorine solution is not suitable for consumption by humans or animals.

I) Pump out odor of disinfectant: After disinfection, pump the well until the odor and taste of chlorine in the water is no longer objectionable. Chlorine is used up as it disinfects. If there is no chlorine odor after the disinfection period, disinfection shoud be repeated. This assures that all the disease-causing bacteria will be destroyed and that there will still be some chlorine available to kill other contaminants which might enter the water at a later time.

The disinfectant compounds and solutions used to disinfect wells can cause irritation to skin and eyes. If you get chlorine on your skin or in your eyes, wash it off with water immediately. Do not rub your eyes until you have washed the chlorine off your hands. Work with chlorine only in areas with good ventilation. Never use chlorine when persons are working inside the well.

Water for the World

Disinfecting Wells
Technical Note No. RWS. 2.C.9

Disinfecting a well is necessary to eliminate the contamination that was introduced by equipment, materials, or surface drainage during construction or repairs. A chlorine compound is generally used for the disinfectant. Disinfecting a well involves calculating the required amount of chlorine compound, mixing a chlorine solution, and applying the solution to the well.

This technical note describes how to disinfect a well. Read the entire technical note before beginning the disinfection process.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

AVAILABLE CHLORINE - The amount of chlorine present in a chemical compound.

DISINFECTION - Destruction of harmful microorganisms present in water, through physical (such as boiling) or chemical (such as chlorination) means.

Materials Needed

To disinfect a well, you will need:

Chlorine compound such as calcium hypochlorite, bleaching powder, or liquid bleach,

Mixing container which should be rubber-lined or made from crockery or glass,

Stiff broom with a long handle, for hand dug wells,

Length of rope,

Length of perforated pipe, 0.5-1.0m long, 50-100mm in diameter, for deep-drilled wells with a high water table.

Caution!

Chlorine compounds or solutions may irritate skin and eyes upon contact. If possible, wear gloves, protective clothing, and glasses when handling chlorine. If you get chlorine on your skin or in your eyes, immediately wash it off with water.

General Information

The most easily obtainable and safest disinfectants are chlorine compounds. These compounds have various amounts of available chlorine, that is, chlorine that can be released to disinfect the water.

Calcium hypochlorite, also knows as high-test hypochlorite or HTH, has 70 percent available chlorine. It is produced as powder, granules, or tablets. Bleaching powders have 25-35 percent available chlorine. Common household laundry bleach, such as Clorox and Purex, has about 5 percent available chlorine.

Chlorine compounds should be stored in their original containers in a cool, dark place.

Calculating the Amount of Compound Needed

To disinfect a well properly, make a mix of available chlorine and water from the well in a ratio of 100 parts per million, ppm. To illustrate: 1 ml per 1000 liters equals 1 ppm; 100ml per 1000 liters equals 100ppm.

Table 1 shows the amounts of HTH, bleaching powder, and chlorine bleach that must be added to various volumes of well water to produce 100ppm of available chlorine. Before you can use the table, you must calculate the volume of water in the well.

The volume of water in a well equals the radius of the well squared times the depth of the water in the well times 3.1416.

$$V = r^2 \times D \times 3.1416$$

The radius, r, equals the diameter, d, of the well divided by two.

$$r = \frac{d}{2}$$

The diameter, d, can be measured directly or read from design drawings or from the driller's log described in "Maintaining Well Logs," RWS.2.C.6.

The depth, d, of the water in the well can be measured directly by lowering a rock tied to a length of twine to the bottom of the well, retrieving the twine, and measuring the wet portion. Or, it can be read from the driller's log.

For example, suppose the diameter of the well is 100mm (0.10m) and the depth of the water in the well is 12m. First, calculate the radius.

$$r = \frac{d}{2} \qquad r = \frac{0.10m}{2} \qquad r = 0.05m$$

Then calculate the volume of water.

$$V = r^2 \times D \times 3.1416$$
$$V = 0.05m \times 0.05m \times 12m \times 3.1416$$
$$V = \text{about } 0.1m^3$$

See Worksheet A Lines 1-4.

From Table 1, you can see that in order to disinfect this well you would need to use 0.2 liters of chlorine bleach, 5 percent available chlorine, or 33 grams of bleaching powder, 30 percent available chlorine, or 14 grams of high-test hypochlorite, 70 percent available chlorine.

For another example, suppose the diameter of the well is 1.2m and the depth of the water in the well is 2.6m. The radius equals the diameter divided by two = $\frac{1.2m}{2}$ = 0.6m Now calculate the volume.

$$V = r^2 \times D \times 3.1416$$
$$V = 0.6 \times 0.6 \times 2.6 \times 3.1416$$
$$V = 2.9m^3$$

See Worksheet A, Lines 5-8.

From Table 1, you can see that the nearest volume to this is 3.0m^3, so to disinfect this well you would need to mix in 6.0 liters of chlorine bleach, or 1010 grams of bleaching powder, or 433 grams of HTH.

Table 1. Amounts of Chlorine Compounds for Well Disinfection

Water in Well (m^3)	Liquid Bleach 5% available chlorine (liters)	Bleaching Powder 30% available chlorine (grams)	Calcium Hypochlorite (HTH) 70% available chlorine (grams)
0.1	0.2	33	14
0.12	0.24	40	17
0.15	0.3	51	22
0.2	0.4	68	29
0.25	0.5	86	37
0.3	0.6	100	43
0.4	0.8	133	57
0.5	1.0	170	73
0.6	1.2	203	87
0.7	1.4	233	100
0.8	1.6	267	113
1.0	2.0	334	143
1.2	2.4	400	173
1.5	3.0	500	217
2.0	4.0	670	287
2.5	5.0	860	367
3.0	6.0	1010	433
4.0	8.0	1330	567
5	10	1700	730
6	12	2000	870
7	14	2300	1000
8	16	2600	1130
10	20	3300	1430
12	24	4000	1730
15	30	5000	2170
20	40	6700	2870

Worksheet A. Calculating the Volume of Water in a Well

Drilled Wells

1. Diameter of well = $\frac{(\ 100\ \text{mm})}{(1000\text{mm/m})}$ = 0.10 m

2. Radius of well = $\frac{\text{Line 1}}{2}$ = $\frac{(\ 0.10\ \text{m})}{2}$ = 0.05 m

3. Depth of water in well = 12 m

4. Volume of water in well = Line 2 x Line 2 x Line 3 x 3.1416 = 0.05 m x 0.05 m x 12 m x 3.14.6 = 0.09 m^3

Hand Dug Wells

5. Diameter of well = 1.2 m

6. Radius of well = $\frac{\text{Line 5}}{2}$ = $\frac{(\ 1.2\ \text{m})}{2}$ = 0.6 m

7. Depth of water in well = 2.6 m

8. Volume of water in well = Line 6 x Line 7 x 3.1416 = 0.6 m x 0.6 m x 2.6 m x 3.1416 = 2.9 m^3

Mixing the Solution

Do not pour the chlorine compound directly into the well. It will not mix properly. First make a chlorine solution.

To make a chlorine solution from chlorine bleach, mix one part of bleach with one part of water, then pour the entire solution into the well. In the second example, this would mean mixing 6.0 liters of chlorine bleach with 6.0 liters of water and pouring 12.0 liters of chlorine solution into the well.

To make a chlorine solution with HTH or bleaching powder, first mix the compound with enough water to form a smooth paste, then mix the paste with water in the ratio of one liter of water per 15 grams of compound. To calculate the amount of water needed to make a chlorine solution, divide the amount of chlorine compound by 15. In the second example,

$\frac{\text{1010 grams of bleaching powder}}{\text{15 grams}}$ =

67 liters of water

$\frac{\text{433 grams of HTH}}{\text{15 grams}}$ = 29 liters of water

Mix the chlorine paste with the water for 10-15 minutes. Allow inert materials to settle and use only the clear chlorine solution. Discard the rest. Pour the clear chlorine solution, about 67 liters in the case of bleaching powder or about 29 liters in the case of HTH, into the well.

Do not mix chlorine solutions in metal containers. Mix them in clean containers that are rubber-lined or made from crockery or glass.

Disinfecting a Hand Dug Well

If the well has no cover, it should be disinfected every day, or as often as possible. If the well is covered it must be disinfected before the first use and every time it is opened for maintenance or repair.

For a dug well with pump and cover:

1. Prepare a chlorine solution to wash the inside of the well casing. Mix 10 liters of water with one of the following: 0.02 liters of chlorine bleach, or 3.3 grams of bleaching powder, or 1.4 grams of HTH.

2. Wash the exterior surface of the pump cylinder and drop pipe with the chlorine solution before they are lowered into the well.

3. Remove all equipment and materials that will not be a permanent part of the well.

4. Wash the inside surface of the well casing with a clean, stiff broom and the 10 liters of chlorine solution. See Figure 1.

5. Install the cover over the well.

6. Calculate the amount of chlorine solution needed to disinfect the well. Prepare the solution and poor it through the access hole in the cover, making sure that the solution covers as much of the surface of the water in the well as possible. See Figure 2.

7. Mix the chlorine solution with the water in the well by using a rope tied to a large, clean rock. Lower the rock into the well and move it up and down in the water.

8. Cover the access hole. Pump water from the well until you can smell chlorine.

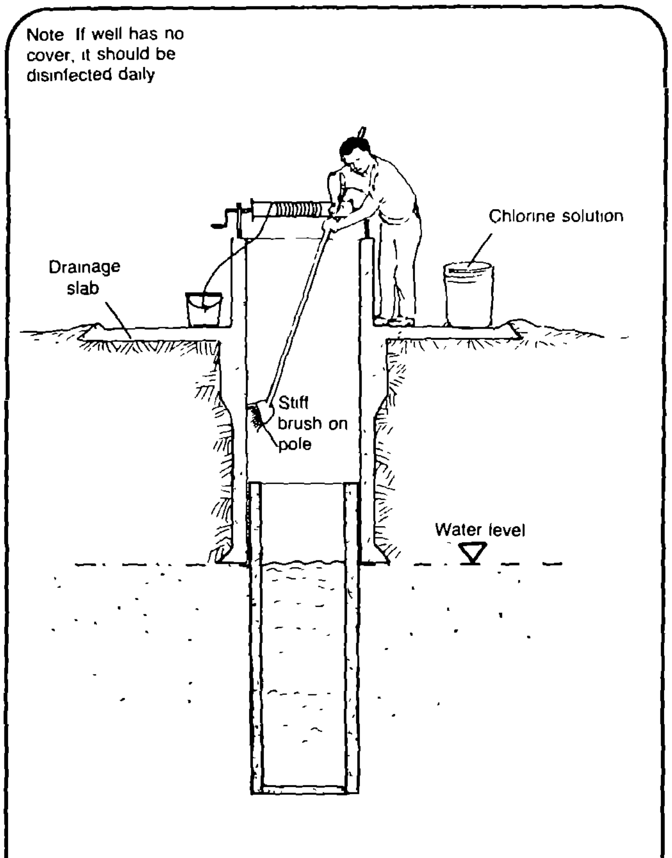


Figure 1. Washing Inside of Casing (Hand-dug well)

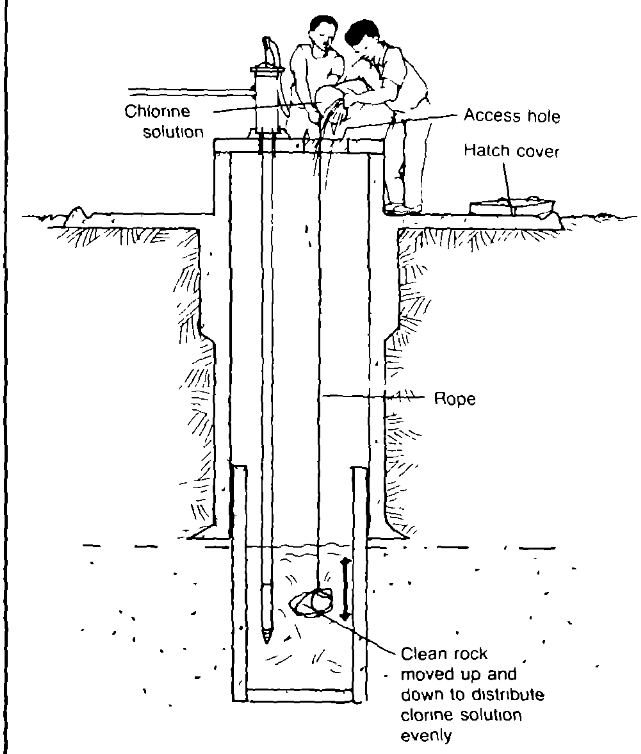


Figure 2 Pouring Chlorine Solution into Well

9. Allow the chlorine solution to remain in the well for 24 hours.

10. Pump water from the well until chlorine can no longer be smelled or tasted. Dispose of this water in a soakaway.

Disinfecting a Driven, Jetted, Bored, or Cable Tool Well

After the well has been tested for yield as described in "Testing the Yield of Wells," RWS.2.C.7, it must be disinfected before its first use and every time it is opened for maintenance or repair.

1. Remove the test pump from the well.

2. Calculate the amount of chlorine solution needed to disinfect the well. Prepare the solution and pour it into the well.

3. Mix the chlorine solution with the water in the well by using a rope tied to a clean rock. Lower the rock into the well and move it up and down in the water.

4. Add 40 liters of clean, chlorinated water to the well to force the solution into the aquifer. This solution can be made by mixing 40 liters of water with either one-half teaspoon of HTH or 20ml of chlorine bleach.

5. Prepare a chlorine solution to wash the pump cylinder and drop pipe. Mix 10 liters of water with one of the following: 0.02 liters of chlorine bleach, or 3.3 grams of bleaching powder, or 1.4 grams of HTH.

6. Wash the exterior surface of the pump cylinder and drop pipe as they are lowered into the well.

7. Pump water from the well until you can smell chlorine.

8. Allow the chlorine solution to remain in the well for 24 hours.

9. Pump water from the well until chlorine can no longer be smelled or tasted. Dispose of this water in a soakaway.

Deep Well with High Water Table

In the case of a deep well with a high water table, you need to take special steps to ensure that the chlorine and well water are properly mixed.

1. Drill a number of small holes through the sides of the pipe that is 0.5-1.0m long and 50-100mm in diameter. Cap one end of the pipe.

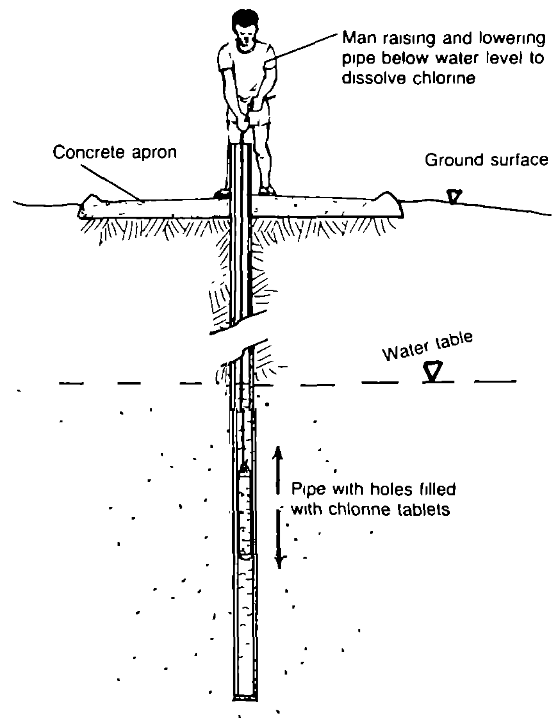


Figure 3. Disinfecting Deep Well with High Water Table

2. Pour the calculated amount of HTH granules or tablets into the pipe. Only HTH can be used in this method.

3. Fit the other end of the pipe with a threaded cap equipped with an eye loop.

4. Tie a rope to the eye loop, lower the pipe into the well, and alternately raise and lower the pipe in the water. Continue until the HTH has dissolved and the chlorine is distributed in the water. See Figure 3.

Notes

SESSION 12

SYNOPSIS OF SESSION 12: Maintaining and Repairing the Pump

Total Time: 4 Hours 30 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	20 Min.		Session Objectives Project Cycle
Introduction to Small Group Activity: Symptoms of Pump Problems	Trainer Presentation and discussion about common pump problems	20 Min.	Handout 12-1: Troubleshooting Pump Problems	
Practice: Trouble-shooting Pump Problems	Participants work with pumps which have been made to exhibit problems and identify symptoms and causes	30 Min.	Pumps exhibiting problems Barrels (see materials and tools list)	Chart for groups to report answers Task instructions
Practice: Repairing the Pump	Each group repairs last pump it inspected	30 Min.	Pumps exhibiting problems Barrels (see materials and tools list) Handout 12-2: Repairing the Shallow Well Pump Handout 12-2: Repairing the Deep Well Pump Handout 12-2: Repairing the Mark II Pump	
Discussing Pump Problems	Each group announces problem with the pump repaired. Right answers are totaled for each group.	20 Min.		
Lecturette: Importance of Maintenance	Lecturette	10 Min.		

SYNOPSIS OF SESSION 12: Maintaining and Repairing the Pump (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Discussion: Possible Causes of Poor Maintenance	Discussion	10 Min.		
Small Group Task #1: Identifying Maintenance Tasks	Small groups review maintenance tasks and schedule	25 Min.	Handout 12-3: Possible Caretaker Tasks Handout 12-4: Schedule for Maintenance of Simple Handpumps	
Discussing Small Group Task #1	Discussion	10 Min.		
Small Group Task #2: Planning for Preventive Maintenance and Repair Activities	Small groups develop a model of optimal maintenance and repair system	30 Min.		
Small Group Reports	Each group reports	30 Min.		
Generalizing and Applying	Participants list things to be remembered	15 Min.		
Closure	Review of Session Objectives	5 Min.		

Session 12: Maintaining and Repairing the Pump

Total Time: 4 hours 30 min.

OBJECTIVES

By the end of this session, the participants will be able to :

1. repair a shallow well and/or a deep well pump
2. understand the importance of on-going maintenance and repair of handpumps
3. identify symptoms and causes of pump problems
4. plan for maintenance and repair activities

OVERVIEW

Handpump maintenance and repair structures vary from country to country. Yet, irrespective of the maintenance and repairs systems employed once the pump has been installed, a safe, clean and continuous supply of water must be available to the village.

There are two major assumptions made in this session:

1. Participants need to know how to maintain and repair pumps in order to train others (particularly village caretakers) and/or to be able to assess how well the tasks are being performed.
2. Village caretakers will be able to perform all maintenance and repair tasks except for deep well pump repair which requires a tripod, block, and tackle.

The emphasis of this session is to learn how to maintain and repair a pump. The emphasis of the following session, "Training the Caretakers," is training others to do the maintenance and repair tasks.

This session begins a new phase of the project cycle. It is the first session of the maintenance and repair phase.

You will need to collect some information (before delivering this session) about the current maintenance structure of the country or region in which you are working. If appropriate and possible, include a resource person who can brief the participants.

The procedures for this session can be used for any type of pump. When more than one type of pump is included in the workshop, Step 3, "Troubleshooting Pump Problems," will need to be repeated for each pump (each additional pump will add about 45 minutes to the session).

Two handouts are included in this session which are for specific pump types. Handout 12-1 describes the symptoms of pump problems for deep and shallow well reciprocating pumps. Handout 12-2 is for the maintenance and repair steps for the AID deep well and shallow well pumps.

A large number of pumps and tools are used in this session. In "Trouble-shooting Pump Problems" the barrels used in Session 11: "Installing the Handpump and Disinfecting the Well" will be used again. Arrangements to procure sufficient quantities of tools and supplies need to be made before the workshop begins. A list of materials, tools and supplies is included at the end of this session.

PROCEDURE

1. Introduction — Time: 20 min.

Develop an introduction to the session from the overview including the following points:

- session objectives and the main steps of the session
- why the session is important
  - Relate stories of projects with good or poor maintenance and repair histories and the reasons for each (ask the participants to tell of some also).
  - Give the following definitions of preventive maintenance and repair: "Preventive maintenance" is an activity that prolongs the life of the pump, preventing it from breaking down or wearing out. "Repair" is done after a part of the pump breaks down or wears out.
- the relationship of the session to the project cycle and workshop schedule (in particular, that the session begins a new phase in the project cycle).

2. Introduction to Small Group Activity: Symptoms of Pump Problems

Time: 20 min.

A) Explain that we will first focus on how to diagnose pump problems and learn how to repair them. Later in the session we will discuss how to prevent problems from occurring.

B) Tell the participants: This activity will teach you how to identify when disassembly of the pump (in order to look for the internal part in need of repair or replacement) is necessary and how to identify the internal part in need of repair or replacement.

C) Ask the participants to relate anything they know about common pump problems. Ask what symptoms are exhibited by pumps with these problems.

D) Discuss the common problems associated with the handpump they have installed at the two sites.

E) Pass out Handout 12-1: Trouble Shooting Pump Problems. Give the participants several minutes to read through the handout before answering any questions.

F) Display several badly worn or damaged pump components that have been removed from field service and are typical of the problems the participants are likely to encounter. Some examples might be:

worn or torn pump cups
worn pins
worn foot valve rubber seal
rusted through pipe connection
cracked cylinder
broken handle

3. Practice: Troubleshooting Pump Problems Time: 30 min.

A) Divide participants into the same number of groups as there are problem pumps. The groups should be composed of three or four members. Assign each group to a barrel. The barrels should be numbered (see Trainer Note 1). Have the groups name one member responsible for tools.

B) Give the following instructions for identifying pump problems:

- You have three minutes to figure out what is wrong with each pump.
- Note the symptom and probable cause of the pump's problem without disassembling it.
- After three minutes, I will say 'switch' and you will move on to the next pump.
- Once you have examined all the pumps and agreed in your group on the symptoms and probable causes, list your answers on the flipchart (see example of the chart below).

	Group 1 Answer	Group 2 Answer	Group 3 Answer	Group 4 Answer	Group 5 Answer	Group 6 Answer	Actual Problem
Pump #1							
Pump #2							
Pump #3							
Pump #4							
Pump #5							
Pump #6							

- When you have listed your answers on the flipchart, wait at the barrel on which you last worked until all have recorded their answers. The next task will be to determine how to repair the pump.

- Begin now.

C) After each group has examined all the pumps and listed the symptoms and probable causes, pass out the appropriate section of Handout 12-2 (Shallow Well Pump or Deep Well Pump) to each group to assist them during the repair activity.

4. Practice: Repairing the Pump Time: 30 min.

A) Give the following instructions after all teams have posted their answers:

- Each group will disassemble the last pump it looked at to discover the cause of the problem. After you discover the problem, do not tell anyone until the trainer asks you to report it. All groups will then see how accurate their diagnosis has been.

- Be thorough in your examination of the pump. A pump may have more than one thing wrong with it. If, in the field, you repair a broken footvalve and do not check the cups, which later you find to have been torn, you cause additional inconvenience to the users and extra work for yourself.

- Once you discover the problem, disassemble the piston and footvalve assemblies until you feel proficient at reassembling the pump.

- Help each other learn; let the least experienced people practice the most with the pumps.

- Begin now.

B) The trainers should move among the participants while they are working on the tasks. The role of the trainer is to:

- Act as a resource person.

- Pose questions instead of solving problems:

  - If you continue to assemble the pump with the pieces like that, what do you think will happen?
  - Is there an easier way of doing that step?

- Observe the work being done closely to spot problems or lack of understanding.

5. <u>Discussing Pump Problems</u> Time: 20 min.

A) Have each group list on the flipchart, and briefly discuss, the problems with the pump they repaired. When all the problems are listed, total up the right answers for each group (see Trainer Note 2).

B) Ask participants some or all of the following questions:

- Which were the easiest pumps to repair? Why?
- Which were the hardest pumps to repair? Why?
- For which kinds of problems does diagnosis seem most accurate?
- Which problems do you anticipate will occur most frequently?
- With which steps do you think caretakers will have the most difficulty?
- What does this indicate for the kind of training and support they will need?

Trainer should be prepared to add information as needed.

C) Remind participants that every time someone works on the pump, the well must be disinfected.

6. <u>Lecturette: Importance of Maintenance</u> Time: 10 min.

To develop this lecturette include information about the structure and delivery of maintenance services in the area as well as the overall maintenance system within which the participants are or will be working. You may want to invite a knowledgeable outside resource person to deliver this lecturette.

In addition, include some or all of the following points as appropriate:

Maintenance systems:

- Many authorities contend that maintenance is the critical element of handpump programs. It is not uncommon to find 30 to 80 percent of handpumps out of operation at one time.

- There are many handpump maintenance programs, but most can be characterized as a one-level or a two-level system. The one-level system is one where all maintenance is the responsibility of the central organization. In the two-level organization, maintenance is shared with local villages or communities.

- In both systems a central organization usually installs the pump and handles major repairs or replacement of the pump. It maintains stores of parts and lubricants and provides transport, warehousing, and training. When the central agency provides routine maintenance, it often uses a roving maintenance person or team who may or may not have a vehicle and who services from 20 to 200 pumps (the numbers vary with circumstances) on a repetitive basis.

- In joint central and local systems the local community (or a resident employed by the central agency) assumes responsibility for all lubrication and minor repairs, for example, replacement of shallow well cup seals ("leathers"). Where villagers deal only with the basic maintenance tasks requiring frequent attention (e.g., lubrication) the back-up service maintenance person may visit the pump at regular intervals for a thorough servicing.

- In some programs, certain villagers may be given thorough training in pump maintenance and virtually all responsibility is left in their hands. This approach is being tried in Kenya and in Tanzania. Before the well is sunk, each village is required to nominate a person who will go to the district office for two weeks to learn about shallow well construction and about handpump maintenance. That person is then responsible for the well once it is sunk and stores a small stock of spare parts. If a major breakdown occurs the person will go back to the district water office and either get the parts needed to do the repairs or else get a district water engineer to do the job.

- The main point to be made in this overview is that a maintenance system needs to exist regardless of the form it takes. Even the best pump in the world, requiring the least maintenance, will eventually fall into disrepair and disuse without a maintenance system.

7. Discussion: Possible Causes of Poor Maintenance — Time: 10 min.

Conduct a large group discussion on the forces that work against effective pump maintenance. Below are some examples. Write the participant responses on flipchart paper or a blackboard.

Forces that hinder good maintenance:

- most handpumps require frequent lubrication which places a large demand on the maintenance system
- the lack of training in preventive maintenance for caretakers
- inadequate tools--few village maintenance people have a device for pulling up pump rod, drop pipe, and cylinder
- lack of transport
- lack of supervision
- lack of appreciation of preventive maintenance
- lack of spare parts
- the community is given insufficient support by local, regional, and/or national institutions in the organization of a system of maintenance
- delays in responding to reports of pump problems by the community
- inappropriate design and use of inadequate equipment such as weak handpumps designed for household rather than community use
- a community view of the handpump as government property and responsibility and not their own
- a low recharge rate leading to long waits, people resorting to polluted sources, or damaging equipment in effort to get water

Small Group Task #1: Identifying Maintenance Tasks — Time: 25 min.

A) Give the participants the following instructions:

- In groups of four to six, review Handout 12-3: Possible Caretaker Tasks.
- Place a check beside each task which is preventive maintenance.
- Add any preventive maintenance tasks missing from the list.
- Look at Handout 12-4: Schedule for Maintenance of Simple Handpumps. What changes would you make when scheduling maintenance for your projects?
- You have 15 minutes to complete the task. Divide into groups of four to six and begin now.

B) Pass out Handouts 12-3: Possible Caretaker Tasks and 12-4: Schedule for Maintenance of Simple Handpumps.

9. <u>Discussing Small Group Task #1</u> Time: 10 min.

While participants are still in their groups:

A) Ask if they added any preventive maintenance tasks to their lists.

B) Discuss the maintenance schedule by asking:

- What changes, if any, did you make in the maintenance schedule?

10. <u>Small Group Task #2: Planning for Preventive Maintenance and Repair Activities</u> Time: 30 min.

While participants are still in the same small groups, give the following instruction:

- Develop a model of what an ideal maintenance and repair system in your area would look like. How would it work? Who would be responsible for what?
- Identify the forces that would prevent your system from being ideal.
- Identify the role you might play to help to put the system in place.
- Prepare a three-minute report for the rest of the group.

11. <u>Small Group Reports</u> Time: 30 min.

Ask each group to give a report. After each report allow up to five minutes for questions.

A) Tell the participants "We have learned how to disassemble and assemble the pumps, how to identify whether the pump needs repair, and how to identify the internal component that needs repair or replacement. Now we will look at how to plan for preventive maintenance and repair."

B) Post the following list of items needed to maintain/repair a pump. Ask participants if they have any additions:

tools
spare parts
labor: village caretaker, agency repair team, helpers
supplies: grease, disinfectant

C) Ask participants the following questions about each item:
<u>Note</u>: It is not necessary to pin down every answer. This exercise is designed to get participants thinking about what needs to be done to plan for maintaining and repairing the pump.

- Tools:
    - What type and quantity do you need?
    - Where are they available?
    - Who is responsible for testing them?
    - Will getting them cost something? Who will pay for it?
    - How long will it take to get them?
- Spare parts:
    - What type or quantity do you need?
    - How many spare parts should be kept on hand per pump?
    - Where are they available?
    - What spare parts should be kept in the village?
    - How does one obtain the spare parts not kept in the village?
    - Who will pay for them?
    - How long will it take to get them?
- Labor:
    - When should an agency repair team be called in?
    - How long will it take for it to come?
    - Who is responsible for calling it in?
    - Will it cost something?
    - Who is responsible for what aspects of maintenance?
    - Who is responsible for what types of repairs?
- Supplies:
    - What type and quantity do you need?
    - Where are they available?
    - Who is responsible for getting them?
    - Will getting them cost something? Who will pay for it?
    - How long will it take to get them?

12. Generalizing and Applying Time: 15 min

A) Ask participants:

- What should be remembered about handpump preventive maintenance? (record answers)
- What should be remembered about handpump repair? (record answers)

B) State the following:

- Now that you have increased your skills in identifying and repairing pump problems, let's think ahead to the next session, "Training the Caretakers" and about applying what you have learned. You may not be doing maintenance and repair work yourself, but instead training or supervising others, or you may be involved in helping a village to set up a system for maintenance and repair.

- Keep the above in mind and complete the following sentences:

  - For me the most difficult part of maintenance and repair will be ____.

  - When I leave this workshop I intend to ________________________.

13. Closure — Time: 5 min.

Review session objectives. Ask how each one was met and what more could be done to better meet the objectives.

MATERIALS

1. Each group will need the small group supplies listed in Section 1.8 of the Introduction for Steps 3 and 4.

2. Each group will need a set of tools and materials listed in "Tools and Materials" following the Trainer Notes.

3. Handout 12-1: Troubleshooting Pump Problems

4. Handout 12-2: Shallow Well: Repairing the Shallow Well Pump

   Handout 12-2: Deep Well: Repairing the Deep Well Pump
   Handout 12-2: Mark II: Repairing the Mark II Pump

5. Handout 12-3: Possible Caretaker Tasks

6. Handout 12-4: Schedule for Maintenance of Simple Handpumps

7. Flipchart paper

8. Marker pens

9. Tape

10. Prepared flipcharts for:
    - session objectives
    - instructions for small group task (step 4)

TRAINER NOTES

1. For this session, the pumps must be forced to exhibit problems. The problems, such as the following, should be quite evident:

   - plunger cage unscrewed
   - plunger rod unscrewed
   - no cups (has symptoms similar to cups being badly worn)
   - foot valve wedged open

- no water in barrel
- suction pipe leaks
- foot valve broken or unscrewed

A pump may have two things wrong with it at the same time. Pumps in the field often exhibit similar problems for different causes. Have only one or two pumps with multiple problems, however, to keep from frustrating the participants.

2. You may want to give a small prize to the group with the most correct answers.

TOOLS AND MATERIALS

This session is practice-oriented and requires a large number of tools, pumps and other supplies. A list of the tools and supplies needed, per group, for the session appears below. A workshop with 20 participants divided into six groups of three and one group of two would require seven times the quantities of the items shown below.

Supplies	Quantity	Tools	Quantity
shallow well pump	1	adjustable wrench	2
deep well cylinder	1	pliers	1
barrel	1	punch	1
pipe nipple	1	pipe wrench*	1
plunger rod section	1	strap wrench*	1
connection	2	hammer	1

* Pipe wrenches and strap wrenches will not be required for the session if all the shallow well pump bases and deep well cylinders are unloosened before the session.

Note: these are some of the same tools and supplies used in the pump installation session (Session 11).

Troubleshooting Pump Problems

A) The pump must be pumped several times before water comes out (particularly in the morning).

Cause:
1. Footvalve is excessively worn or dirt is allowing water to leak past.
2. A leak has developed in the drop pipe (loss of water) or suction pipe (loss of vacuum).

Remedy:
1. Examine footvalve. Clean or replace as necessary.
2. Examine drop pipe or suction pipe. Correct leak.

B) The amount of water pumped per stroke is significantly less than when the pump was new.

Cause:
1. Plunger cups are worn and not sealing against the cylinder walls.
2. The footvalve is excessively worn or dirty.
3. A leak has developed in the drop pipe (loss of water) or suction pipe (loss of vacuum).
4. Dirt and debris are obstructing the flow of water.

Remedy:
1. Examine the plunger cups for excessive wear or a tear. Replace as necessary.
2. Examine the footvalve. Clean or replace as necessary.
3. Examine drop pipe or suction pipe. Correct leak.
4. Examine drop pipe, suction pipe, foot valve, and plunger valve for dirt and debris. Remove the dirt and debris.

C) No water can be pumped.

Cause:
1. Footvalve is broken or is stuck in the open position
2. Plunger cage is broken
3. Plunger assembly or a section of plunger rod has become unscrewed from the rest of the plunger rod

Remedy:
1. Examine footvalve. If broken, replace. If stuck, clean it or remove the blockage: if the valve still sticks, replace it.
2. Examine plunger assembly. A broken plunger cage is usually the result of the plunger rod being too long or too short. To prevent the plunger cage from being broken after it has been replaced, it is necessary to determine how much too short or long the plunger rod is and make the needed adjustment in length.
3. Examine the plunger assembly and plunger rod. Reconnect the joint tightly. In the case of an unscrewed plunger assembly, be sure that the lock nut on the plunger rod is tightened securely.

TROUBLESHOOTING PUMP PROBLEMS

COMMON HAND PUMP TROUBLES AND REMEDIES

TROUBLE	LIKELY CAUSE	REMEDY
1. Pump handle works easily but no water delivered	A No Water at the source Well dry	Rehabilitate well, or develop a new source or sources of water
	or	
	B Level of water has dropped below suction distance of pump	Can be checked with vacuum gauge or with weighted string Reduce pumping rate or lower pump cylinder
	or	
	C Pump has lost its priming	Prime the pump If the pump repeatedly loses its priming it may be periodically pumping the well dry, the suction line may be leaking, or the suction valve or discharge check valve may be leaking Repair line or valve Also check 1-A and 1-B
	or	
	D The cylinder cup seals ("leathers") may be worn out	Renew the cylinder cup seals ("leathers")
	or	
	E The valves or valve seats may be worn or corroded	Renew valves and repair or renew seats
	or	
	F With a deep-well plunger pump the plunger rod may be broken	This trouble would be indicated by the pump running freer and and probably quieter Turn the pump over by hand and note if there is resistance on the upstroke Broken rods must be renewed and this usually means pulling the drop pipe and cylinder out of the well
	or	
	G Shutoff valve may be closed (force pump)	Open valve
	or	

Continued

TROUBLE	LIKELY CAUSE	REMEDY
1 Pump handle works easily but no water delivered (continued)	H Hole in suction pipe	Renew suction pipe Cylinder may be lowered below water level in well
	or	
	I. The suction pipe may be plugged with scale or iron bacteria growth or sediment	Can be checked with vacuum gauge Remove suction pipe and clean or renew
	or	
	J The pump cylinder may be cracked	Renew the cylinder
	or	
	K Leak at base of cylinder	Renew cylinder gasket
	or	
	L One or more check valves held open by trash or scale	Remove valves and inspect for trouble With deep-well plunger pumps this may mean pulling the pump cylinder or plunger and valves out of the well
2 Pump runs but delivers only a small amount of water	A. Plunger leathers badly worn (plunger and piston pumps)	Renew leathers
	or	
	B Well not yielding enough water	Decrease demands or establish new sources of water
	or	
	C Cracked cylinder (plunger or piston pump)	Renew cylinder
	or	
	D. Check valve(s) leaking	Repair valve(s)
	or	

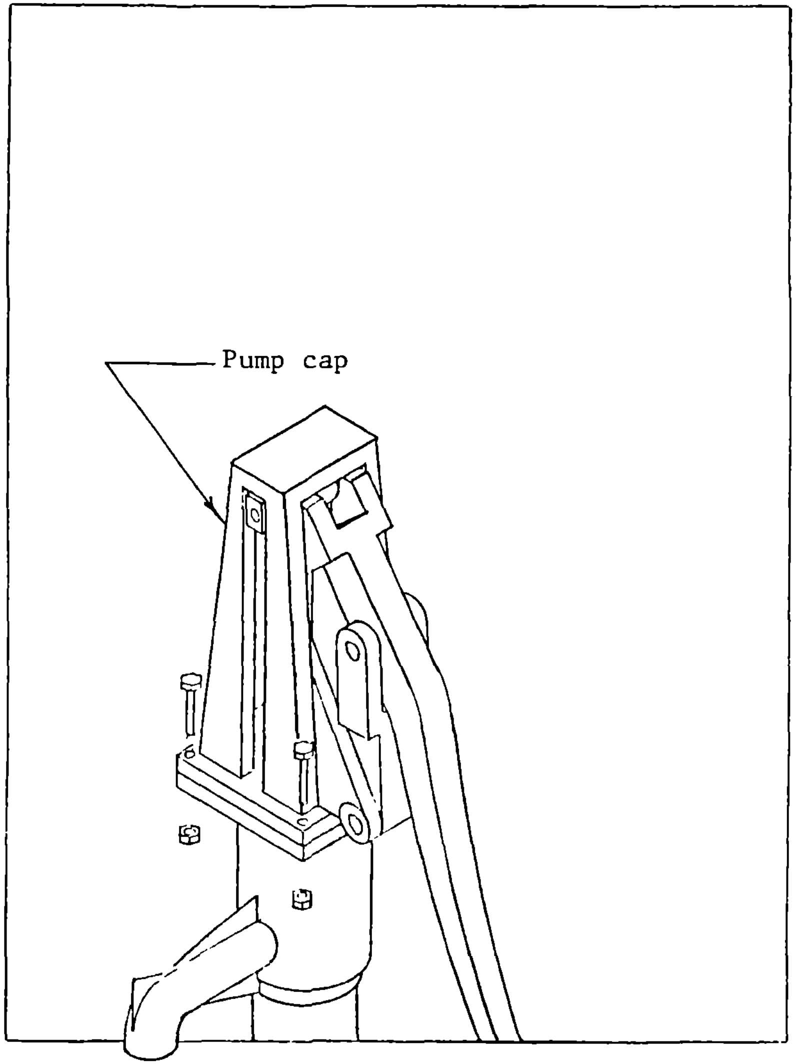
Continued

TROUBLESHOOTING PUMP PROBLEMS

TROUBLE	LIKELY CAUSE	REMEDY
2. Pump runs but delivers only a small amount of water. (continued)	E Screen or suction valve may be obstructed.	Remove and clean
	or	
	F Suction pipes are too small	Can be checked with vacuum gauge Install pipe with larger diameter, or for deep well pump, lower pump cylinder below water level in well
	or	
	G Suction valve(s) may be out of order.	Repair valve(s)
	or	
	H Cracked drop pipe or coupling	Renew drop pipe or coupling.
3 Pump needs too many strokes to start	A Pump has lost its priming	Prime the pump If the pump repeatedly loses its priming, it may be periodically pumping the well dry, or the suction line or the suction valve may be leaking. Repair or renew line or valve.
	or	
	B. The cylinder cup seals ("leathers") may be worn out	Renew the cylinder cup seals
4 Handle springs up after down stroke	A Suction pipe plugged up below pump cylinder	Remove pump and clean out suction pipe If well has filled with dirt up to suction pipe, the well should be cleaned out or the pipe cut off
	or	
	B Plunger check valve fails to open or to close	Repair check valve
	or	
4 Handle springs up after down stroke (continued)	C Suction pipe too small	Replace with larger suction pipe
	or	
	D Water too far below pump (suction pipe too long)	Place cylinder nearer water
5 Leaks at stuffing box	A Packing worn out or loose.	Renew or tighten packing. Leave packing nut loose enough to allow a slow drip of water The water serves as a lubricant
	or	
	B Plunger rod badly scored	Renew plunger rod
6 Pump is noisy	A Bearings or other working parts of the pump are loose	Tighten or renew parts
	or	
	B Pump is loose on mountings	Righten mountings
	or	
	C With deep-well plunger pumps having a steel plunger rod the rod may be slapping against the drop line	Use a wooden rod or install guides for rod or straighten drop pipe if crooked

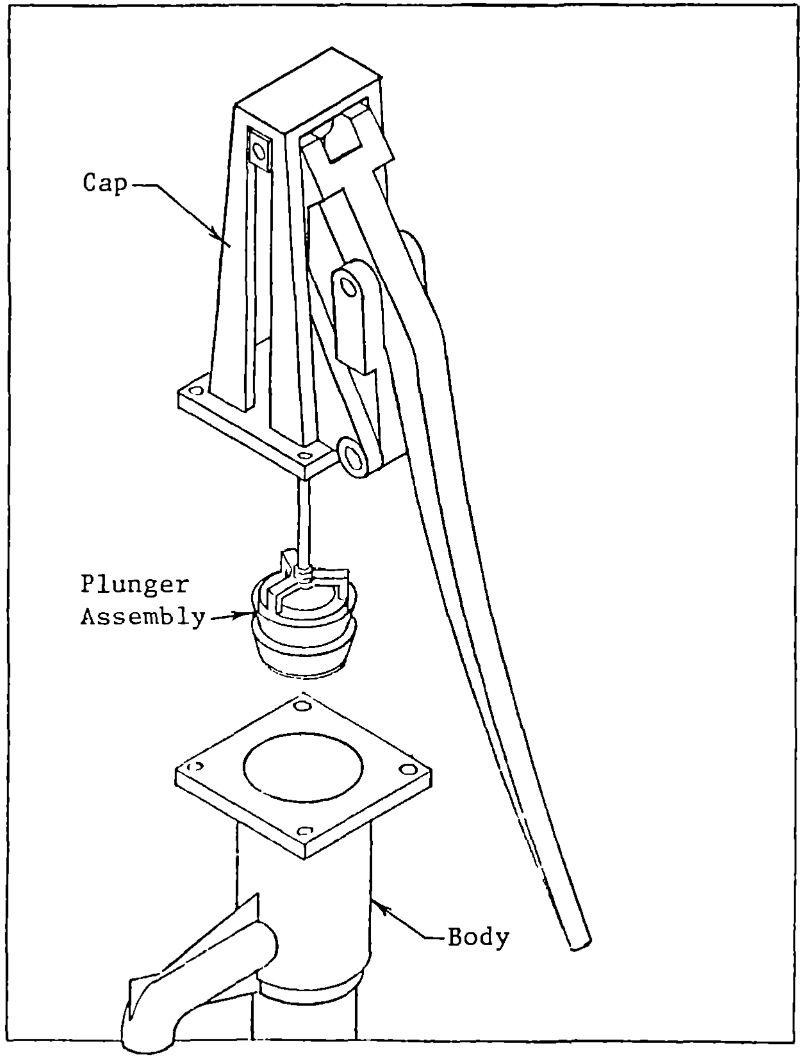
Continued

REPAIRING THE SHALLOW WELL PUMP



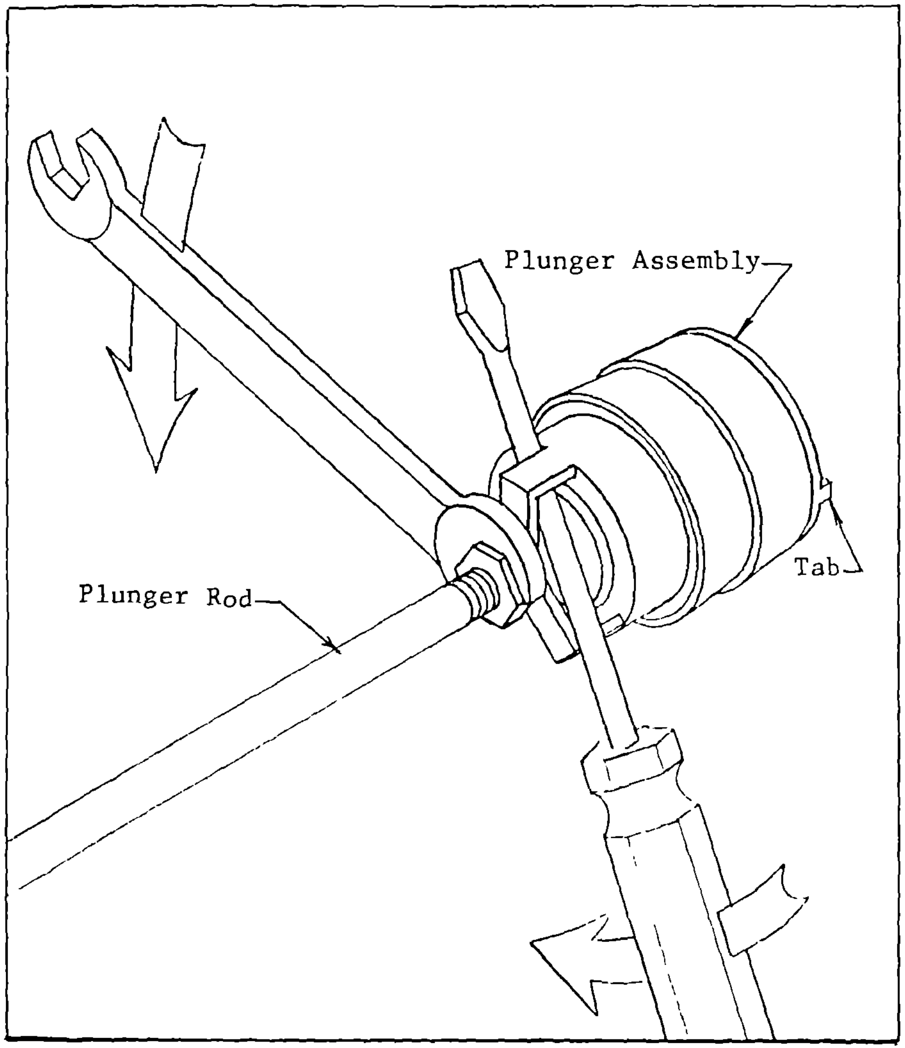
CUP REPLACEMENT

Remove the four bolts holding down the pump cap.

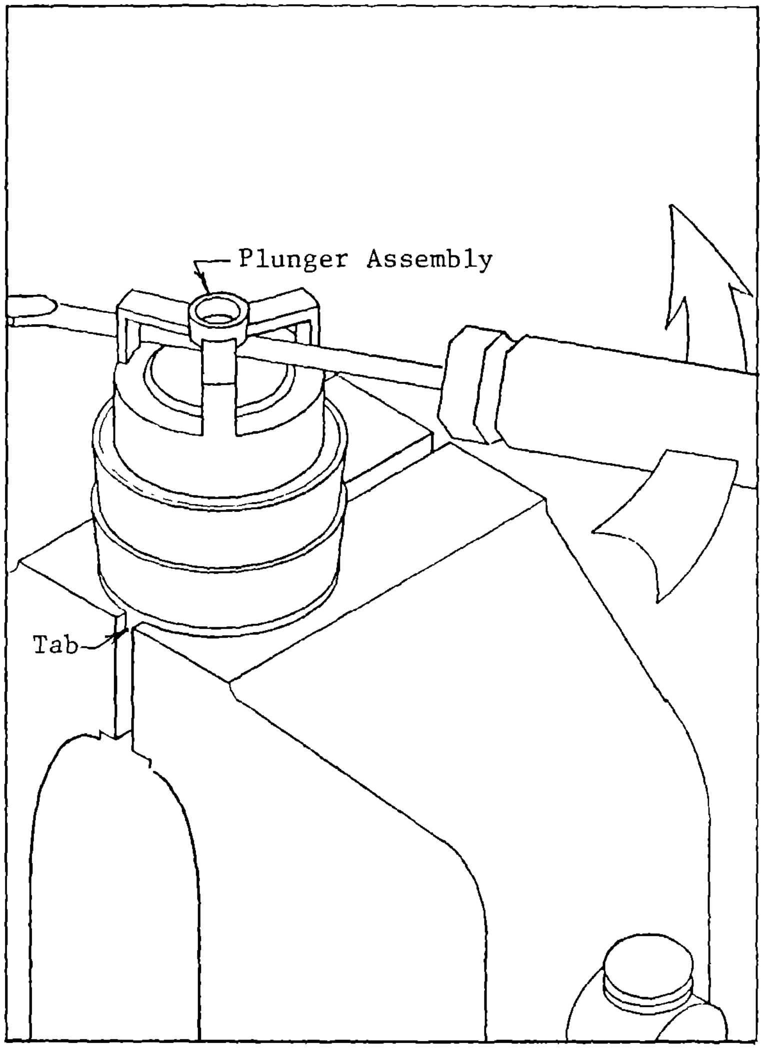


Lift the cap off of the pump body.

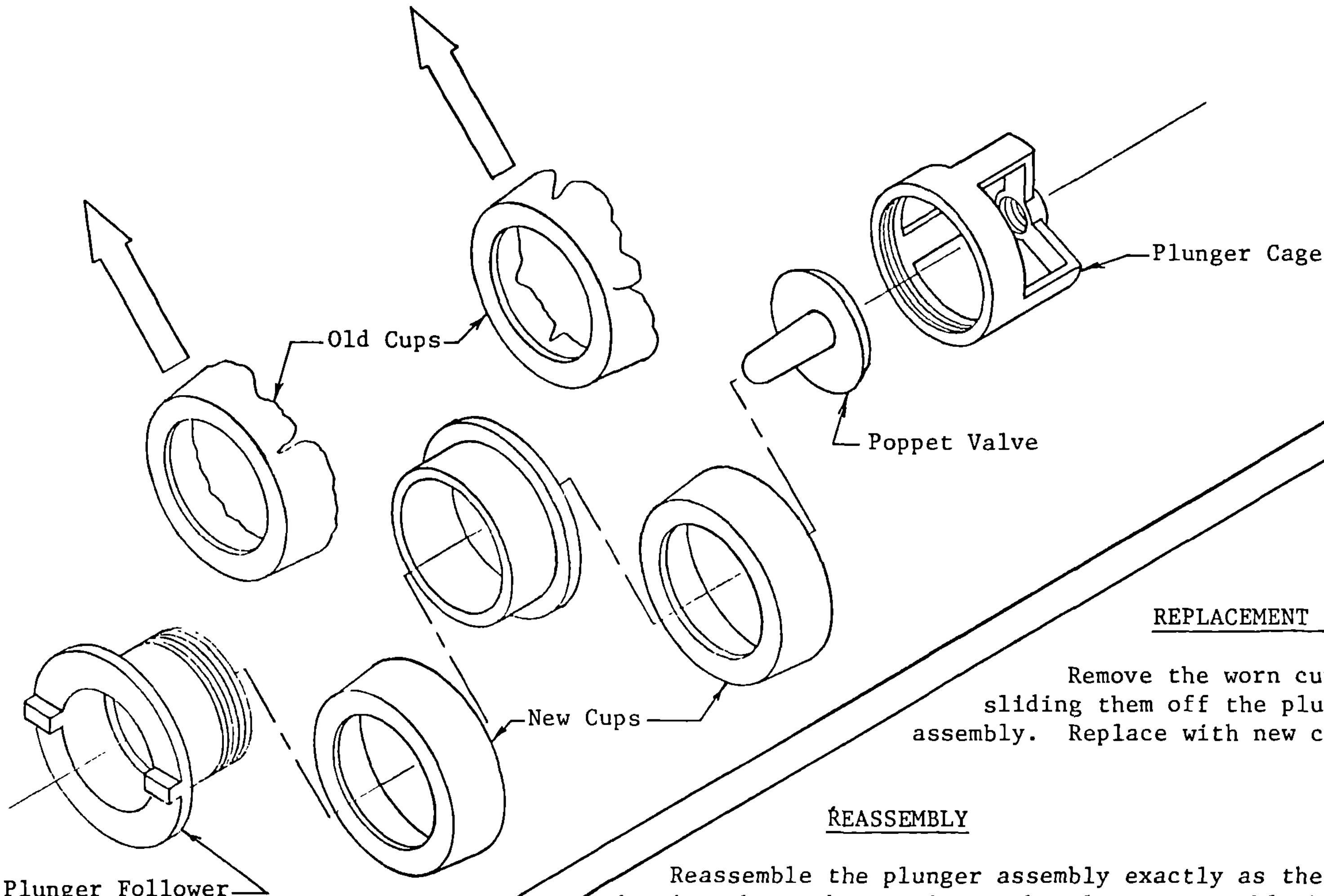
REPAIRING THE SHALLOW WELL PUMP



Unscrew the plunger assembly from the plunger rod.



Unscrew the plunger assembly. A wrench can easily be used in place of the vice to grip the tabs.



REPLACEMENT OF CUPS

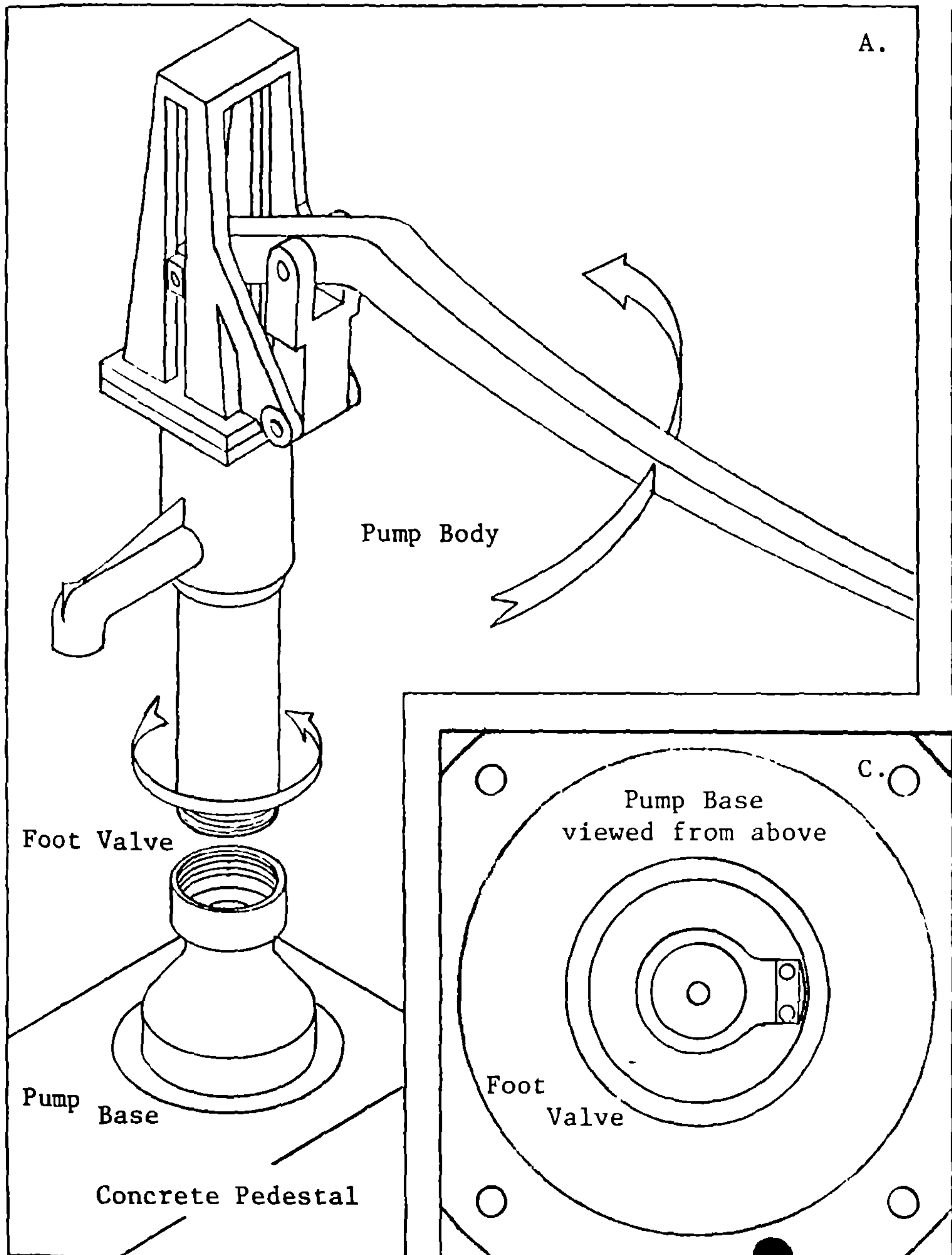
Remove the worn cups by sliding them off the plunger assembly. Replace with new cups.

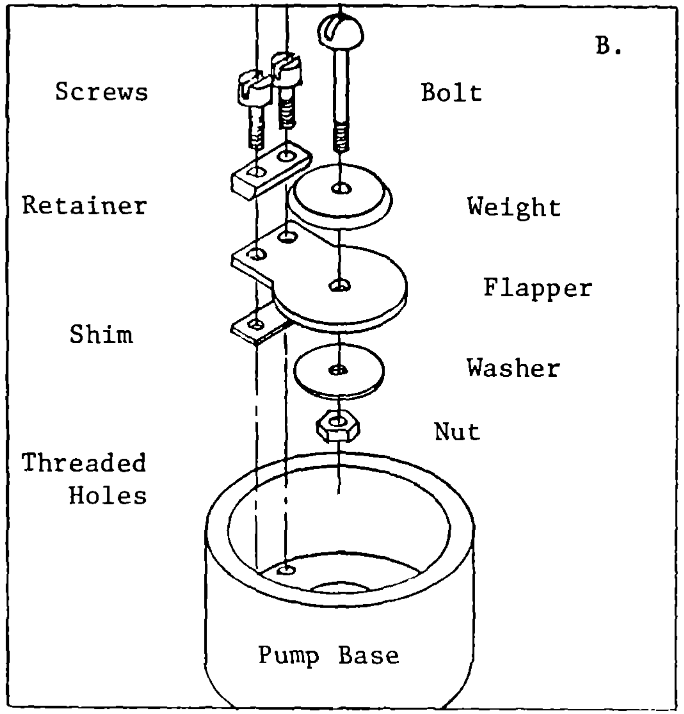
REASSEMBLY

Reassemble the plunger assembly exactly as the drawing above shows. Screw the plunger assembly back together snugly, but not too tightly. This will make disassembly next time very difficult. Be sure that the lock nut is tightened firmly on the plunger rod. Replace the pump cap and rebolt.

FOOT VALVE REPLACEMENT

REPAIRING THE SHALLOW WELL PUMP





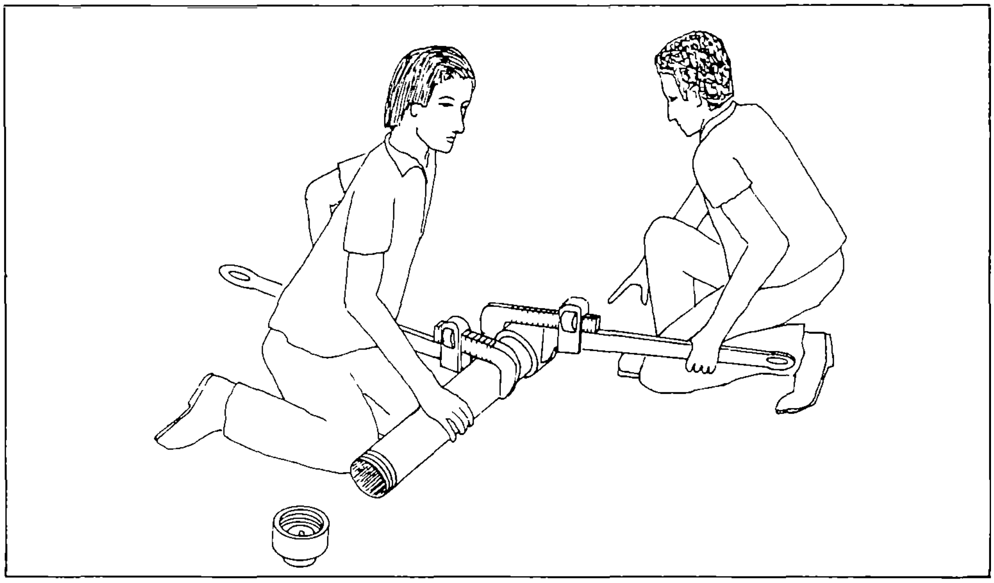
A. Unscrew the pump body from the pump base. If a large pipe wrench is unavailable, the handle may be used as a lever.

B. Replace the old footvalve flapper. Wipe any oil or dirt off the valve seat. Reassemble as shown.

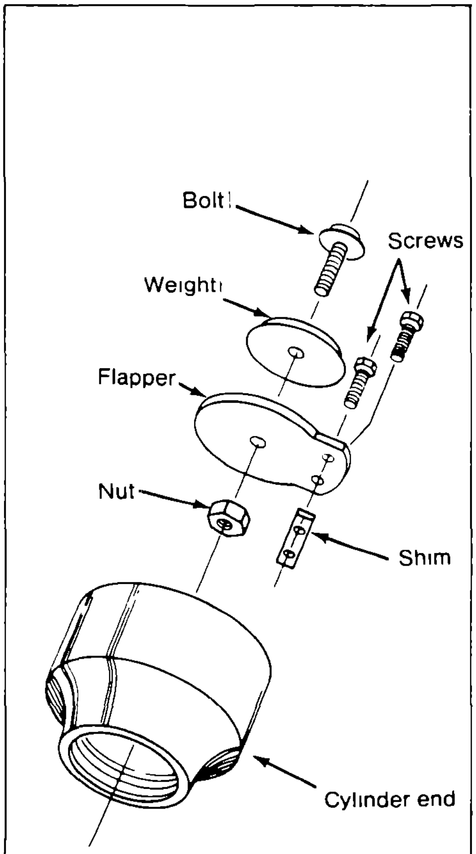
C. The reassembled valve should be centered as shown when viewed from above.

REPAIRING THE DEEP WELL PUMP

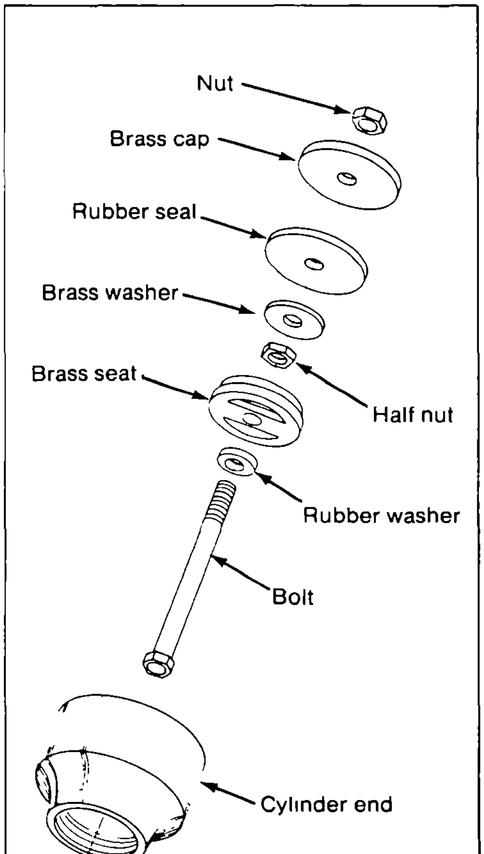
1 Take both ends off of the cylinder



2. Look at the foot valve and repair worn or broken parts

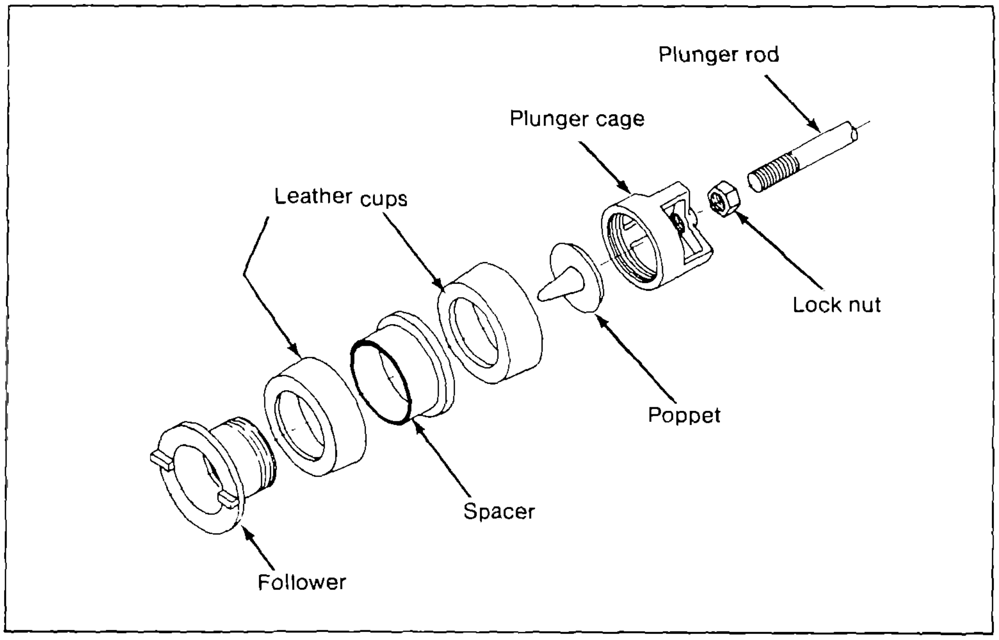


Flapper Foot Valve



Poppet Foot Valve

3 Examine the plunger assembly for worn or broken parts



4 Double-check your repair.

- Did you see any pipe joints leak when you took the cylinder out of the well? Did you repair these?
- Did you examine **all** the cylinder components?
- Are all the pipe joints resealed with pipe sealant or teflon tape?
- Does the cylinder leak after reassembly?
- Are all the lock nuts tight?
- Are all rod joints tight?
- Are all pipe joints tight?
- Did you test the pump for smooth operation, flow rate and leak rate? Are they acceptable?

Step-by-Step Procedure for Pump Overhaul

Before you move out of any handpump site, consult the India Mark II Handpump Installation Manual for checklist of tools and materials, and use this checklist to ensure you have all the tools and materials with you on the vehicle.

When starting the work, ensure that all the tools you will require are within hand's reach to facilitate your work. You can spread out a gunny bag or some other material upon which you can put the tools to protect them from dirt. You should do the same for all the handpump components you are going to remove. Ensure here also that the components are kept off the ground and protected from any dirt. Also, a pipe stand can be used to keep the G.I. pipes and rods off the ground.

DISMANTLING THE PUMP

1. Remove top-head front cover.
2. Disconnect handle from chain by removing the nyloc nut and bolt.
3. Take out handle-axle. While removing, use axle punch to protect axle threading and remove handle from top-head.
4. Remove top-head flange bolts.
5. Insert one pipe lifting spanner into the holes provided in the top-head and lift top-head (see step 21 of Manual).
6. Fit the connecting rod vice onto the water chamber top flange and tighten.
7. Remove chain and chain lock nut and remove top-head.
8. Remove bottom flange water tank bolts.
9. Lift water tank by using lifter pipe & lifting spanners.
10. Fit heavy duty clamp and tighten, and remove water tank.
11. Disassemble rising main and connecting rods. Remove, at a time, three metre lengths only.
12. While removing the pipes and rods ensure that you place these off the ground (see step 9 of Manual). Continue doing so until the entire below-ground assembly has been removed from the tube-well.
13. Disconnect cylinder from the last pipe.
14. Check all the pipe threads, clean out the threads by using wire brush. Remove any dirt and rust from the pipes by using sandpaper or wire brush. Re-thread if necessary. If any pipe is damaged, replace. Ensure that all pipe couplings are intact and fit properly.

CONNECTING RODS

15. Check all the connecting rod threads and couplings. Clean out threads with wire brush. Remove any dirt and rust from the rods by using sandpaper or wire brush. Fit lock nuts. If any connecting rod lock nut is missing, replace. Re-thread connecting rods if required. Check each rod for straightness. If rods are bent, try to straighten them. If not possible, replace.

CYLINDER OVERHAUL

16. Unscrew top and bottom reducer caps using heavy duty clamp and wrench. Remove piston assembly and foot-valve. Check piston and foot-valve assembly and replace any worn out components. Replace, if

From: INALSA

necessary, leather cup-washers, leather sealing ring, rubber seating etc. Check for cracks which may have developed in the cylinder components. Replace parts if necessary. Assemble complete cylinder assembly.

IMPORTANT :

Check cylinder assembly for any leakage. Put cylinder in a bucket of water and move piston up and down. When cylinder is full of water, hold up and check whether any water is seeping through the foot-valve. If so, re-open cylinder, check piston and foot-valve assembly again for correct assembly and proper tightening. If necessary, replace foot-valve.
Lock the upper valve seat and rubber seat retainer of the cylinder by punching at right angle at circumference of mating surface.

PUMP BODY OVERHAUL

17. Clean inside of water chamber and top-head Remove all dirt and rust inside and outside the handpump body. Use wire brush and/or sandpaper to remove rust patches. Apply anti-rust paint.

    Assemble the handpump following the handpump installation procedures, as shown in the Manual.

PLATFORM CHECKING

As you know, the India Mark II Handpump ought to be installed with a proper concrete platform and pedestal. A handpump platform is essential since: (1) it provides the foundation for the pump pedestal; (2) it acts as a hygienic seal; (3) prevents any surface water percolation into the tube-well and hence excludes any contamination of the tube-well water. Therefore, special attention should be paid to the platform condition and (1) you should check for cracks which may have developed in the platform and (2) check whether the pump pedestal is tightly secured to its foundation.

If the platform has any cracks, or if the pedestal is loose, do the following:

18. Fill up cracks in the platform with cement. Make sure that exposed platform brickwork is covered again with cement plaster.
19. To reinforce the handpump pedestal base, dig out a circular space of minimum 5 cms. wide and 10 cms. deep around pedestal base and fill this up with a 1:2:4 concrete mixture. Whenever cement plaster for concrete mixture is re-applied to an existing platform, curing time should be allowed which is normally 7 days. Disconnect the handle from the chain so that nobody can operate the pump and ask the villagers not to use the hand pump for the duration of the prescribed time. The required setting time can be reduced if quick setting compound is mixed with the cement and concrete mixtures. When quick setting compound is used, 24 hours curing time is required.

CHLORINATION OF THE TUBEWELL

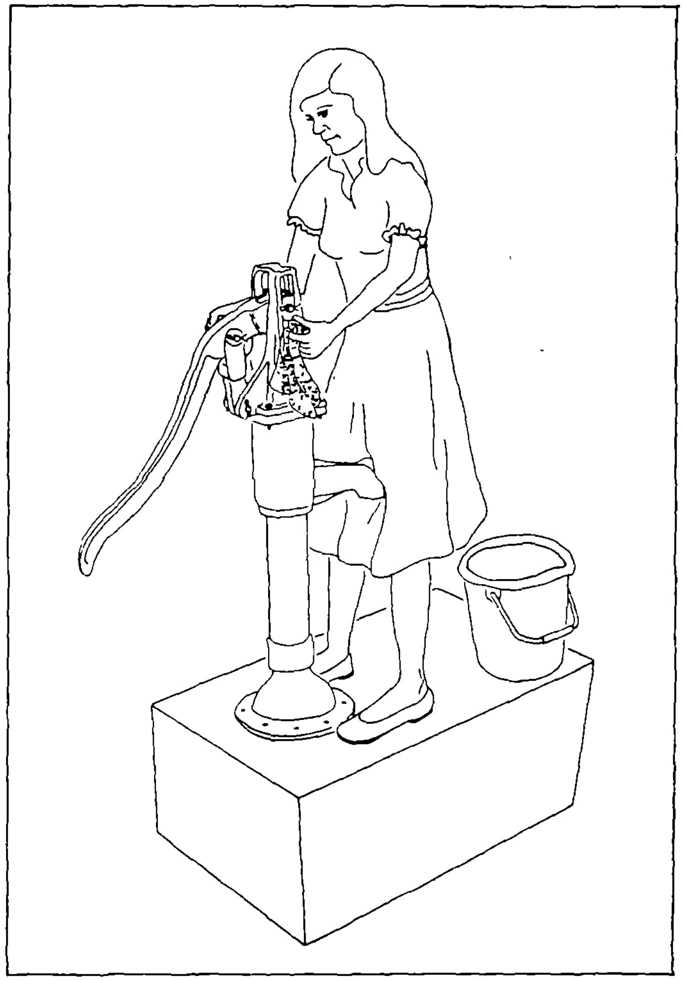
20. Upon completion of the overhaul job, the tubewell should be chlorinated. Follow the chlorination instructions as indicated on page 38 of the manual.

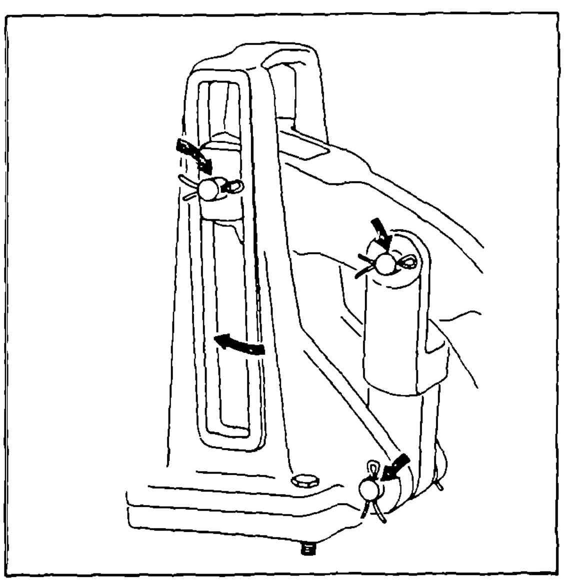
Possible Caretaker Tasks

- Lubricate wear surfaces on pump periodically
- Clean pump periodically
- Replace bushings, pins
- Replace shallow well cups
- Repair shallow well foot valve
- Repair shallow well plunger assembly
- Replace broken handle, fulcrum or other above ground part
- Repair deep well foot valve
- Replace deep well cups
- Repair deep well plunger assembly
- Fix leaks in drop pipe or suction pipe
- Order spare parts
- Request assistance from water supply agency
- Collect user fees
- Keep animals away from pump surroundings
- Discourage villagers from spilling water off the apron
- Drain water away from well site
- Teach villagers how to correctly operate pump
- Keep children from playing with pump
- Prevent vandalism of pump
- Tighten nuts, bolts and connections periodically
- Keep record of pump repairs
- Keep record of fees collected and costs of maintenance and repair
- Disinfect the well
- Teach villagers how to keep water clean while storing it
- Lock and unlock the pump at hours agreed by the village
- Clean the apron periodically
- Record any comments from users about irregularities in pump operation
- Paint all exposed parts to prevent development of rust
- Repair any cracked concrete in apron or drain
- Periodically test pump for footvalve leaks and worn leather cups
- Inspect pins and bushings wear

LUBRICATING THE PUMP

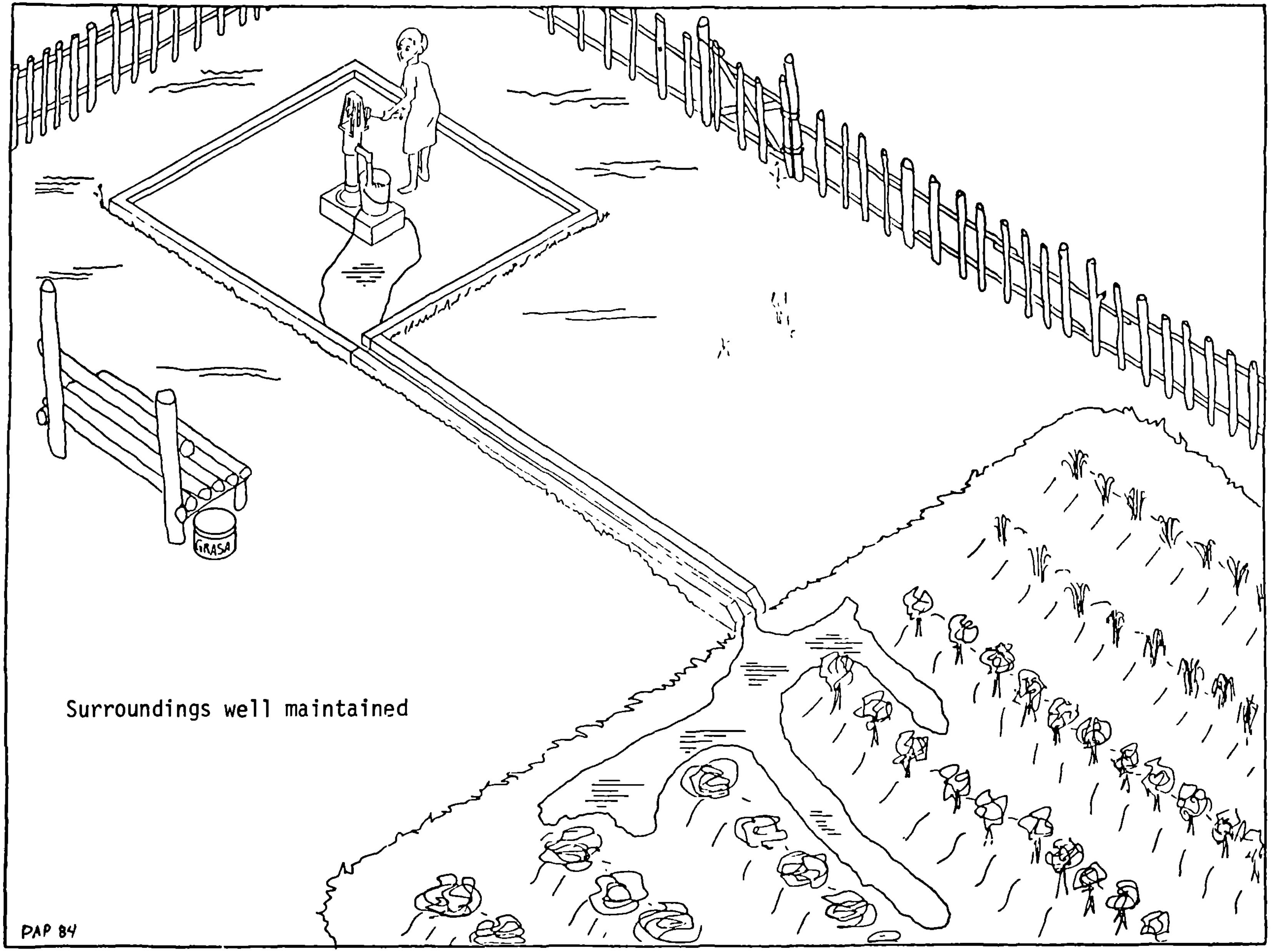
First, clean off the old lubricant with a rag





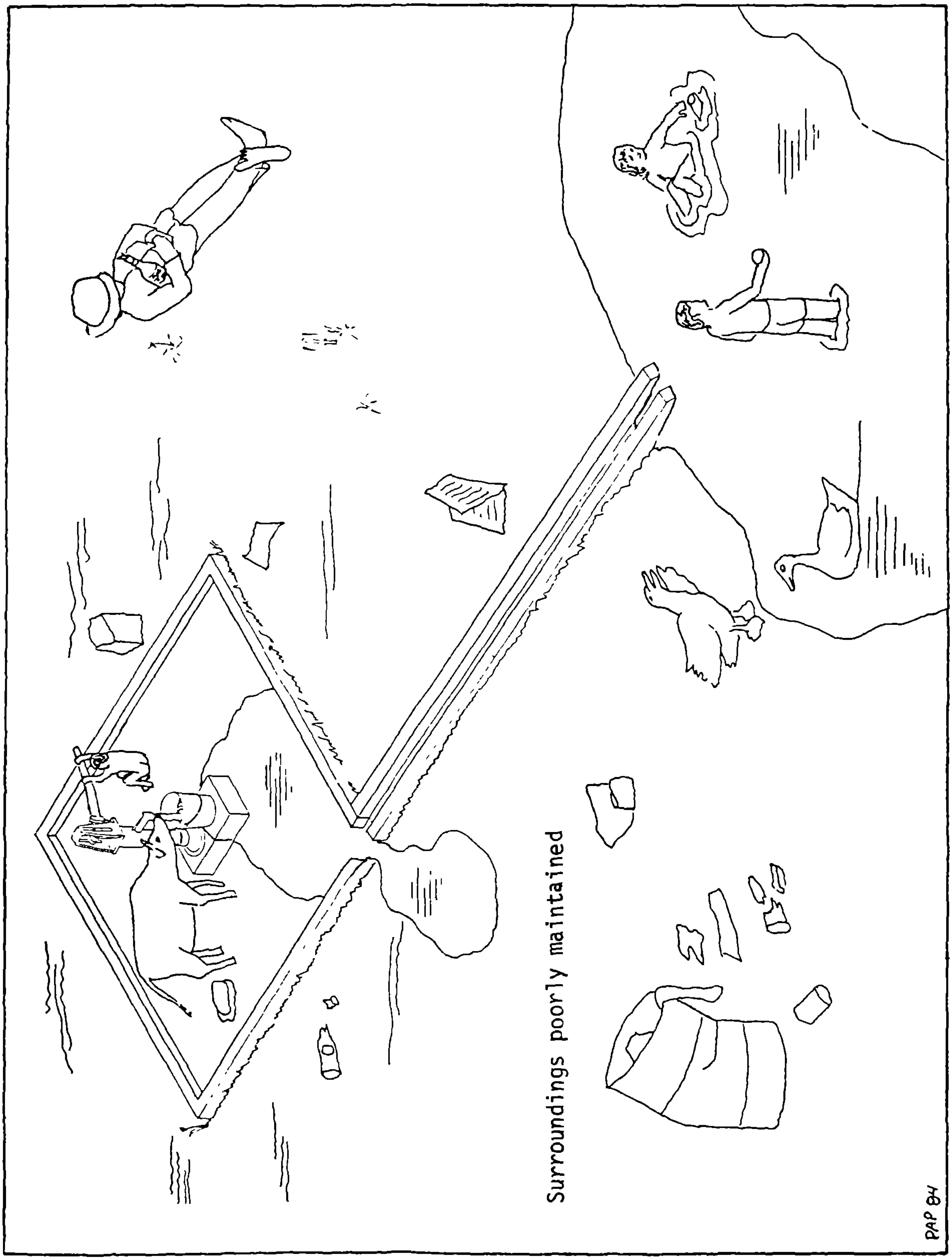
Put new lubricant on the parts indicated by the arrows

Remove the pins to lubricate them.



Surroundings well maintained

MAINTENANCE OF THE PUMP AND SURROUNDINGS



SCHEDULE FOR MAINTENANCE OF SIMPLE HAND PUMPS

daily

1. lock and unlock the pump at hours agreed by the village.
2. clean the well-head.

weekly

1. thorough clean-up of pump, well-head and surroundings.
2. oil or grease all hinge pins, bearings, and sliding parts, after checking that no rust has developed on them.
3. record any comments from users about irregularities in working (tightness of parts, leaks from stuffing box, fall-off in water raised). Correct these when possible.

monthly

1. if necessary, adjust the stuffing box or gland (this does not apply to the Craelius pump). Usually this is done by tightening the packing nut. This should not be too tight - there should be a slight leak when the adjustment is correct.
2. check that all nuts and bolts are tight, and check that there is no evidence of loose connections on the pump rods.
3. check for symptoms of wear at the leathers, noting any comments from users about any falling off in the water raised. If the pump fails to raise water when worked slowly (e.g., at 10 strokes per minute), replace the leathers.
4. carry out all weekly maintenance tasks.

annually

1. paint all exposed parts to prevent development of rust.
2. repair any cracked concrete in the well-head and surrounds.
3. check wear at handle bearings and replace parts as necessary. On the Craelius pump, worn bushes can be replaced by short sections of pipe of suitable diameter.
4. check plunger valve and foot valve; replace if found leaking.
5. check the pump rod and replace any defective lengths or connectors.
6. replace packing at the stuffing box or gland (does not apply to the Craelius pump).
7. carry out all monthly maintenance tasks.

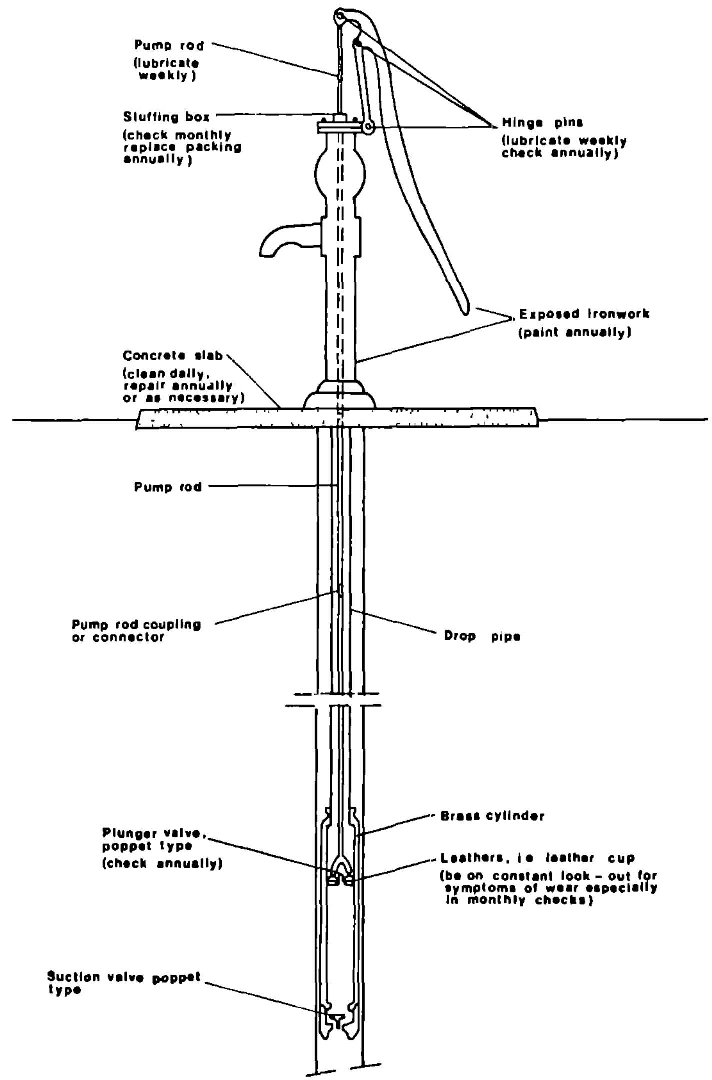


FIGURE 4-4 MAINTENANCE NEEDS OF HAND PUMP COMPONENTS

(after Pacey, 1976)

SESSION 13

SYNOPSIS OF SESSION 13: Training the Caretakers

Total Time: 2 Hours
40 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	10 Min.		Session Objectives
Lecturette: Operation and Maintenance: Training and Appointment of Local Persons	Lecturette	15 Min.		Division of Maintenance Roles (in overview)
Reviewing Caretaker Tasks	Discussion	20 Min.		Handout 12-3: Possible Caretaker Tasks
Brainstorm: Characteristics of a Good Trainer	Brainstorm and Discussion	10 Min.		
Practice Training Session	In pairs, participants practice teaching the "Caretaker" a task.	1 Hour	See small group activity supplies in Section 1.8 of Introduction	Task Instructions
Discussing the Practice Session	Discussion	20 Min.		
Generalizing from the Practice Sessions	Discussion	10 Min.		
Application: Improving Your Training Skills	Individuals identify strengths and areas for improvement	10 Min.		
Closure	Review Session Objectives	5 Min.		

Session 13: Training the Caretakers

Total Time: 2 hours 40 minutes

OBJECTIVES

By the end of this session, the participants will be able to:

1. train a caretaker in one area of responsibility

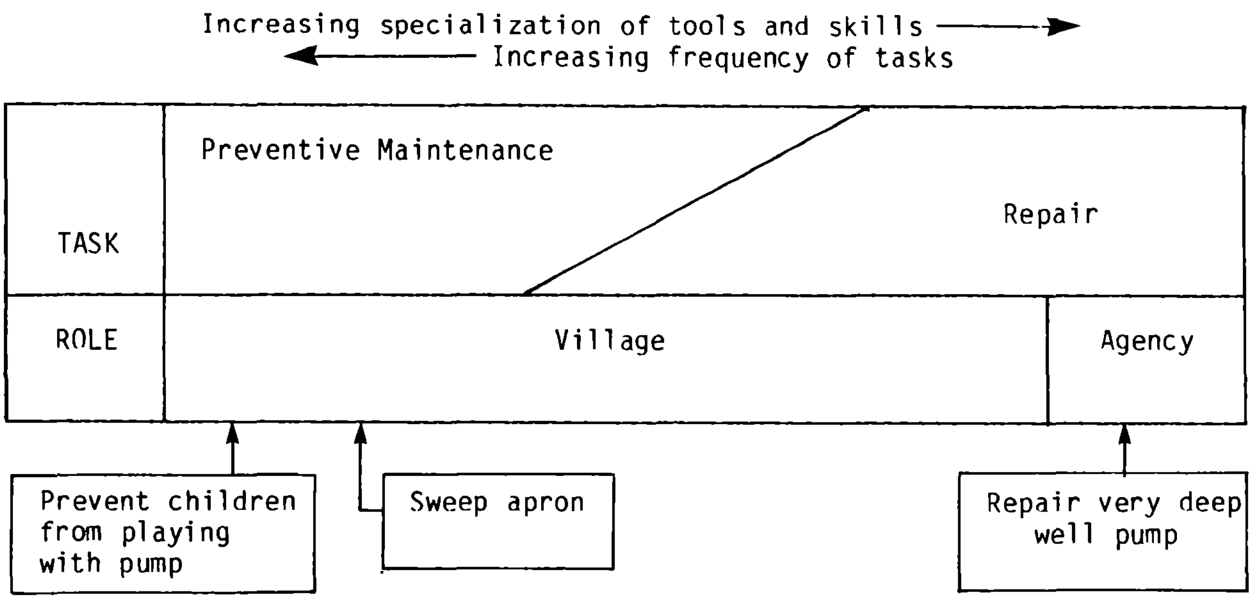
2. identify a good trainer

OVERVIEW

A goal of village-based development is to make villagers as self-reliant as they can and want to be. There are many handpump maintenance and repair tasks within their capability provided the necessary tools and supplies are available and that the villagers are well trained. This session addresses villager training, notably the caretaker of the pump(s).

The division of the maintenance and repair tasks between the village and the water supply agency can be pictured from the chart below.

Division of Maintenance Roles



Notice that the necessity for specialized tools or skills increases to the right of center. Typically, the frequency of the task increases toward the left. An example of a far-right task is the repair of a very deep well pump where a block and tackle or a tripod and pulley are required. A far left task is sweeping the apron or preventing children from playing with the pump.

A goal of village-based maintenance and repair programs is to expand the role of the village as far as possible to the right without lessening the effectiveness of the program. This should result in a raise of the confidence and self assuredness, and shifts the responsibility for maintenance and repair to the users--those most affected when the pump is out of service.

This session focuses on techniques for training caretakers. It follows the sessions that cover the skills a caretaker must learn. It comes after those sessions because a trainer cannot teach a skill effectively before he/she is able to do it. During this session the major steps will be:

- to determine what tasks caretakers perform and in what area they must therefore receive training
- brainstorm caretaker training techniques
- practice training techniques
- discuss, generalize, and apply important points and ideas learned in the practice sessions

In practice, caretaker training can be very informal. If possible, the extension worker should involve the caretaker in the project during project feasibility assessment. If the caretaker is involved in the early stages of the project, he/she will learn firsthand about the project criteria and reasons behind them. Early involvement will help explain why sources of contamination cannot be allowed near a handpump site after installation, for example. Later, the caretaker can assist in pump installation and learn the steps of the task. At this time, the extension worker may train the caretaker in maintenance and repair.

The practice training activity will be done using pumps and tools. See Trainer Note 1 for how to set up the activity.

PROCEDURE

1. Introduction — Time: 10 min.

Develop an introduction to the session from the material in the overview which includes the following points:

- session objectives
- why caretakers should be trained
- how the session relates to the project cycle and the workshop schedule
- main steps of session

2. <u>Lecturette: Operation and Maintenance: Training and Appointment of Local Persons</u>

Time: 15 min.

Develop a lecturette from the following points:

- The following lecturette is focused on a maintenance approach that utilizes village caretakers. As discussed in Session 12 there are many different ways of providing maintenance capability. With increased village responsibility and involvement in the handpump project as a goal, the development of a village-based maintenance capability is important. The object of training in this approach is to develop that capability.

- When compared to others, water agencies sometimes appear to overemphasise self-help labor. Too little attention, however, has been paid to training and appropriate support of community members for the operation and maintenance of the water supply systems.

- Precise allocation of responsibility is of the greatest importance. Unless it is very clear who is responsible for preventive maintenance, organizing a work party to repair a cracked apron, or to take the initiative in carrying out a repair to the pump, it is very likely that these tasks will remain undone--at least until the pump or well site breaks down completely. The well-known principle that a responsibility shared is a responsibility diminished (each person tends to wait for another to take the action required, and when others are inactive, to follow that lead and take no action himself) applies here. In some communities, there is also a reluctance to take on a leadership function, unless one is a recognised leader, such as chief or priest. If these formal leaders do not take up the task, others may fear criticism for doing so.

- It follows that it will be necessary to identify publicly one individual as primarily responsible for the water supply, or where the responsibility is divided, to make it clear who has which duties and rights (the right, for example, to call for assistance).

  The individual(s) should also have the authority within the community structure to suggest action when it is needed.

- There is also a need for training given by the water agency--practical training, which prepares the person(s) responsible to carry out all required tasks. Often this training is done by the extension workers of the water agency as they carry out their daily functions such as conducting an assessment for project feasibility or installing the pump.

- Following initial training, there may be a need for supervisory visits by a professional maintenance team. Each visit may be seen as an occasion for further training in preventive maintenance tasks, and if the training goes smoothly it should be possible for the visits to be reduced. Attention has to be paid to ensure that the caretaker takes adequate account of early trouble signs, has sufficient tools, can obtain spare parts, and can otherwise remedy a potential problem before there is a breakdown.

- Post the flipchart "Division of Maintenance Roles."

  Maintenance tasks done frequently, such as sweeping the apron or lubricating the pump, appear on the left hand side of the chart. These tasks can usually be handled easily by the village. The repair of a deep well pump which requires specialized tasks and skills, such as the use of a tripod and pulley, appear on the right hand side of the chart. A given maintenance program falls somewhere on the continuum of roles. The greater the ability of the village to carry out maintenance and repair, due to improved skills and increased accessibility to specialized tools, the greater the village role can be. Shown on the chart is the highly developed village maintenance and repair capability that can carry out all but the most complex maintenance and repair tasks.

- Because a goal is to increase village responsibility and involvement in the handpump project, the selection of village caretakers is important. The appointment of a local person to be in charge of operation and maintenance might involve the following steps:

  - to decide whether the caretaker should be a man or a woman, whether more than one person should be trained, and whether the functions should be combined with related work (in consultation with the community)

  - decide to whom he or she will be responsible

  - settle the salary or other form of compensation, including the time during training

  - select the individual(s) in consultation with the community

  - arrange initial training which might be combined with more general training, in health and health education, in sanitation, or in mechanical skills

  - arrange subsequent on-the-job training and supervision

  - provide adequate tools, materials, and spare parts required for preventive maintenance and minor repairs

  - ensure that there is a mechanism for resolving any difficulties arising over compensation, assistance, repairs, etc.

3. Reviewing Caretaker Tasks Time: 20 min.

Post on flipchart Handout 12-3: Possible Caretaker Tasks. Begin the discussion by asking:

- What kind of caretaker training is currently being done in your region/area/country?

- Which of these tasks are being done by villagers?

- Are there any tasks that could be added to make the villagers more self-reliant and less dependent on outside expertise?

- What would have to happen to make more self-reliance possible? (Refer to the chart, "Division of Maintenance Roles," when asking the last two questions.)

Note: Some of task can be performed by the caretaker only if the proper tools and training are given or provided. Whenever the participants suggest such a task as if expecting the caretaker to do this task make sure the task is reasonable given the constraints of the water program and the community resources.

4. Brainstorm: Characteristics of a Good Trainer   Time: 10 min.

A) Ask the participants to think about all the workshop sessions and write down which trainer characteristics helped them learn. After several minutes, list what most helped them on flipchart paper or a blackboard. Post the list on the wall. The list should include, or be expanded to include, the following:

Characteristics of a Good Trainer

- shows enthusiasm
- relates the subject to everyday life and the participant's experience
- encourages participation
- speaks and writes clearly
- speaks in words the participant understands
- gives examples and tells stories to illustrate ideas and concepts
- treats participant as equal
- knows subject adequately
- responds to participant errors with positive criticism, patience, and encouragement
- provides plenty of practical experience as a part of training
- leaves out what is not important or too detailed
- trains using methods that participants can use to train others

B) Go over the list talking about how this list applies to caretaker training (i.e. Why would "encouraging participation" be important in training a caretaker?).

5. Practice Training Session   Time: 1 hour

A) Give the following instructions to the participants and post them on flip chart paper. See Trainer Note 1 for the equipment necessary to set up for the practice training session:

  - During the practice training session you will be both trainer and caretaker. Choose one task from the list of possible caretaker tasks and show how you will train the caretaker (30 min.).

- Then divide into pairs of trainer and caretaker. Choose someone near you to be your partner. The trainer trains the caretaker in the task (10 min.). The caretaker should play the role of a village person unfamiliar with the task and the equipment.

- The caretaker gives feedback to the trainer using the list of good trainer characteristics as a guide (5 min.).

- Switch roles after receiving feedback and repeat the above.

- Develop any teaching aids or visual aids during the preparation period and pick up the tools or equipment you need.

B) Tell the participants to begin. Keep track of time and let the participants know when it is time to plan, train, give feedback and switch roles.

6. <u>Discussing the Practice Session</u> Time: 20 min.

Ask the participants the following questions:

- What was the most important information you received?

- How did it feel to be a trainer?

- What do you think will be the most difficult task to train caretakers?

7. <u>Generalizing from the Practice Sessions</u> Time: 10 min.

Refer to the list "Characteristics of a Good Trainer" and ask "What other characteristics of a good trainer should be added to the list based on your experiences from the practice session?" List the characteristics on the flip-chart with the others.

8. <u>Application: Improving Your Training Skills</u> Time: 10 min.

Refer the participants to the list of good trainer characteristics. Ask them to tell a friend the characteristics or skills on the list in which they feel they are strongest. Then ask them to think for a few minutes about what steps they will need to take to improve their skills. Have them list the steps in their notebooks.

9. <u>Closure</u> Time: 5 min.

Review objectives and ask what additional steps are necessary before participants will be able to train caretakers in the tasks given in this session.

MATERIALS

1. See the list of small group activity supplies in Section 1.8 of the main introduction for the pumps, barrels and accessories needed in this session. After the participants have selected the tasks in which they will train a caretaker, they can check out the necessary tools from the store room.

2. Flipchart paper

3. Marker pens

4. Tape

5. Flipchart prepared beforehand for:
   - session objectives (step #1)
   - division of maintenance roles (step #2)
   - possible caretaker tasks (step #3)
   - instructions for the practice training session (step #5)

TRAINER NOTE

The practice training sessions will be done using pumps and tools. See the list of small group activity supplies in Section 1.8 of the Introduction for pumps, barrels, and accessories that need to be set out before the session begins. The participants, once they have chosen the tasks in which they will train the caretaker, can check out the tools they will need from the store room.

SYNOPSIS OF SESSION 14: Developing a Project Cost Estimate and Construction Work Plan

Total Time: 4 Hours 15 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Lecturette/Discussion: Background Information Needed for Preparing the Cost Estimate	Questions and Discussion	25 Min.		
Large Group Task: Estimating the Cost of Lining the Well	Large Group goes through steps for calculating material quantities and cost for lining well.	45 Min.	Handout 14-1: Calculating Material Quantities	Well measurements and unit costs
Individual Task: Estimating the Total Cost of Constructing the Apron, Finishing the Site, and Installing the Handpump	Individuals calculate cost of materials for the well site he/she worked on	45 Min.	Handout 14-2: Construction Tasks Handout 14-3: Cost Estimate Sheets	Task instruction Apron dimensions, other site measurements Per unit material costs
Large Group Discussion: Comparing Cost Estimates and Adding Tools and Labor	Discuss differences in figures and answer questions. Discuss labor and tool costs.	20 Min.		Chart for comparing figures
Large Group Discussion: Operational Costs	Discussion of life cycle costs	15 Min.		
Lecturette: What is a Construction Work Plan	Lecturette	5 Min.		
Large Group Discussion: Delays in Work Plan	Generate list of delays	10 Min.		

SYNOPSIS OF SESSION 14: Developing a Project Cost Estimate and Construction Work Plan (Cont'd)

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Small Group Activity: Making a Work Plan	Small groups develop work plan	45 Min.	Handout 14-4: Work Plan Guide Handout 14-5: Planning Chart	
Discussing the Work Plan	Each plan is critiqued	30 Min.		Discussion Questions
Closure	Review learnings and session objectives	10 Min.	Handout 14-6: Desirable Tool and Material Qualities	

Session 14: Developing a Project Cost Estimate and Construction Work Plan

Total Time: 4 hours 15 min.

OBJECTIVES

By the end of this session the participants will be able to:

1. prepare a cost estimate for the handpump project
2. develop a construction work plan for the project

OVERVIEW

In order to complete the project construction smoothly and quickly, the village leadership and the sponsoring water agency together have to make decisions about the best way to implement the handpump project; the well improvements have to be agreed upon and designed; costs must be estimated; materials have to be ordered; and labor must be recruited and/or hired. The project plan is an instrument by which activities are organized, completion time is estimated, responsibilities assigned, and completion dates are set.

This session is concerned with two critical elements of the overall project plan: the project cost estimate and the construction work plan. A project cost estimate is prepared so that the cost of the project can be anticipated by the water agency and by the village where the project will be located. The water agency and the village can then evaluate the project by cost. It should be noted, however, that considerable preparatory work is done prior to the cost estimate, such as discussing the financial obligations of the village with village leaders, deciding the apron design (if negotiable within the water agency guidelines), and discussing other construction and site options with the village. This preparatory work was discussed in Session 6: "Preparing for Conducting Initial Village Assessment for Project Feasibility."

The construction work plan is an instrument by which the activities necessary to prepare for and implement the construction tasks are organized. Included in the construction work plan is an estimated activity completion time, an indication of the person responsible for each activity, and the target completion dates.

The construction sessions normally follow the development of the work plan, but for the purpose of allowing the concrete to cure, the construction sessions were scheduled earlier in the workshop.

This session deals with cost estimating and preparing a work plan for lining a well, constructing and finishing the apron, and installing the pump. The handouts and Step 3 of the session should be reviewed in advance of the workshop and revised as necessary. The trainer must also prepare in advance to give the participants information about the physical dimensions of each well site and the unit cost of each material.

PROCEDURE

1. Introduction Time: 5 min.

Give the session objectives and develop an introduction from the overview which includes the following points:

- the reasons for preparing a project cost estimate and construction work plan

- how this session relates to the project cycle and the workshop schedule

- main steps of the session

2. Lecturette/Discussion: Background Information Needed for Preparing the Cost Estimate Time: 25 min.

A) Ask the participants the following questions regarding the steps leading to developing a cost estimate:

- Based on the assessment for project feasibility that you conducted in the village (Session 7), what design decisions will have to be made before a cost estimate can be prepared? What design alternatives are available to the village?

  Note: Some water agencies may allow several alternative designs from which the village can choose (size of apron, materials, etc.) while others have only one standard design. Usually the village does (or should) decide in which direction the apron should be sloped and where the waste water should flow (garden, ditch, sump).

- What are the implications for costs of these decisions? For other variables (such as user acceptance)?

B) Tell participants that a cost estimate will be developed for the training program's two handpump sites. They already know a fair amount about the materials, tools, and the labor needed because they have completed two sites.

3. Large Group Task: Estimating the Cost of Lining the Well Time: 45 min.

A) When only drilled wells are being covered in the workshop, change this step to "Estimating the Cost of Constructing the Apron and Finishing the Well" (see Trainer Note 1).

B) Tell participants that they will start out the cost estimate by calculating the cost of relining one of the two project wells. Since the participants did not get hands-on experience in well lining, this is a good time to introduce those steps.

Materials Needed	Unit Cost	Quantity	Total Cost
		Total Cost for Relining =	

C) Ask participants what steps are involved in lining a well. Provide the following list if participants cannot give them (write on flipchart paper):

- prepare well for lining
- excavate walls to desired diameter
- cut and place reinforcing
- place forms
- pour lining
- remove forms and finish rough concrete
- remove debris from well

D) Ask participants what materials will be needed to accomplish the necessary steps. List should include the following:

cement
sand
gravel
reinforcing bars
tying wire
forms (wood or metal)
nails (wooden forms)

E) Ask participants which measurements of the well will be needed to calculate the quantities of materials. The measurements needed are:

depth to which lining will be poured
diameter of well
thicknesss of lining

F) Provide the above measurements for the two well sites.

G) Give participants the unit costs for the materials needed. For example:

1 bag of cement
1 cubic meter of sand
1 kilo of tying wire
1 length of drop pipe

H) Ask participants to calculate the total cost of materials to reline the well site he/she worked on. Use the format below presented on flipchart paper. Pass out Handout 14-1: Calculating Material Quantities to help them with their calculations.

I) Ask participants to give their calculations of the total cost of relining the well site each worked on. Record answers for each well site on flipchart paper. Discuss any major differences in the calculations for a particular well site.

4. Individual Task: Estimating the Total Cost of Constructing the Apron, Finishing the Site and Installing the Handpump

Time: 45 min.

A) Tell participants they should each attempt to calculate only the cost of materials for completing the well site worked on. They will be calculating the total cost of materials for:

- constructing the apron and finishing the site
- installing the handpump

Once each participant has arrived at his/her calculation, have them share and compare answers.

B) Give participants the following data about each well site:

- diameter or width of apron
- diameter of well
- thickness of the concrete
- length, width, and materials of the drain
- size and materials for the sump (dry well)
- depth at which the pump cylinder or end of the suction pipe will be installed

C) Explain the following in your own words: Once the alternatives have been explored and design decisions have been made by the extension worker and the village, we are ready to develop the cost estimate. Assume that we are now at that point. We know the shape and size of the apron and drain, the depth to the water table and of the well, and the type and diameter of the well.

D) Give participants the per unit cost for the following materials used (substitute as needed):

cement
sand

gravel
anchor bolts
form material
nails
string
reinforcing bar (dug well)
tying wire (dug well)
planking and joints (dug well)
straw, burlap
pipe section (dug well)
concrete blocks
drop pipe (deep well: 3 or 6 meter sections)
plunger rod (deep well: 3 or 6 meter sections)
pipe connectors (deep well)
rod connectors (deep well)
Teflon tape or pipe joint compound
suction pipe (shallow well)
PCV solvent (shallow well)
grease

E) Pass out Handouts 14-2: Construction Tasks and 14-3: Cost Estimate Sheet.

F) Give participants the following task to accomplish individually:

- Given the measurements for your well site and the per unit costs of all the materials we used, use Handout 14-1: Calculating Material Quantities to help you arrive at the total cost of the materials you used.

- Enter the costs on the cost estimate sheets. You will notice that tools and labor are included on the sheets. Calculate costs for materials only at this point.

5. Large Group Discussion: Comparing Cost Estimates and Adding Tools and Labor — Time: 20 min.

A) Prepare a flipchart like the one below. Ask each participant for his/her estimated cost for his/her well site and record the answers on the flipchart.

Well Site # 1	Estimated Total Cost	Well Site # 2	Estimated Total Cost
Team member # 1		Team member # 1	
# 2		# 2	
# 3		# 3	
etc.		etc.	

B) Discuss any major differences in figures and answer any questions.

C) Explain that the cost estimate is not complete until the cost of tools and labor are added. Direct participants to review the list of tools on each of the two cost estimate sheets and provide whatever information is available on the cost of the tools. Labor is often contributed by the village and is considered a part of its contribution. However, in some cases, labor may have to be purchased. Ask participants:

- Which materials, tools, and labor could be provided by the village? By the water agency?
- How would you go about insuring and that you are using the lowest cost source for procuring materials?
- What role could the village play in arriving at this cost estimate?
- Who has to make decisions about whether or not to proceed based on the cost estimate?

Explain that once the additional costs for labor and tools are determined that these costs can be summed up and added to the estimated total cost of the well.

6. <u>Large Group Discussion: Operational Costs</u> Time: 15 min.

A) Begin the discussion by saying "We now have a cost estimate for the initial expenses of constructing the apron through installing the pump. As time goes on, however, the pump will need maintenance, such as lubrication, and will need repairs, such as replacing the cups. The cost of the grease for lubrication and of the new cups and labor for changing them are called operational costs. (List grease, cups and labor on a flipchart or blackboard.) What are some other examples of operational cost?"

For instance: other spare parts
disinfectant
replacement tools
concrete and mortar to fix cracks in apron
bus fare into town to tell repair crew to come fix the pump

B) List the responses on flipchart paper or a blackboard then ask "Which of these items would have the greatest impact on the village (i.e. which operational costs would the village incur both in terms of money and donated time, labor, etc.)?

C) Conclude the discussion by saying "The actual total cost of the project is not just the initial cost but the sum of the initial and operational costs. This total is usually called the life-cycle cost. Since it is the village people who usually pay most of the operational costs, it is important that the apron construction, handpump installation, and caretaker training be done properly to reduce costs."

7. <u>Lecturette: What is a Construction Work Plan</u> Time: 5 min.

Make the following points:

- The work plan that will be developed is for the construction activities. These are the activities on the construction line chart. Post the line chart. The work plan is primarily for the extension worker to coordinate his activities with the village and his agency so that the materials, tools, labor, and village will be ready for construction on the same day, and so that a schedule can be developed that can serve as a guide for the completion of the activities.

- A work plan is developed from the tasks to be done. The activities are constructing the apron, finishing the site, and installing the pump. Each of the activities can be completed in one day or less. However, at least three days must be allowed between constructing the apron and finishing the site to allow the apron to cure.

- The next step in developing the work plan is to determine what must happen so the materials, tools, and labor as well as the villagers will be ready before construction begins. What must happen before construction begins will be determined in the next small group activity.

- The third step of the work plan is to put all that must happen in chronological order, assign estimated times to each activity, determine who is responsible for seeing that it gets done, and set a date by which the activity is to be completed. To determine who is responsible and set completion dates should be done with the village leaders.

8. <u>Large Group Discussion: Delays in the Work Plan</u> Time: 10 min.

A) Ask the participants the following question:

What are the potential bottlenecks or delays that could affect the construction work plan?

Answers may include:

strikes (material, labor, transportation)
vacations and holidays
season (rainy, harvest, planting)
animosity, tension, fear between villagers and government agents
internal village tensions, disputes, factionalism
tendency of villagers to say "yes" to outsiders when they really mean "no"

B) Write the answers on flipchart paper or a blackboard. Explain that the list will be used in the following group activity.

9. Small Group Activity: Making a Work Plan Time: 45 min.

A) Pass out Handouts 14-4: Work Plan Guide and 14-5: Planning Chart. Give the participants several minutes to read the guide and familiarize themselves with the chart.

B) Divide participants into groups of three or four (or regional groupings may be appropriate) and give the following instructions:

- For the purpose of the activity, assume it requires one day to complete each of the construction tasks on the line chart. Allow three days between constructing the apron and finishing the site.
- Use the "Work Plan Guide" to develop a chronological list of activities related to the construction phase that must occur before construction begins and enter the list on the planning chart. Then add the actual construction tasks.
- Assume that the first construction task is to begin one month from today.
- You have 30 minutes to complete this task.

10. Discussing the Work Plan Time: 30 min.

Have the groups form pairs and discuss their work plans with one another. Also post the following points to be discussed later between the groups:

- Are all the preparation activities included?
- Are the completion dates reasonable?
- Does each preparatory activity have someone responsible for it?
- Are the persons responsible the most appropriate people?
- Is there any need to revise the completion dates based on the current time of year or country situation? (See list of bottlenecks and delays.)

11. Closure Time: 10 min.

A) Give the participants a few minutes to write down what they want to remember from this session.

B) Review the session objectives to see that they have been met.

C) Pass out Handout 14-6: Desirable Tool and Material Qualities.

MATERIALS

1. Handout 14-1: Calculating Material Quantities
2. Handout 14-2: Construction Tasks
3. Handout 14-3: Cost Estimate Sheets
4. Handout 14-4: Work Plan Guide
5. Handout 14-5: Construction Planning Chart
6. Handout 14-6: Desirable Tool and Material Qualities
7. Flipchart paper
8. Marker pens
9. Tape
10. Prepared flipcharts for:
    - session objectives
    - relining cost estimate (Step 3/G)
    - apron dimensions, other site measurements (Step 4/B)
    - per unit material costs (Step 4/D)
    - large group discussion (Step 5/A)
    - discussion questions (Step 10)

TRAINER NOTES

1. When only drilled wells are discussed in the workshop Step 3 should be modified to cover estimating the cost of constructing the apron and finishing the well or of installing the pump. To modify Step 3, replace the relining steps (Step 3b), materials (Step 3c), and measurements (Step 3d) with the appropriate steps taken from Handout 14-2: Construction Tasks and Handout 14-1: Calculating Material Quantities.

Calculating Material Quantities

A. Calculating the volume of concrete needed for the lining.

1. Determine the thickness, the length and the perimeter of the lining.

2. Use the following approximation to determine the volume of concrete needed for the lining:

   Thickness x Length x Perimeter = Volume (approx.)

B. Finding material requirements for concreting the lining.

1. Refer to the table, "Lining Concrete Material Quantities." The table assumes a 1:2.5:5 concrete mix. The numbers mean that one bucket of cement is mixed with two and one half buckets of sand and five buckets of gravel to make the concrete mixture.

2. Using the table:

   a. Find the volume of the lining calculated in step A.2 above on the left hand side of the table.

   b. Read the required number of leters of cement, sand and gravel from the table.

   c. When the total amount of cement needed to line the well, pour the apron, plaster the apron sides and construct the drain is known, convert the number of liters of cement to bags of cement using the table, "Cement Conversion: Liters to Number of Bags."

C. Determining apron size

1. Follow the standards established by the sponsoring water agency, or, if none exists,

2. Follow the widely accepted standard that the apron should extend 1-1/2 meters beyond the edge of the well and that the drain should be 5 meters in length.

D. Finding material requirement for concrete

1. Refer to the table, "Apron Concrete Material Quantities." The table assumes a 1:2:3 concrete mix and a 10 cm thick apron slab. The numbers 1:2:3 mean that one bucket of cement is mixed with two buckets of sand and three of gravel to form the concrete mixture. Both the concrete mixture and the apron thickness are recommended for a durable apron.

2. Using the table:

   a. If the shape of the apron will be round, use the upper half of the table which has a circle beside it. If the apron will be square use the lower half of the table with the square beside it.

   b. Find the diameter or width (length of the side) of the apron on the table.

   c. Read the number of liters of cement, sand and gravel required from the table.

   d. When the total amount of cement needed to line the well, pour the apron, plaster the apron sides, and construct the drain is known, convert the number of liters of cement to bags of cement using the table, "Cement conversion: Liters to Number of Bags."

E. Finding the size and quantity of rebar required for dug wells.

1. For drilled wells, the use of reinforcement is optional. Reinforcement should be used when the soil under the apron is soft or recently tamped e.g., when a substantive fill is used to raise the ground level around the well.

   Reinforcement suggested for drilled wells is a steel fabric mesh whose members are 3 to 6 mm (1/8 to 1/4 m) in diameter spaced on 7.5 to 10 cm (3 to 4 in) centers. The mesh should be placed roughly in the middle of apron slab (5 cm from top or bottom) and extend to the perimeter of the apron. For a 3-meter square apron, approximately 9 square meters of fabric mesh will be required.

2. For dug wells, reinforcement is need in the concrete that spans the well. For most hand dug wells 10 mm (3/8 in) rebar on 15 cm (6 in) centers will be sufficient for normal maximum loadings. Above 1 1/2 or 2-meter diameter wells, the reinforcing material and diameters should be calculated for each well.

   When the slab covering the well opening is raised above the apron, the rebar should be extended to within 3-5 cm (1-2 in) of the outer edge of the slab. When the slab covering the well opening is construceted as an integral part of the apron, the rebar should be extended 30-50 cm (12-18 in) beyond the edge of the well opening.

   To use the "Rebar Quantities" chart, find the longest length of rebar needed to span the well in the left column. The right column gives the total amount of rebar needed for that well.

3. The lining of a well should be reinforced with 10 mm (3/8 in.) rebar. Usually the rebar is on 30 to 50 cm (12-18 in) centers. To find the quantity of rebar, add the number of vertical and

horizontal rebars used and multiply them by their length. For vertical rebar, the length is roughly that of the lining depth. For horizontal rebar, the length is the perimeter of the well.

F. Finding form requirements

1. Measure the perimeter of the apron and of any other structures requiring forms (eg. pump pedestal, if used).

2. Add all the perimeters and select enough form material (wood, brick, metal, etc.) to make the apron. See handout on constructing the apron which was passed out in Session 5 for an example of using wooden forms to form the apron.

G. Finding plaster and mortar requirements for the apron and drain

Total quantities of sand and cement used to plaster the apron and mortar the drain is small but not negligible. A fixed quantity of 40 liters of cement and 80 liters of sand should be alloted to make sure there is enough.

H. Finding the quantity of gravel to be spread around site

Gravel is needed around the well site so it won't become muddy. Estimate the gravel requirements at 250 liters of gravel for each meter of the apron's diameter or width. Note: There may be design alternatives available to keep the apron site from becoming muddy.

I. Finding brick or concrete block requirements for the drain

Bricks or concrete blocks are usually used to make the drain. To find the number of blocks or bricks needed, divide the length of the drain by the length of the blocks. This is the number required for one side. The drain has two sides so multiply by 2.

J. Finding the number of sections of plunger rod and drop pipe (or suction pipe) for installing the pump

The drop pipe and plunger rod will be cut to length during installation. At this time, it is necessary only to determine the sufficient quantity of pipe and rod to be procured. The length depends on several factors which are discussed in Session 11. For example, if the cylinder is to be installed 15 meters deep, it is necessary to procure at least 15 meters of pipe and rod. If the pipe and rod are available in six meter sections, three sections of both drop pipe and plunger rod will be needed.

"Lining Concrete Material Quantities"

(Based on 1:2.5:5 mix)

Volume of Lining (cubic meters)	Cement (liters)	Sand (liters)	Gravel (liters)
.20	37	91	184
.40	74	184	368
.60	110	276	552
.80	147	368	736
1.0	184	460	920
1.2	221	552	1104
1.4	258	644	1288
1.6	294	736	1472
1.8	331	828	1656
2.0	368	920	1840

Apron Concrete Material Quantities

(Based on a 1:2:3 mix)

Apron Diameter (meters)	Cement (liters)	Sand (liters)	Gravel (liters)
2.0	70	140	210
2.5	110	220	330
3.0	160	320	480
3.5	215	430	650
4.0	280	560	850
4.5	360	720	1,100
5.0	440	880	1,300
5.5	550	1,100	1,600
6.0	650	1,300	1,900

Side of Apron (meters)	Cement (liters)	Sand (liters)	Gravel (liters)
2.0	90	180	270
2.5	140	280	420
3.0	200	400	610
3.5	225	550	830
4.0	360	720	1,100
4.5	455	910	1,400
5.0	550	1,100	1,700
5.5	700	1,400	2,000
6.0	800	1,600	2,400

Cement Conversion: Liters to Number of Bags

Liters	Bags of Cement
0 - 33	1
34 - 66	2
67 - 99	3
100 - 133	4
134 - 166	5
167 - 199	6
200 - 232	7
233 - 266	8
267 - 299	9
300 - 332	10
333 - 365	11
366 - 398	12
399 - 432	13
433 - 465	14
466 - 498	15
499 - 531	16
532 - 564	17
565 - 598	18
599 - 631	19
632 - 664	20
665 - 697	21
698 - 730	22
731 - 764	23
765 - 797	24
798 - 830	25
831 - 863	26
864 - 896	27

Re-bar Quantities for Dug Well Cover Slab

Length of Longest Re-bar (meters)	Total Quantity of Re-bar Rquired* (meters)
1	11
1.2	15
1.4	20
1.6	27
1.8	33
2.0	40
2.2	51

*Based on re-bar spacing of 15 cm (6 in) on center

Construction Tasks

Name of Village: ____________________ Name of Well: ____________________

Diameter of Well: ____________________ Diameter or Width of Apron: _______

Depth to Cylinder: ____________________

Place a check next to construction tasks to be undertaken and add steps as needed:

Lining the Well

______________ prepare well for lining

______________ excavate walls to desire diameter

______________ cut and place reinforcing

______________ place forms

______________ pour lining

______________ remove forms and finish rough concrete

______________ remove debris from well

Constructing the Apron

______________ clear and level apron site

______________ measure and cut form material

______________ assemble forms

______________ cut and place planking over well opening (Dug Well)

______________ locate and place pipe section and access hatch forms (Dug Well)

______________ cut hole under pipe section (Dug Well)

______________ place apron forms

______________ cut, place and tie rebar (Dug Well)

_____________ place anchor bolts

_____________ mix and place concrete

_____________ construct access hatch cover (Dug Well)

_____________ cover concrete for curing

Finishing the Site

_____________ remove forms from apron (if removable)

_____________ cut hole in planking for access hatch and place-access hatch form (Dug Well)

_____________ plaster newly exposed apron surfaces

_____________ dig drainage ditch and sump

_____________ lay drain

_____________ fill sump with gravel and cover with clay

_____________ grade area around apron, drain low spots

_____________ spread gravel around apron

Installing the Pump (Shallow Well)

_____________ cut suction pipe to length

_____________ glue adapter to end

_____________ place suction pipe in well

_____________ attach suction pipe to pump

_____________ bolt pump to apron

_____________ test the pump

Installing the Pump (Deep Well)

_____________ cut drop pipe to length and thread

_____________ install cylinder, drop pipe and plunger rod to desired depth

_____________ attach drop pipe to base

_____________ cut rod to length and thread

_____________ attach cap to rod and body

_____________ bolt pump to apron

_____________ test the pump

COST ESTIMATE SHEET FOR LINING THE WELL

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Cement				
Sand				
Gravel				
Reinforcing bars				
Tying wire				
Forms (wood or metal)				
Nails (wood forms)				
Tools				
Hammer	1			
Screed	1			
Trowel	1			
Shovel	2			
Bucket	2			
Pick/Maddox	1			
Tape measure	1			
Wire brush	1			
Wire cutter	1			
Hack saw				
Pliers				
Labor				
Skilled mason	1			
Unskilled worker	2			
Subtotal for Construction task				

Handout 14-3, p. 1

COST ESTIMATE SHEET FOR CONSTRUCTING THE APRON AND FINISHING THE SITE

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Cement				
Sand				
Gravel				
Anchor bolts				
Form material				
Nails (for wooden forms)				
String				
Reinforcing bars (Dug well)				
Tying wire (Dug well)				
Planking and Joints (Dug well)				
Straw, burlap				
Pipe section (Dug well)				
Tools				
Hammer	1			
Screed	1			
Trowel	1			
Shovel	2			
Bucket	2			
Wire brush (Dug well)	1			
Wood saw	1			
Square	1			
Pick/Maddox	1			
Tape measure	1			
Clear plastic hose or level	1			
Wire cuter (Dug well)	1			
Hack saw	1			
Keyhole saw (Dug well)	1			
Rebar bender (Dug well)	1			
Marker	1			
Pliers (Dug well)	1			
Labor				
Skilled mason	1			
Unskilled worker	2			
Subtotal for construction task				

COST ESTIMATE SHEET FOR INSTALLING THE PUMP

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Drop Pipe (DW) 6-meter sections)				
Plunger Rod (DW) (6-meter sections)				
Pipe connectors (DW)				
Rod connectors (DW)				
Teflon tape				
Suction Pipe (SW)				
PVC solvent (SW)				
Grease				
Tools				
Strap wrench	1			
Pipe wrench (8-10 cm grip) (DW)	1			
Adjustable wrench	2			
Tape Measure	1			
Pipe clamp (DW)	1			
Hack saw	1			
Wire brush	1			
Pipe wrench (5-6 cm grip) (SW)	1			
Pipe threader for plunger rod (DW)	1			
Pipe threader for drop pipe (DW)	1			
Pliers	1			
Punch	1			
Hammer	1			
Tripod (DW)	1			
	1			
Pulley (or block and tackle) (DW)	1			
Heavy rope (DW)	1			
Labor				
Skilled pipe fitter	1			
Unskilled worker	2 (minimum)			
DW - Deep well pumps only SW - Shallow well pumps only				
Subtotal for Cosntruction Task				
Total Construction Cost Estimate				

WORK PLAN GUIDE

Materials:

What must happen so that all the materials will be ready for the day construction begins:

Examples of tasks:

- determine what materials are available locally (donated?)
- determine what materials must be procured outside of village (purchased?)
- materials procured
- materials delivered

Tools:

What must happen so that all the tools will be available for the day construction begins?

Examples of tasks:

- determine what tools available locally or can be borrowed
- determine what tools must be purchased
- tools purchased/arrangements made to borrow
- tools brought to work site

Labor:

What must happen so that the needed labor is available for the day construction begins?

Examples of tasks:

- determine what skills are available locally and at what times i.e. village labor is dependent on harvest season, etc. and on festivals and holidays
- determine what skills must be brought to the village
- arrange work date and method of payment

Villagers:

What must happen so that the villagers who use the well will have safe water during the construction period?

Examples of tasks:

- inform users of impending construction
- locate alternative sources of drinking water
- communicate which days construction will be

CONSTRUCTION PLANNING CHART

ACTIVITY	TIME TO COMPLETE ACTIVITY	RESPONSIBILITY	TARGET COMPLETION DATE

Handout 14-5

Desirable Tool and Material Qualities

The following is a summary of desirable qualities of tools and materials to be procured for the handpump project. The use of higher quality tools and materials results in longer tool life and reduced maintenance requirements for the apron and pump installation.

A) Poor quality will result in shortened life and having to buy tools more often. What to look for in tools:

- forged steel (hardness, durability)
- large cross sections (strength)
- interchangeable teeth (when they wear out, buy new teeth not a new tool)
- brand with good reputation among craftsmen

B) Poor quality can result in cracking, etc. What to look for in materials:

- Cement: It should be dry, powdery and free of lumps. Lumpy cement should not be broken up and reused like sugar or salt. Store cement in a dry place away from exterior walls, off damp floors, and stacked close together to reduce air circulation. The covered storage time is limited to between six months and one year depending on conditions.
- Water: In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Use only enough water to make the concrete workable. Too much water will result in weaker concrete.
- Aggregates: Fine aggregates (sand) and coarse aggregates (gravel) together occupy 60 to 80 percent of concrete volume.
  - Size: Sand should range in size from .25 mm to 6.3 mm. Sand from sea shores, dunes or river banks is usually too fine for normal mixes. The larger the size of the gravel, the less water and cement will be required to get the same strength concrete. The maximum gravel size should not exceed 2 cm.
  - Shape: The shape and surface texture of aggregates affect properties of freshly mixed concrete more than they affect hardened concrete. Rough textured or flat and elongated particles require more water to produce workable concrete than do rounded or cubical aggregates.

- Cleanliness: It is extremely important to have clean gravel and sand. Silt, clay, or bits of organic matter, even in low concentrations, may ruin concrete. A very simple test for cleanliness makes use of a clear widemouth jar. Fill the jar about half full of sand and small aggregate to be tested, and cover with water. Shake the mixture vigorously, and then allow it to stand for three hours. In almost every case, there will be a distinct line dividing the fine sand suitable for concrete and that which is too fine. If the very fine material amounts to more than 10 percent of the suitable material, the concrete made from it will be weak.

  Solution: Other sand should be sought, or the available material should be washed to remove the material that is too fine. This can be done by putting the sand (and gravel if necessary) in a container such as a drum. Cover the aggregate with water, stir thoroughly, let stand for a minute, and pour off the liquid. One or two treatments will remove most of the very fine material and organic matter.

• Galvanized Pipe: Use Schedule 40. Thinner pipe rusts through more rapidly resulting in a leak.
  - ends should not be crushed (have to rethread them)
  - galvanizing should not be scratched off (may rust through at this point)

• Plunger Rod: It should not be out of round (cannot be threaded) and not badly bent (will rub on pipe).

• PVC Pipe: Use PVC solvent to bond pipes (versus a glue which will allow the joint to crack in time).

SYNOPSIS OF SESSION 15: Developing and Implementing User Education Strategics

Total Time: 2 Hours
55 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Group Brainstorming	Group brainstorms skill and knowledge users must have	15 Min.		
Lecturette: User Education	Lecturette	15 Min.		
Small Group Work	Small groups identify strategies to train users and large group discusses.	45 Min.		Task Instructions
Preparing User Training/Education	Small groups prepare presentation	45 Min.	Handout 15-1: User Education Topics Handout 15-2: User Education Resource Material	Task Instructions
User Education Strategies Exercise	Small groups exchange strategies and critique	30 Min.		
Generalizing and Applying	Participants identify and record learnings	15 Min.		Task Instructions
Closure	Trainer summarizes and refers to session objectives	5 Min.		

Session 15: Developing and Implementing User Education Strategies

Total Time: 2 hours 55 min.

OBJECTIVES

At the end of the session, participant will be able to:

- identify the skills and knowledge handpump users should have
- identify effective ways of transmitting them
- present a strategy for conducting user education

OVERVIEW

Handpump users must have ultimate responsibility for making certain the handpump functions properly and, in fact, supplies safer, more convenient water. If this is to happen, users need to know and understand the basics of how to keep a handpump project functioning properly and how to keep their water supply safe.

This session is intended to help participants plan and implement appropriate user education strategies that will enable villagers to assume responsibility for ensuring an effective project and one that assures they achieve maximum benefit from the improved water source.

PROCEDURE

1. Introduction — Time: 5 min.

Present the information contained in the overview and review the session objectives.

2. Group Brainstorming — Time: 15 min.

A) Have the group brainstorm a list of skills and knowledge that users should have to effectively care for their handpump and drinking water. Put this list on a flipchart.

Note: It is important to encourage participants to be as specific as possible. Instead of just listing water handling and storage, encourage them to include what needs to be communicated about handling and storage. For example:

washing the bucket before collecting water
covering the bucket when transporting water
washing and covering the storage vessel
washing hands before giving water to children

You now have an opportunity to make sure all participants know the importance of sanitary practices and which ones need to be particularly stressed.

B) Ask the group to identify some strategies that could be used to get important information to the villagers. Put the list on a flipchart.

3. <u>Lecturette: User Education</u> Time: 15 min.

Make the following points adding any information about how user education is currently being conducted in this area/region/country:

- User education is distinctive from health education in that it focuses specifically on the skills and knowledge that the users of a handpump need in order to:
  - help them understand and practice improved methods of hygiene in order to maximize the benefits of the improved water supply
  - know what to do in case of problems with the water supply; for example, where to report and what to report if the water stops
  - know and understand the reasons for the rules and regulations governing the use of the handpump and how to correctly use it

- User education can occur informally from the initial point of entry into the village throughout the life of the project. A good extension worker is also a good teacher or trainer. Before the pump is installed, it is important to have developed a strategy to communicate the information, and teach the skills that users will need, so they may be able to practice them immediately. User education can be done in previously arranged public meetings, in short training sessions with smaller groups using methods such as discussion, talks and demonstration, and in follow-up on-the-spot discussions over the first months of the project. Informal education gives an opportunity to make a few points to an individual user, a small group of users, or a community in a spontaneous way.

- These informal, on-the-spot user education discussions usually occur in response to an observation on the part of the extension worker, caretaker, etc. or a problem voiced. Before giving advice about an observation or problem, it is important to find the reasons for the problem. To find out the reasons, it is advisable to ask a number of questions which will tell you the background of the problem.

- For example, if an extension worker finds a woman washing her clothes in the river after a handpump has been installed and immediately starts telling her how bad it is rather than let her explain why she is doing it, the extension worker may later find that his instructions have not changed the practice of the woman and have alienated her. If you remember our discussions about water diseases in Session 3, water-based diseases such as schistosomiasis can be contracted by entering infected water to bathe, wash clothes or swim. Water-related insect vector diseases, such as river blindness, malaria, and yellow fever, are transmitted by insects which breed in or near streams and rivers.

- Here are some ways in which this discussion might go:

  - Example #1

    Extension worker: Why are you washing clothes in the river?

    Woman: Because there is not enough water in the well?

    Extension worker: Why isn't there enough water?

    Woman: There never is late in the afternoon.

    Extension worker could talk about alternate ways to wash with safer water.

  - Example #2

    Extension worker: Why are you washing clothes in the river?

    Woman: Because I always have.

    Extension worker: Do you know the dangers of washing clothes in the river?

    Women: No, I don't.

  Extension worker could talk about the dangers of washing clothes in rivers.

- The women may have answered the question in many other ways. Some of these include:

  - Because the leaders do not allow me to use the tap for washing clothes.

  - Because washing in the river is easier. I have stones for washing on and there is plenty of water which I do not have to carry to the house in buckets.

  Each answer requires a different strategy on the part of the extension worker and provides an opportunity for user education and problem solving.

- The responsibility for user education can be that of the caretaker, the village health worker, the installation team, the extension agent, or another development worker. This varies from country to country depending upon the overall program structure. It is important, however, to think about developing a village capacity to conduct user education. This can result in early identification and resolution of situations and problems rather than relying on the not always frequent visits by extension workers and others not living in the village.

4. Small Group Work Time: 45 min.

A) Divide the group into groups of four. Have them discuss the following points and prepare to give their conclusions in summary format with the total group. Give them 15 minutes. Use a flipchart to present the instructions.

- With what strategies are you familiar to train users in the skills and knowledge they need to have?
- Which ones worked the best? Why?

B) Lead the total group in a discussion based on the discussion focus points:

- Ask each group for several examples of strategies they have used or have seen used.
- Ask which strategies work best and why.
- Ask the large group what kinds of methods and strategies were used in this workshop to promote learning. Would any of these be effective for use with the community?

This discussion should take no more than 30 minutes. Comment that training and education strategies that involve the learner in active ways such as discussions, planning or problem solving meetings and demonstrations, followed by practice, are all usually more effective than more passive roles for learners such as lectures and presentations.

5. Preparing User Training/Education Time: 45 min.

A) Divide participants into four groups and pass out Handouts 15-1: User Education Topics and 15-2: User Education Resource Material.

B) Give them this task (post on flipchart):

- You are a group responsible for the education of handpumps users at ______________________ (project site);
- Choose an area of user education (from Handout 15-1);
- Be prepared to present the following:

  what should be taught (be specific)
  how it should be taught
  to whom it should be taught
  who should teach it.

- You will have 10 minutes for your presentation.

C) When the 30 minutes are up, give the groups another five to eight minutes to prepare to describe their session to another group.

6. User Education Strategies Exercise Time: 30 min.

Have two small groups join together to exchange strategies. Two will be conducted simultaneously with one trainer in each group. Each team should take eight to ten minutes to describe its plan. Then the other group should take five to eight minutes to offer suggestions, comments, or advice on how it might be improved.

7. Generalizing and Applying Time: 15 min.

A) Write the following questions on a flipchart and ask them to think about them individually:

- What I feel are the essentials of an effective user education program.
- Some strategies I plan to use in my community to cover the essentials I have listed.

B) Suggest that they record the ideas in their notebooks.

8. Closure Time: 5 min.

Summarize, refer to the objectives, link to the next training activities and close the session.

MATERIALS

1. Handout 15-1: User Education Topics
2. Handout 15-2: User Education Resource Material
3. Flipchart paper
4. Marker pens
5. Tape
6. Flipcharts prepared for:
   - session objectives
   - small group task instructions (step 4)
   - small group task instructions (step 5)
   - generalyzing and applying instructions (step 7)

User Education Topics

A. Water and Your Life

- list/discuss uses for water
- most important use of water for people in your community
- kinds of water which can make people ill
- what happens when you drink water that is not clean
- who gets sick most often
- what you can do so that children don't get diarrhea often

B. Collecting, Storing, and Using Water

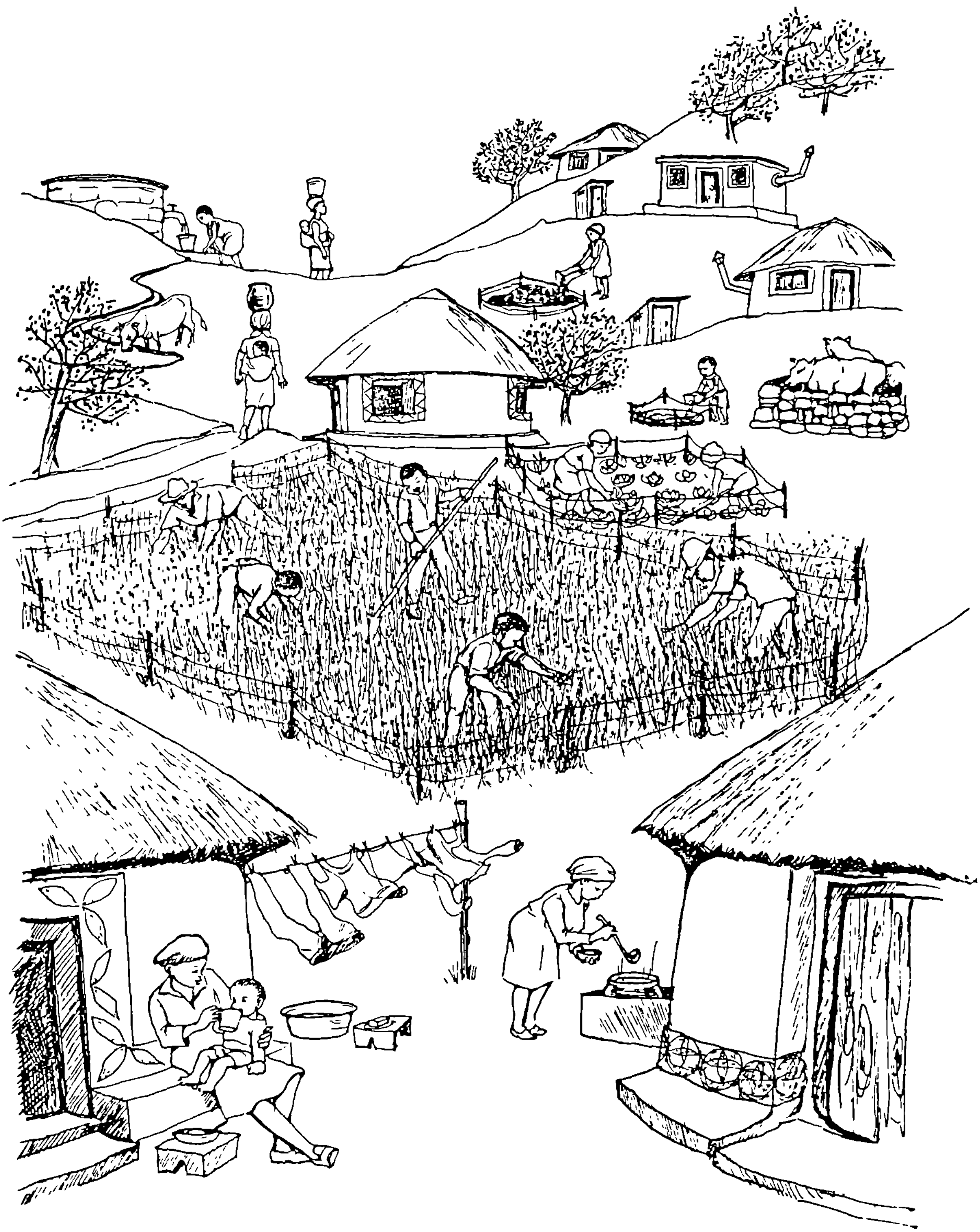
- sources of water people use in your community
- best sources for drinking water
- some communities have clean water but children still get diarrhea. Why?
- how people in your community collect water
- how people store water
- how water gets dirty
- some things a mother can do so that her child gets clean water

C. Using your New Handpump

- why a particular well is a source of clean water
- what needs to happen to keep water clean
- how the handpump can be protected from damage
- signs that could mean the handpump needs repairing
- to whom you should report repairs
- what needs to happen to maintain the handpump and site

USER EDUCATION RESOURCE MATERIAL

Many things help to keep you, your home, and the community healthy. You have already discussed some of these things. Now look at this picture of a community carefully.



Look at this picture of another community.

Is this a healthy community? What things that are good for health do you think are missing from this community?

____

____

____

____

Look at other pictures in the booklet, "Health Problems in the Community." You can use the pictures to discuss health problems in your community.

What is happening in the picture above? Do you see this in your community? Can this cause any health problems? What kind of health problems?

____

____

____

____

SESSION 1

Water and Your Life

Water is useful for everyone in many ways. People, animals, and plants cannot live without water. How many ways do people use water in your community?

List and discuss some of the uses of water in your community.

____

____

____

____

____

____

What is the most important use of water for people in your community?

____

____

Everyone needs water to drink. Without water to drink everyone would die. Water keeps people healthy. But some water can make people ill. What kind of water can make people in your community ill?

Water that is not clean can make people ill.

What happens when you drink water that is not clean?

____

____

____

Unclean water can give you belly trouble. You can get pains in your belly. You may get diarrhea. Sometimes you get ill soon after you drink unclean water. Sometimes you do not get ill until two or three days after you drink unclean water.

Who do you think gets sick most often from unclean water in your community?

Old people _____
Mothers _____
Fathers _____
Young children _____

Young children get diarrhea from unclean water most often in the community.

Why is this?

____

____

____

Young children get ill easily. Young children are not as strong as older persons. That is why young children get sick and have diarrhea more often than older persons.

Young children get diarrhea because they eat and drink from many sources. Children get diarrhea often when they eat food or drink water that is not clean. Older persons who drink the same unclean water do not get diarrhea as often. This is because older persons are stronger. Many children can die with diarrhea in the community.

What can you do in your community so children do not get diarrhea often?

____

____

____

____

SESSION 2

Collecting, Storing, and Using Water

In this session you will learn how water gets dirty. Look at these pictures. These pictures show different places people get water. What sources of water do people use in your community?

List and discuss which sources of water have the best water for drinking.

___

___

___

Some sources of water are clean and some are not. Some water looks clean but may not be clean, and can make people ill. Water that is not clean can cause diarrhea. Some communities have clean water, but children in the community still get diarrhea.

Why is this?

___

___

___

Water can get dirty after people collect the water. How do people in your community collect water?

___

___

___

How do people in your community store water?

___

___

___

Water can get dirty in many ways. Look at these pictures. Think about where and how water can get dirty.

Write about and discuss how water gets dirty.

Think about how clean water can get dirty when mother collects, stores, and uses water.

The bucket mother uses for collecting water may not be clean.
Mother may have dirty hands when she collects water.
The storage vessel mother uses at home may not be clean.

Can you think of other ways water can get dirty?

If water gets dirty in any of these ways, a child who drinks the water can get diarrhea.

How Do Things We Eat and Drink with Get Dirty?

Children can get sick if they eat and drink with things that are dirty. The dirt goes into the belly and makes them sick. Water goes into the belly. Food goes into the belly. Mother uses her hands to cook the food and feed her child. All these things can get dirty.

How do things you eat and drink with get dirty?

Flies sit on stool and other rubbish. Flies carry dirt on their legs. Flies carry dirt to water, and things you eat or drink with. This is one way things get dirty and make you sick.

A person's hands get dirty when he goes to the toilet. When the person's hands touch something, the thing gets dirty. What should the person do after going to the toilet?

The person should wash his hands after going to the toilet.

Can you think of other ways things get dirty?

Look at the pictures on page 9 again. What should mother do so her child gets clean water to drink?

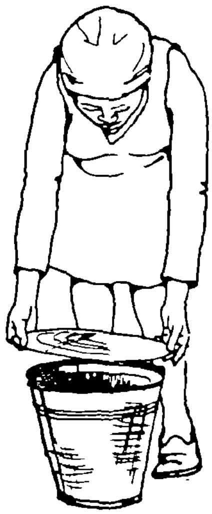
Here are some things that mother can do so her child gets clean water.

Mother should wash her hands before picking up the bucket.

Mother should wash the bucket before collecting the water. Then she will not make the water dirty.

Mother should wash her hands.

Mother should also wash the bucket before filling it with water.



Mother should cover the bucket. Then the water will not get dirty when mother is carrying the water.

Mother should wash the storage vessel after she gets home. Mother should also wash the scoop she uses to take out the water.

Mother should cover the water to make sure that the water does not get dirty. Mother should also cover the scoop.

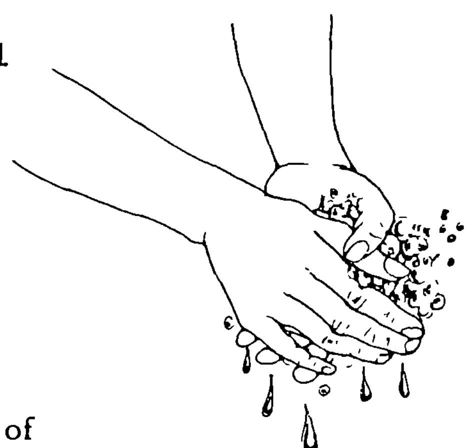
Mother should wash her hands before giving the water to her child.

Mother should also wash the cup for her child.

If mother takes such good care, then her child will stay healthy. Her child will not get diarrhea often.

Why Must You Wash Your Hands?

You must wash your hands so that your hands are clean. If you prepare food for your child with clean hands, your child will not get ill.



You can make other members of your family ill by cooking with dirty hands. You can also make yourself ill by eating with dirty hands.

When Should You Wash Your Hands?

You should wash your hands as often as possible. You must always wash your hands with soap and water:

After going to the toilet
After cleaning your child's toilet
Before preparing food
Before feeding your child
Before eating food
Before taking water from the storage vessel

When else should you wash your hands?

____

____

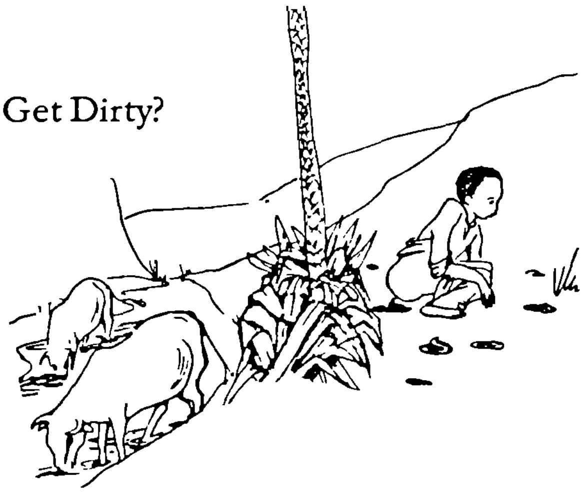
____

____

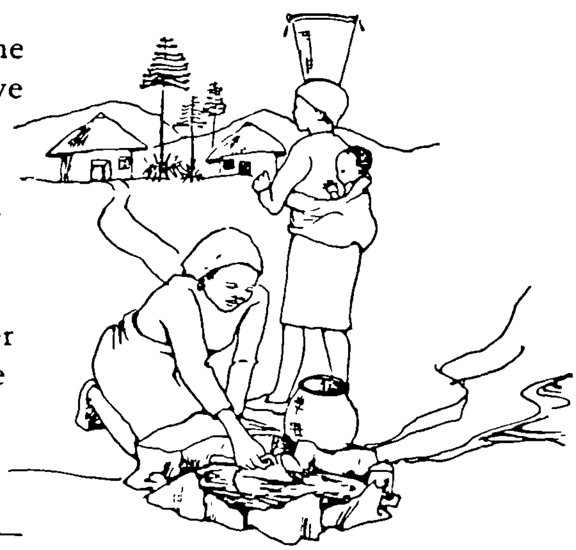
How Should You Wash Your Hands?

You should wash your hands with soap and running water. You can have running water by asking someone to pour water for you. You should wash your hands well with soap. Put soap all over your hands and wrists. Clean your nails well with soap and clean water. Also keep your nails short.

How Does Water at the Source Get Dirty?



The water gets dirty if people pass stool above or near the water. Try to get people to find another place to go to the toilet. You can show people how to build latrines. Then the water for everyone will not get dirty.



Rain water can make the spring dirty. You should ask people in the community to keep the area above the spring clean. Fence the area above the spring. Then animals and people will not dirty the area.

Rain water also flows along the ground and brings stool and other dirt with it. How can you stop the rain water from flowing into the source?

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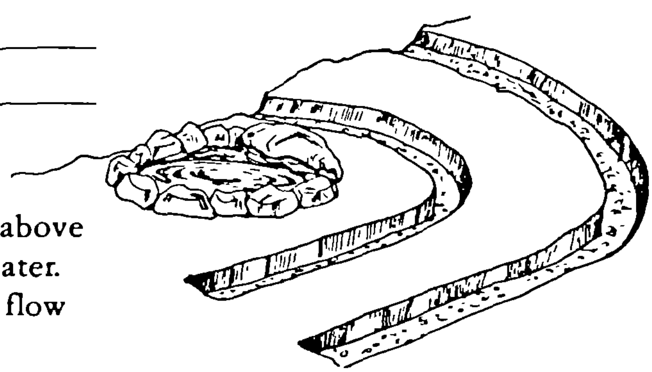


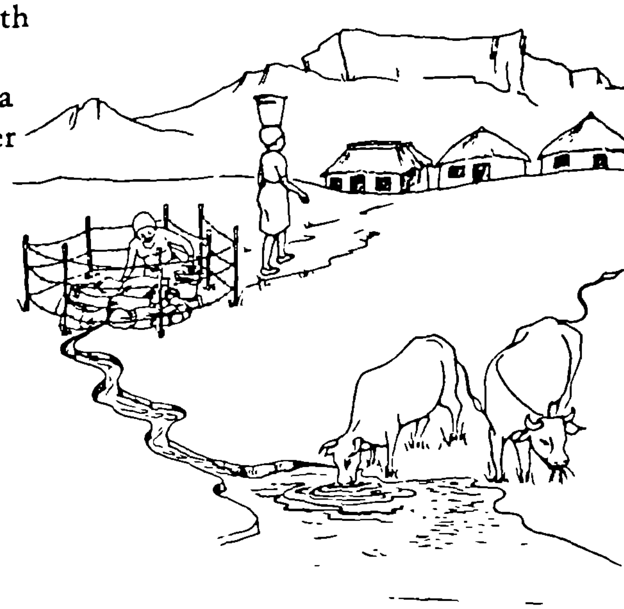
You can build two trenches above the spring to stop the rain water. Then the rain water will not flow into the spring.

What can you do if animals make the water at the source dirty?

____

____

Make sure that animals do not drink from the same places that people get water. Make a sėparate place for animals to drink. Do not let animals come near the water that people drink. Animals can dirty the water with stool and with their dirty feet. Protect the water source with a fence or a wall. Cover the water source so that animals cannot reach the water source.



What can you do if rubbish in the community makes the water dirty?

____

____

____

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You can show people how to dig rubbish pits or how to make compost pits. You can also show people how to burn rubbish.

Basic Messages

1. Always drink clean water.
2. Protect your source of water.
3. Clean water can get dirty when you collect, store, and use water.
4. Always collect water in a clean container.
5. Always wash your hands before pouring, drinking, or using water.
6. Always store water in a clean container.
7. Boil water for young children if the water is not clean.
8. Make a separate place for animals to drink.
9. Build latrines or bury all stool to keep your community clean.
10. Cover all food and water to keep away flies.

SESION 16

SYNOPSIS OF SESSION 16: Linking Up to Regional and National Efforts

Total Time: 2 Hours
40 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	15 Min.		Session Objectives
Large Group Brainstorming: Identifying Problems in Service Delivery	Brainstorming	30 Min.		List developed in Session 3, "Resources Available for Planning and Implementing a Handpump Project"
Small Group Task: Developing Strategies for Improving Delivery of Services	Small groups develop strategies	45 Min.		Task Instructions
Small Group Reports and Discussion: Sharing Strategies	Small group reports and discussion	45 Min.		
Application	Individuals note things he/she can do to overcome service delivery problems	20 Min.		
Closure	Trainer Presentation	5 Min.		

Session 16: Linking up to Regional and National Efforts

Total Time: 2 hours 40 min.

OBJECTIVES

By the end of this session the participants will be able to:

- identify current gaps and problems in the delivery of services to the village-based handpump project
- develop strategies for overcoming the problems

OVERVIEW

Village handpump projects do not exist in isolation. In every developing country there is one or more government institutions and most likely one or more donor organizations that have some role in handpump programming. Every country has organized its resources differently. In some, well construction is the first step and when the digging or drilling has been finished the well receives a handpump. In others, equal importance is placed on refurbishing existing wells and then installing a handpump. Sometimes there is one fully separate body that has responsibility for all aspects of handpump programming. In others, the responsibilities are split between ministries.

Some countries have decided to centralize maintenance operations, others have decided to de-centralize operations, which places greater responsibility on villagers for maintenance and repair.

Regardless of the way a government executes its program for increasing safe water supply, it is important that a village-based handpump project have ready access to expertise, equipment, and materials to implement its project and sustain it over time. The key to access is the extension worker, who is the link between a village program and provincial, state, or national institutions.

Extension workers must know how services are to be coordinated in the field and be ready to play a role in helping the coordination to occur.

This session builds on Session 3: "Implementing Water Supply Programs with Handpumps" in which participants identified the resources available for planning and implementing handpump projects. It assumes that more than one ministry or agency is involved directly or indirectly in improving water supply and that coordination of these agencies is most likely an area that could profit from discussion and action planning.

PROCEDURE

1. Introduction   Time: 15 min.

- Give objectives and introduce the session using information from the overview.

- Make the following points:

  - As we have noted in previous sessions, a project is not complete because a pump has been installed. In fact, it has just begun. A village-based project needs supportive services and access to resources to keep things going smoothly. Some of these services have been planned for and are currently available. Others are not, and a strategy must be developed for how they will be provided.

  - For services that are available, clear communication channels from the village to the institutions/agencies providing them at local, regional, or national levels must be developed. If a goal is to maximize the self-sufficiency of the project, and to encourage the development of problem-solving skills in the village, it is important for the village to understand how it can initiate the delivery of services rather than rely on the schedules and priorities of institutions.

  - Much of the discussion of ways in which community participation can be approached, and of how its successes may depend on the characteristics of the community, assumes that difficulties with the approach are to be expected. But difficulties are at least as likely to be found within the agencies themselves. Attention needs to be paid to:

    Keeping agreements over large and small matters which have been made with communities

    Avoidance of delays, particularly when it has been agreed for the work to take place during an agricultural slack season

    Coordination between the various aspects of a program, including user education and the training of local persons in operation and maintenance

  - When supportive services are not available, plans for how they can be provided need to be developed. For instance, some can be provided by the village on its own after initial training or problem solving.

2. Large Group Brainstorming: Identifying Problems with Service Delivery

Time: 30 min.

A) Introduce the brainstorming activity by bringing out the list developed in Session 3: "Resources Available for Planning and Implementing a Hand-pump Project." Remind participants of all the activities that are a part of planning, implementing, and maintaining a handpump project by reviewing past session titles and referring to the project cycle chart.

B) Tell participants to review the list developed in Session 3 and to jot down answers to the following questions. Give them five minutes.

- Given what you now know about handpump projects, are there any services which are currently not being provided?

- What problems can you identify with the existing services?

C) Lead a large group brainstorming session to identify answers to the above questions. List them on flipchart paper under the heading "Problems in Service Delivery."

3. <u>Small Group Task: Developing Strategies for Improving Delivery of Services</u>

Time: 45 min.

- Divide participants into groups of four to six and assign each group one or more of the problems identified in the previous brainstorming activity.

Give the following instructions (post them on flipchart paper):

- You will have 30 minutes to develop a strategy to overcome the problems assigned to your group. Be prepared to make a three-minute presentation.

- Keep the following in mind as you develop your strategy:

  Be realistic. Consider strategies that are within your power to implement or recommend.

  Decide whether your strategy should be aimed at improving existing services or exploring alternatives, or both.

  Decide who would have to be involved in order to make the strategy work.

4. <u>Small Group Reports and Discussion: Sharing Strategies</u> Time: 45 min.

Each group makes a brief three minute report. After each presentation allow a few minutes for questions of clarification and then ask:

- Which strategies did you like? Why?

- Were any unrealistic? Why?

- Do the strategies support community participation? How?

- Would you be able to assist in making the strategies you heard work? Why? Why not?

5. Application Time: 20 min.

Ask participants to write down three things that they personally could do to overcome some service delivery problems. Ask each to pair up with another person and share lists adding to their own if the other person has an idea they like. Ask for one example from each pair.

6. Closure Time: 5 min.

Remind participants that it is the people in this room, who know enough about the needs of the village on one hand, and about the workings of the bureaucracy on the other, who can make a significant difference in the effectiveness of village-based projects.

MATERIALS

1. Flipchart paper

2. Marker pens

3. Tape

4. Flipcharts prepared for:
   - session objectives
   - small group task instructions (step #3).

SESSION 17

SYNOPSIS OF SESSION 17: Evaluating the Handpump Project

Total Time: 2 Hours
25 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	10 Min.		Session Objectives Project Cycle Chart
Small Group Reviewing and Evaluating	Individuals fill out "Project Evaluation Checklist" Participants discuss in groups of three	45 Min.	Handout 17-1: Project Evaluation Checklist	Task Instructions
Group Discussion: Sharing Analyses	Discussion	45 Min.		
Conclusions	Questions and Discussion	30 Min.		
Application and Closure	Individuals note what they learned and applications	15 Min.		

Session 17: Evaluating the Handpump Project

Total Time: 2 hours 25 min.

OBJECTIVES

1. evaluate the strengths and weaknesses of the handpump training and identify ways to improve future projects

2. describe simple, basic steps useful in evaluating handpump projects

OVERVIEW

This session moves the workshop into the last phase of the project cycle, evaluation. Knowing how to evaluate a project is an important skill for extension workers. In this session the training group will have an opportunity to critically review all that has been done in the handpump training project. Both elements in the project that worked successfully and areas of difficulty will be identified. The group will make recommendations on how to further improve handpump project efforts.

PROCEDURE

1. Introduction — Time: 10 min.

A) Review the rationale for the session presented in the overview. Give the objectives and say that this session begins the evaluation phase of the project cycle. Answer questions. State that evaluation can take place at several different points during the life of the project. At each point the evaluators are looking at different aspects of the project. Give the handpump project completed during the training program as an example. Ask:

At what stage of the project cycle is our project right now?

If we were to evaluate it at this point, at what kinds of things would we look?

B) Tell participants that a checklist has been prepared that could be used to evaluate a project that is at this stage in the project cycle (construction phase completed and maintenance and repair phase about to begin).

2. Small Group Reviewing and Evaluating — Time: 45 min.

A) Distribute Handout 17-1: Project Evaluation Checklist. Ask participants to suggest additions to the checklist.

B) Ask individuals to fill out the checklist.

C) Divide the group into trios. Ask each trio to work together to complete these tasks (put tasks on flipchart paper):

- identify the elements of this project that worked especially well
- identify difficulties and/or problems and make recommendations for how improvements could be made
- prepare to exchange your analyses with others

3. Group Discussion: Sharing Analyses — Time: 45 min.

Lead a total group discussion around these questions:

- What did you identify as elements in the project that went especially well? Not so well?
- What recommendations for improvement did you make?
- Given that evaluation should be linked to follow-up action, what next steps would you suggest for our projects sites?

4. Conclusions — Time: 30 min.

A) Comment on the importance of conducting participatory evaluation activities and ask group how it could use the checklist they just completed with villagers.

B) Ask the group to comment on why they feel that evaluating a recently completed project would be useful. Explain that evaluating a project at this stage (instead of waiting until it has been in operation for six months or a year) may provide some ideas about better ways of completing the first three phases of the project cycle.

C) Ask group to think about what they might look for if they came back to this village six months from now? What kinds of questions would they add to this checklist? Write down the suggestions on flipchart paper or a blackboard.

5. Application and Closure — Time: 15 min.

Ask the participants to spend a few minutes to write down their thoughts and ideas on how they will evaluate the handpump projects they help initiate.

MATERIALS

1. Handout 17-1: Project Evaluation Checklist

2. Flipchart paper

3. Marker pens

4. Tape

5. Flipcharts prepared for:
   - session objectives
   - small group task (step 2)

PROJECT EVALUATION CHECKLIST

Name ______________________________

Date ______________________________

Village ______________________________

1. How adequate is the water for the users?

2. How adequate is the site design? How does it take into account the needs and desires of the users?

3. How solid and sound is the structure?

4. Comment on the adequacy of the materials.

5. Comment on the labor force in terms of numbers, who was involved, and how effectively it worked.

6. How much did the project cost? Who paid for it?

7. How would you rate the finished area in terms of aesthetics and usefulness?

8. How adequate is the site drainage?

9. How has the well been protected from contamination and surface waters?

10. Evaluate the water quality (taste, clarity, etc.)

11. Comment on plans for a water committee or other village group responsible for the on-going project.

12. What arrangements have been made for pump and site maintenance, including training for caretakers?

13. How convenient is the handpump to use? How satisfied are the users?

14. What plans have been made for a user education strategy?

15. Other comments.

SECTION 18

SYNOPSIS OF SESSION 18: Planning a Handpump Project

Total Time: 2 Hours
35 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	10 Min.		Session Objectives
Large Group Discussion/Review	Discussion	15 Min.		
Developing an Action Plan for Implementing a Handpump Project	Trainer demonstrates how to write an action plan, small groups develop, plans are reviewed and discussed by total group	2 Hours	Handout 18-1: Action Plan	Task Instructions
Summary and Closure	Summarize and refer to session objectives	10 Min.		

Session 18: Planning a Handpump Project

Total Time: 2 hours 35 min.

OBJECTIVES

By the end of this session, trainees will have:

1. developed an action plan to implement a handpump project

OVERVIEW

This session is intended to help participants think about their activities as related to handpump project implementation and to plan how they will proceed in the weeks immediately following the workshop. Because the participants who attend these workshops are likely to have different roles and responsibilities for handpump programming (i.e., some may have primary responsibility for supervising maintenance and repair teams; others may have responsibility for user education), this session may need minor adjusting.

It may be that the participants in your workshop group do not have responsibility for all phases of the project cycle from pre-planning and assessment through evaluation. In some countries the responsibilities for handpump programming is shared among ministries and donor organizations. Even within one ministry, different employees may have responsibility for different aspects of handpump programming.

Participants have already developed an action plan in Session 14: "Developing a Project Cost Estimate and Construction Work Plan." In this session they consider other activities that need to occur. This workshop has spent a good deal of time on the technical skill and knowledge for installing a handpump. Of equal importance is the skill and knowledge required to effectively plan and carry out a handpump project with full community involvement. Planning, organizing, and skills coordinating are especially significant since the village water supply is disrupted while construction activities take place. If resources and activities are not effectively coordinated delays can cause numerous problems.

PROCEDURE

1. Introduction — Time: 10 min.

Relate overview information and state the session objectives.

2. Large Group Discussion/Review — Time: 15 min.

A) Tell participants that they will be devising an action plan for how they will proceed with handpump project implementation--not just the construction stage--but for all the activities that need doing before and after.

B) Lead a quick review of:

- the work done in Session 14 (particularly the development of a plan for construction)

- the steps involved in the project cycle

C) Identify concerns and questions.

3. <u>Developing an Action Plan for Implementing a Handpump Project</u>

Time: 2 hours

A) Tell participants that they will develop an action plan to implement a handpump project in the village where they conducted the project feasibility assessment.

B) Introduce the concept of an action plan as a mechanism by which the participants can organize, schedule, and coordinate the resources and activities necessary for timely and successful completion of goals. Pass out <u>Handout 18-1: Action Plan</u> and tell participants it will be used in the next activity.

C) Demonstrate how to fill in the action plan by using an example. Make sure participants understand the characteristics of a goal:

specific
measurable
realistic
time-phased

D) Lead a short discussion on the following items which are considerations for developing an action plan:

- The "next steps" that you identified from conducting the project feasibility assessment should become part of your action plan

- Do efforts need to be coordinated with other ministries or within the ministry?

- How much time can you devote to one handpump project?

- How many trips can you make to the designated village?

- What resources are there in the village, both skills and materials?

- What other resources are there?

- Who should know about this project and who should be involved? Who will have primary responsibility for accomplishing each task?

E) Divide participants into the same groups in which they conducted the project feasibility assessment. Give the following instructions which you have posted on a flipchart:

- Fill out the action plan format you have received, identifying:

  goals
  tasks to accomplish each goal
  person responsible
  people who need to be involved

- Realistically estimate how long each task would take and in what sequence the tasks should occur.

- Transfer the format to flipchart paper so that other participants can review your work.

- You have 45 minutes to do this task.

F) After the participants have finished their action plans, post the flipchart action plans on the wall and ask participants to spend 15 minutes reviewing those done by other groups and to write down any questions about what they see.

G) Lead a discussion for about 30 minutes with the total group around these questions:

- What questions, if any, do you have about the action plans you reviewed?

- What are some examples of activities you feel should occur in week one, week two, week three, week four?

- Which activities did you feel would take the most time?

- What problems might you anticipate in scheduling these activities?

- Throughout the project cycle, there are critical coordinating points, places where/when several elements have to come together for desired activity to occur. In looking back over the project cycle, where are some of these "critical coordinating" points? (Examples are listed below.)

  Recruiting work force and fitting it into their daily/seasonal activities
  Arranging for user surveys
  Collection of monies prior to construction
  Arranging for alternative water sources during construction

4. <u>Summary and Closure</u> Time: 10 min.

Refer to the goals of this session. Engage the participants in a brief discussion about whether they feel the goals have been reached. Summarize and emphasize the importance of planning, and encourage participants to continue working on this action plan as a tool for managing their handpump activities.

MATERIALS

1. Handout 18-1: Action Plan

2. Flipchart paper

3. Marker pens

4. Tape

5. Prepared flipcharts for:
   - session objectives
   - small group task (step 3)

ACTION PLAN

	MONTH 1				MONTH 2				MONTH 3				MONTH 4				WHO IS RESPONSIBLE	WHO NEEDS TO BE INVOLVED
GOAL: TASKS:																		
GOAL: TASKS:																		
GOAL: TASKS:																		

SYNOPSIS OF SESSION 19: Workshop Evaluation

Total Time: 1 Hours 30 Min.

STEPS	PROCEDURE	TIME	HANDOUTS/MATERIALS NEEDED	FLIPCHART REQUIRED
Introduction	Trainer Presentation	5 Min.		Session Objectives
Written Evaluation	Individuals fill out workshop evaluation form and review the self assessment inventory he/she filled out in Session 1 to measure growth	45 Min.	Handout 19-1; Workshop Evaluation Form Handout 1-3: Self Assessment Inventories filled out in Session 1	
Oral Feedback	Trainer leads discussion and records evaluation responses on flipchart	30 Min.		Flipchart to record feedback
Closure	Trainer Presentation	10 Min.		

Session 19: Workshop Evaluation

Total Time: 1 hour 30 min.

OBJECTIVES

By the end of this session participants will have:

1. filled out the workshop evaluation questionnaire

2. provided feedback on the workshop

OVERVIEW

It is assumed that the trainer will be able to evaluate the workshop both formally and informally. Each session contains objectives which are generally verifiable by observation: skills can be either demonstrated or not. It is also assumed that the recipients of this training are well-motivated adults who will seek help if they don't understand something. The ultimate evaluation measure, however, will be demonstrated long after the workshop when the participant is working to implement handpump projects. If the training has been successful, the participant will be able to use the handouts introduced in the workshop to promote a technically and socially sound project.

This evaluation session provides an additional source of data. It is based on the participant's feelings and observations about the workshop. The information gained from this session can be used to both improve the training design and help the trainer do a better job next time. This session uses two tools: a written opinionnaire and an informal oral feedback session. The written portion should be collected to provide a record for the trainer. It is intended to be anonymous to ensure more open feedback. The oral portion is designed to gather information about the workshop which will help explain and interpret the written data and provide an opportunity for give-and-take between the trainers and the participants. In addition, participants are given a copy of the self-assessment inventory which they filled out in Session 1 and are asked to complete it again now that the workshop has come to a close.

PROCEDURE

1. Introduction — Time: 5 min.

Introduce the evaluation session by stating the objectives and explain that the evaluation is important to the trainers as a way to learn how the training has been received. Describe the written and oral parts of the evaluation and the time constraints.

2. Written Evaluation — Time: 45 min.

A) Distribute Handout 19-1: Workshop Evaluation Form and the same "Self Assessment Inventory" that participants filled out in the beginning of the workshop (Session 1). Make the following points:

- The workshop evaluation form is a tool to help the trainers evaluate the workshop. They are to be turned in, but the participants do not have to sign their names.

- The self assessment inventory is to help the participants measure their growth and identify specific skill areas for additional training. The self assessment inventory will not be collected.

B) Answer questions about the instructions on the forms.

C) Give the group time to fill out the forms and then collect the workshop evaluation form.

3. Oral Feedback — Time: 20-30 min.

A) Draw on the flipchart a two-column space divided as follows:

Workshop Strengths	Suggestions for Improvement

B) Ask the participants to volunteer comments. Record the comments as they are given. After each comment, it is good to verify the comment with others in the group to see if the statement expressed is shared by others or is only one person's opinion. It is particularly important that the trainer not act defensively and spend a lot of time explaining weaknesses. This will only serve to discourage constructive feedback.

C) Whenever suggestions are made for additional training needs not covered by the workshop, record them on a separate flipchart sheet. This information should be included with the workshop evaluation and forwarded to the sponsoring agency.

4. Closure — Time: 10 min.

When the group has sufficiently discussed their feedback, close the session by acknowledging all of the good ideas and feedback.

MATERIALS

1. Handout 19-1: Workshop Evaluation Form
2. Handout 1-3: Self-Assessment Inventory (used in Session 1)
3. Flipchart paper
4. Marker pens
5. Tape
6. Prepared flipchart beforehand for:
   - session objectives

Handpump Workshop Evaluation Form

(Please do not sign your name)

A. Goal Attainment: Please circle the appropriate number to indicate the degree to which the workshop goals have been achieved.

1. Identify resources necessary for a village handpump project.

   1 Low　　2　　3　　4　　5 High

2. Conduct a project feasibility assessment and determine next steps.

   1 Low　　2　　3　　4　　5 High

3. Identify and apply strategies for involving the community in all phases of the handpump project.

   1 Low　　2　　3　　4　　5 High

4. Survey, evaluate, and select sites for handpumps including an assessment of the quantity and quality of water needed to warrant installation.

   1 Low　　2　　3　　4　　5 High

5. Facilitate the formation and functioning of a water committee or other appropriate village organization.

   1 Low　　2　　3　　4　　5 High

6. Develop a project cost estimate.

   1 Low　　2　　3　　4　　5 High

7. Develop and implement work plans and logistics necessary for project start-up with appropriate village organization.

1	2	3	4	5
Low				High

8. Coordinate and monitor construction activities and the procurement and delivery of materials.

1	2	3	4	5
Low				High

9. Prepare selected sites for receiving handpumps.

1	2	3	4	5
Low				High

10. Install locally available shallow or deep well pump.

1	2	3	4	5
Low				High

11. Operate, maintain, troubleshoot and repair handpump.

1	2	3	4	5
Low				High

12. Design a user education strategy.

1	2	3	4	5
Low				High

13. Train village caretakers in appropriate maintenance and repair tasks.

1	2	3	4	5
Low				High

14. Identify alternative strategies for solving most common non-technical problems which develop before, during and after handpump installation.

1	2	3	4	5
Low				High

15. Monitor and evaluate the effectiveness of the handpump project.

1 Low   2   3   4   5 High

16. Develop an awareness of national and regional handpump program resources.

1 Low   2   3   4   5 High

B. <u>Workshop Feedback and Learning</u>: Please answer the following questions as fully as possible so that the trainers can learn the effectiveness of the workshop.

1. What was the most positive thing about this workshop? Comments:

2. What was the most negative? Comments:

3. What stands out as most important? Comments:

4. What have you learned that you did not know before? Comments:

C. Workshop Organization and Training

1. What do you have to say about the way the workshop was planned and carried out?

2. What can be done to improve similar workshops?

3. What specificly do you need to learn more about in order to successfully promote and develop a handpump project in the future?

4. What comments do you have about the trainers?

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PARTICIPANT

PARTICIPANT REFERENCE PACKET

WORKSHOP GOALS

1. Identify resources necessary for a village handpump project
2. Conduct an assessment for project feasibility and determine next steps
3. Identify and apply strategies for involving the community in all phases of the handpump project
4. Survey, evaluate, and select sites for handpumps (including an assessment of the quantity and quality of water)
5. Facilitate the formation and functioning of a water committee or other appropriate village organization
6. Develop a project cost estimate
7. Develop and implement, with appropriate village organization, work plans and logistics necessary for project start-up
8. Coordinate and monitor construction activities and the procurement and delivery of materials
9. Prepare selected sites for receiving handpumps
10. Install locally available shallow or deep well pumps
11. Operate, maintain, troubleshoot, and repair handpumps
12. Design a user education strategy
13. Train village caretakers in appropriate maintenance and repair tasks
14. Identify alternative strategies for solving most common non-technical problems which develop before, during, and after handpump installation
15. Monitor and evaluate the effectiveness of the handpump project
16. Develop an awareness of national and regional handpump program resources

WORKSHOP SCHEDULE

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
a.m.	Session 1 Introduction to the Handpump Workshop	Session 3 Implementing Water Supply Programs with Handpumps: an Overview	Session 5 Constructing the Apron	Session 5, pt. 2 Constructing the Apron	Session 6, pt. 2 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7, pt. 2 Conducting the Assessment and Analyzing Assessment Results Session 8 Working with the Village Community	O F F
p.m.	Session 2 Work Site and Handpump Orientation	Session 4 Determining Well Recharge Rate		Session 6 Preparing for Conducting Initial Village Assessment for Project Feasibility	Session 7 Conducting the Assessment and Analyzing Assessment Results	Session 9 Mid-Point Evaluation	

	DAY 8	DAY 9	DAY 10	DAY 11	DAY 12
.m.	Session 10 Finishing the Site	Session 11, Pt. 2 Installing the Handpump and Disinfecting the Well	Session 13 Training the Caretakers	Session 15 Developing and Implementing User Education Strategies	Session 17 Evaluating the Handpump Project Session 18 Planning a Handpump Project
).m.	Session 11 Installing the Handpump and Disinfecting the Well	Session 12 Maintaining and Repairing the Pump	Session 14 Developing a Project Cost Estimate and Construction Work Plan	Session 16 Linking Up to Regional and National Efforts	Session 19 Workshop Evaluation

SELF-ASSESSMENT INVENTORY

Rank yourself in terms of how well you feel you now do each of the tasks below. This is for your use to help you in your learning. Please be accurate and honest with your answers.

PRE-PLANNING AND ASSESSMENT

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
1. Identify and be familiar with availability of national/regional resources for a handpump program, for example: - pumps - funds - political support - technical expertise - spare parts	4	3	2	1
2. Conduct a preliminary assessment of villages in area to determine most likely villages for initial projects. Criteria to include: - need - interest - leadership capabilities - technical difficulties	4	3	2	1
3. Meet with and explain to village leaders what your role is, what handpump/well improvement is, why it is needed in the village, how it will help the villagers.	4	3	2	1
4. Discuss and assess with village leaders: - past projects in village and reasons for success/failure - potential resources to initiate - potential role of women and men in project - current practices re: water - current problems with wells and pumps.	4	3	2	1
5. Conduct an assessment of existing wells and pumps in village including type, total depth, depth to water table, water quality (taste, bacteria if possible), reasons for non-use and use, past dry periods, number of users, etc.	4	3	2	1

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
6. Develop a cost estimate for handpump program in village with varying options.	4	3	2	1
7. Be familiar with and have solutions for the most common problems a field worker encounters in implementing and maintaining a handpump program.	4	3	2	1
8. Help leaders determine how to form a water committee in keeping with village characteristics and interest.	4	3	2	1
9. Assess with leaders village resources including finances, labor for installation and maintenance, materials, tools, equipment.	4	3	2	1
10. Present recommendations and cost estimates to leaders on how to proceed with the handpump program.	4	3	2	1
11. Discuss and arrive at decision with village re: - commitment of village resources to program - determination of roles/responsibilities before, during, after installation - determination of community financing system and procedures - development of criteria and selection of caretakers and determination of compensation - rules and guidelines for use of pump.	4	3	2	1
12. Orient committee members to the concept of clean water for health using handpumps and plan strategies for introducing concept to different group in the village.	4	3	2	1

PLANNING AND DESIGN

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
13. Know how to competitively select and care for quality tools and train caretakers in the same.	4	3	2	1
14. Select site by analyzing information collected during the assessment for project feasibility.	4	3	2	1
15. Familiarize caretakers in reasons and criteria for well selection.	4	3	2	1
16. Assess the extent of repairs required to sanitarily protect the well and calculate costs.	4	3	2	1
17. Determine the apron size, shape, orientation (for drainage) and need/ size for soakage pit.	4	3	2	1
18. Calculate the required amounts and types of materials (sand, gravel, cement, rock, brick, re-bar, forms, etc.) and determine what will be procured locally and what must be imported.	4	3	2	1
19. Determine the amount and quality of labor and determine if it is available locally or if it must be hired from outside.	4	3	2	1
20. Discuss costs of materials, tools, and labor with water committee if substantially different than estimates or previous agreements.	4	3	2	1
21. Procure materials, tools and hire labor. Arrange such things as transport, payment, wages.	4	3	2	1

CONSTRUCTION

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
22. Construct apron following 11 major steps.	4	3	2	1
23. Construct soakage pit if no existing drainage trench is nearby.	4	3	2	1
24. For drainage, clear and grade an area around the apron. Cover this area with packed gravel.	4	3	2	1
25. Identify and locate necessary materials and tools.	4	3	2	1
26. Describe and perform pump installation tasks.	4	3	2	1
27. Describe and perform steps with caretaker and water committee for installing and repairing a handpump above ground.	4	3	2	1
28. Explain to water committee/users what well disinfection involves and why it helps water supply.	4	3	2	1
29. Identify and perform steps for disinfecting well.	4	3	2	1

MAINTENANCE AND REPAIR

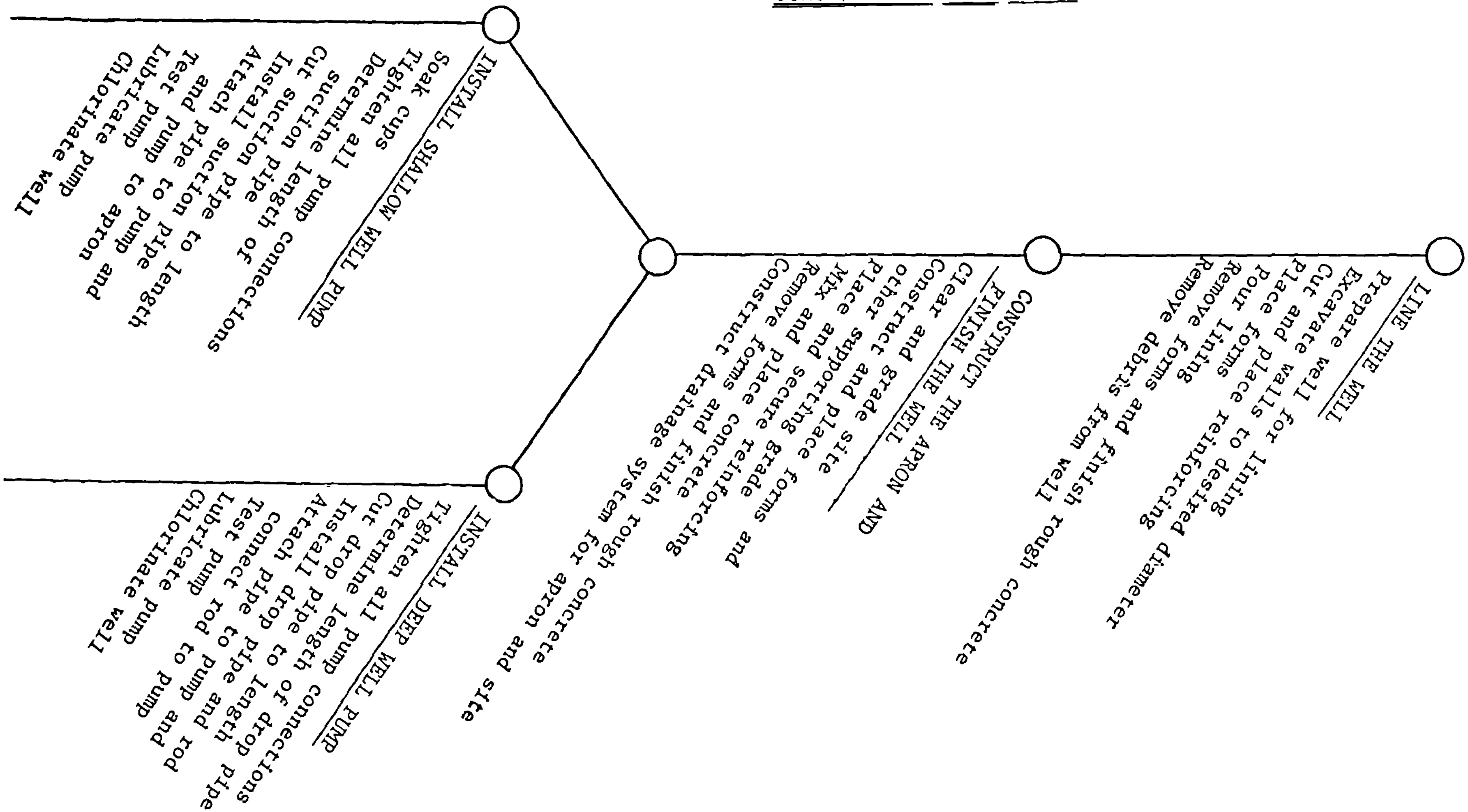
	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
30. Perform and instruct caretaker in pump lubrication and site maintenance.	4	3	2	1
31. Develop with caretaker a maintenance schedule.	4	3	2	1

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
32. Identify and solve technical problems which may arise with shallow or deep well pump such as poor flow rate and leakage and train caretakers to do same.	4	3	2	1
33. Set up procedures for acquiring outside technical assistance, material and spare parts and train caretakers in knowing when and how to use these resources.	4	3	2	1
34. Understand community problems that affect the use of the pump and success of the program. Develop strategies with the water committee for overcoming problems and for enforcing rules/guidelines for use of pump.	4	3	2	1
35. Know and demonstrate how to troubleshoot by identifying possible causes of various symptoms of pump problems.	4	3	2	1
36. Apply principles of water contamination and protection in a variety of situations and develop appropriate user education sessions demonstrating clean water handling and storage techniques.	4	3	2	1

EVALUATION

	DO WELL (4)	DO OKAY (3)	DIFFICULT TO DO (2)	CAN'T DO (1)
37. After completion of initial project, analyze what worked, what didn't, and why and identify changes in strategy for next venture.	4	3	2	1
38. Encourage the village to celebrate and feel proud of its handpump program.	4	3	2	1

CONSTRUCTION LINE CHART



Operation of Deep Well Pumps

The cylinders of deep well pumps are usually located below the water level to prevent loss of priming. Water is lifted to the surface by the reciprocating action of the plunger assembly. The operation of a deep well pump is as follows:

1. On the first upstroke, the water in the cylinder is raised and more water enters the cylinder through the foot valve as in Figure 1A below. Note that the cylinder is submerged.

2. Upon completion of the upstroke, the foot valve closes by gravity, trapping the water that has just entered the cylinder, as shown in B.

3. On the downstroke, the plunger valve opens, allowing water to pass as shown at C.

4. When the plunger assembly reaches the bottom of the cylinder and stops, the plunger valve closes, trapping the water above the plunger assembly as shown at D.

5. On the next upstroke, more water is lifted up the drop pipe and more is introduced into the cylinder. On each stroke the process is repeated until water comes out of the pump spout. Note: If the foot valve is holding water well, the drop pipe should usually remain full of water. Water should then be delivered within a few strokes if not on the first.

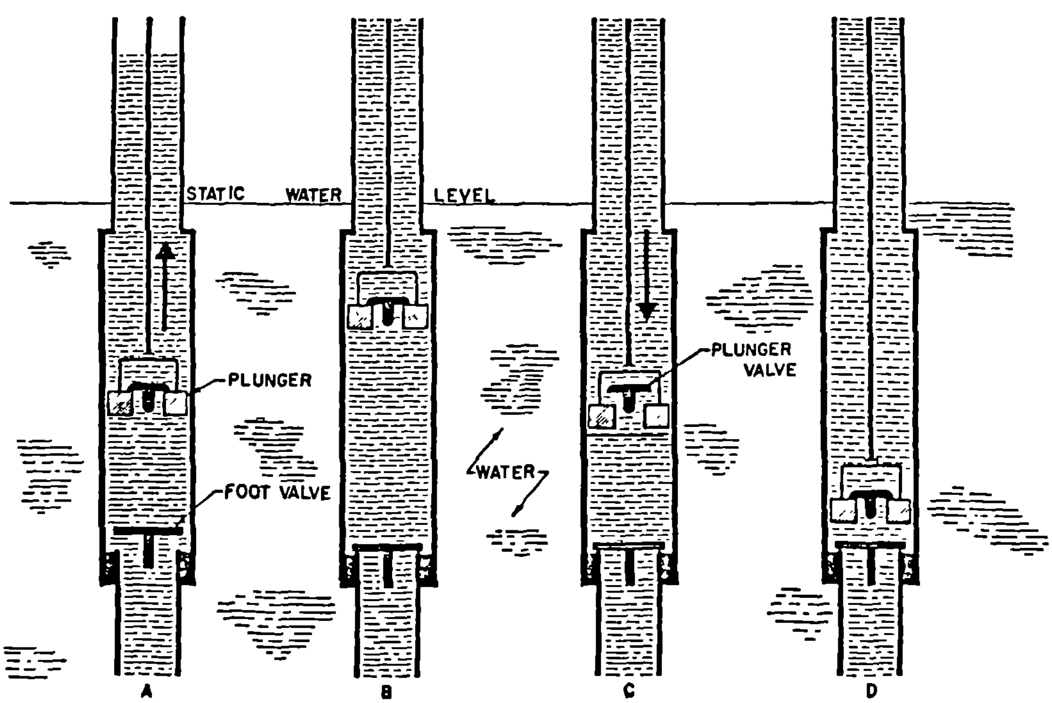


Figure 1. Deep Well Pump Operation.

Adapted from Pashkevich and Gass

Sometimes it may be necessary to attach a length of suction pipe to the bottom of deep well pump cylinders. Some examples (Figure 2) would be in the case of a lowered water table since the time of original installation due to overpumping of the source (irrigation, industry, etc.), drought or geological disturbances and the use of undersized casing when drilling through difficult subsurface strata (small boulders, etc.). However, the water table during pumping cannot be more than about 8 meters below the cylinder for water to be pumped with this arrangement.

The deep well pump is shown in Figure 3.

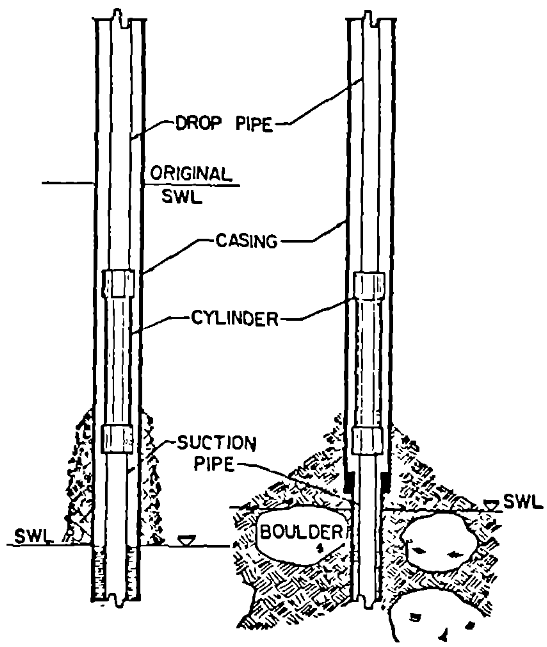


Figure 2. Optional Installation for Pump Cylinder.

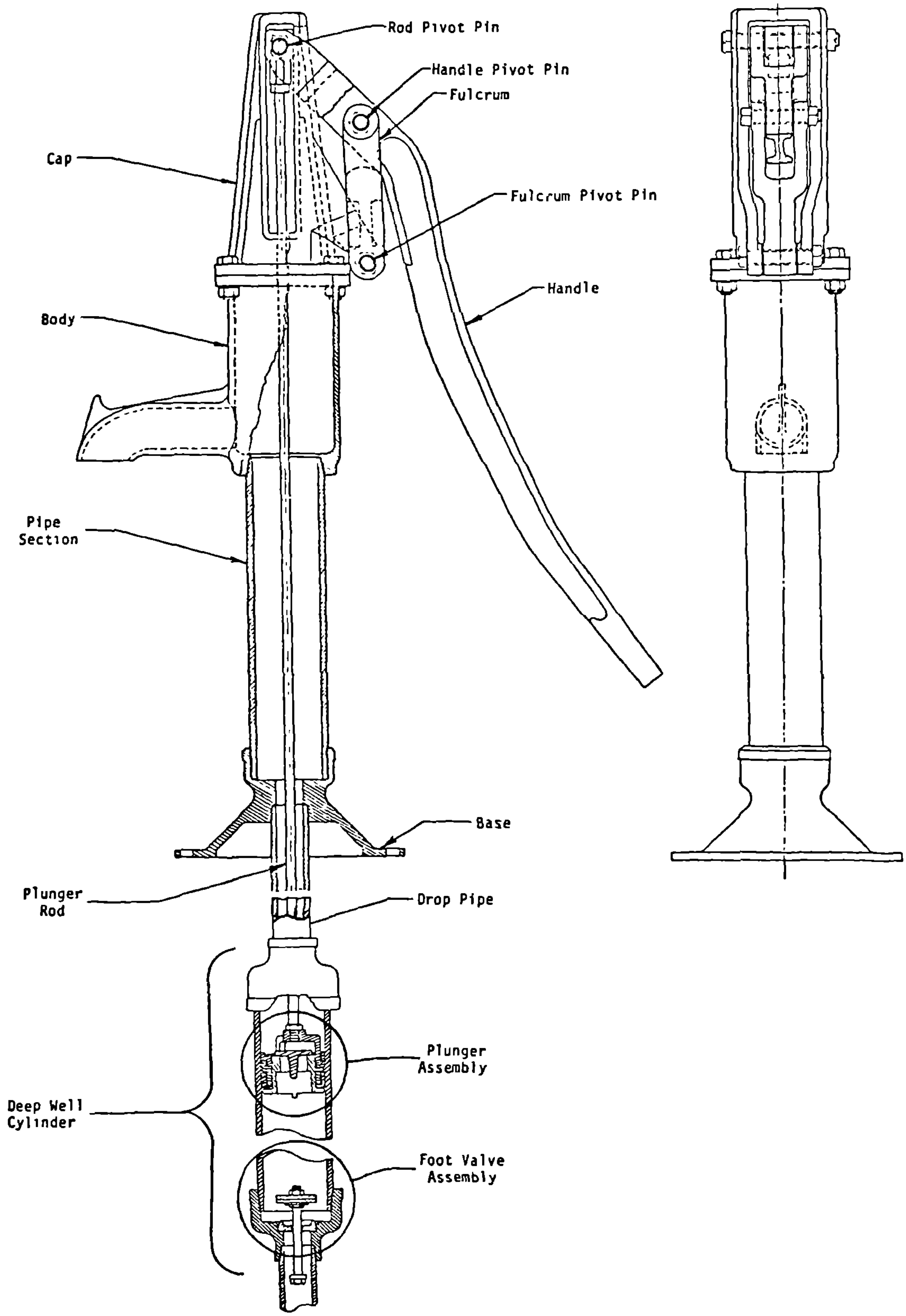


Figure 3. Deep Well Pump

Operation of Shallow Well Pumps

Figure 1 shows the components of a shallow-set pump. The body of the pump contains a valved plunger assembly which moves up and down during operation. The principle of its operation may be followed by examination of Figure 2.

Its operation is as follows:

1. With the pump primed, as shown at A, the plunger is raised. As air cannot pass the plunger owing to the water seal, a partial vacuum is created in the cylinder thereby reducing the air pressure on the surface of the water in the suction pipe. The atmospheric pressure on the water in the well is now greater than the air pressure on the water in the pipe, thereby forcing the air and water in the pipe upward. The space in the cylinder below the plunger fills with air from the pipe.

2. At the top of the cylinder the plunger stops, and the foot valve closes by its own weight, thus trapping air in the cylinder.

3. On the next downstroke the entrapped air is compressed between the plunger and the bottom of the cylinder. When the pressure becomes greater than the atmospheric pressure above the plunger plus the weight of the valve and of the priming water, the air will lift the plunger valve and escape through the priming water as shown at B.

4. On the next upstroke more air will be drawn out of the pipe and the water will rise higher, eventually flowing into the cylinder under the plunger as shown at C.

5. With the cylinder and pipe full of water as at C, the foot valve closes by gravity, trapping water in the cylinder.

6. On the next downstroke the plunger and valve pass through the water as shown at D.

7. When the plunger reaches the bottom of the cylinder and stops, the plunger valve closes, thus trapping the water above the plunger as shown at E.

8. On the next upstroke the water above the plunger is lifted out of the pump as shown at F. At the same time more water is forced into the cylinder through the foot valve.

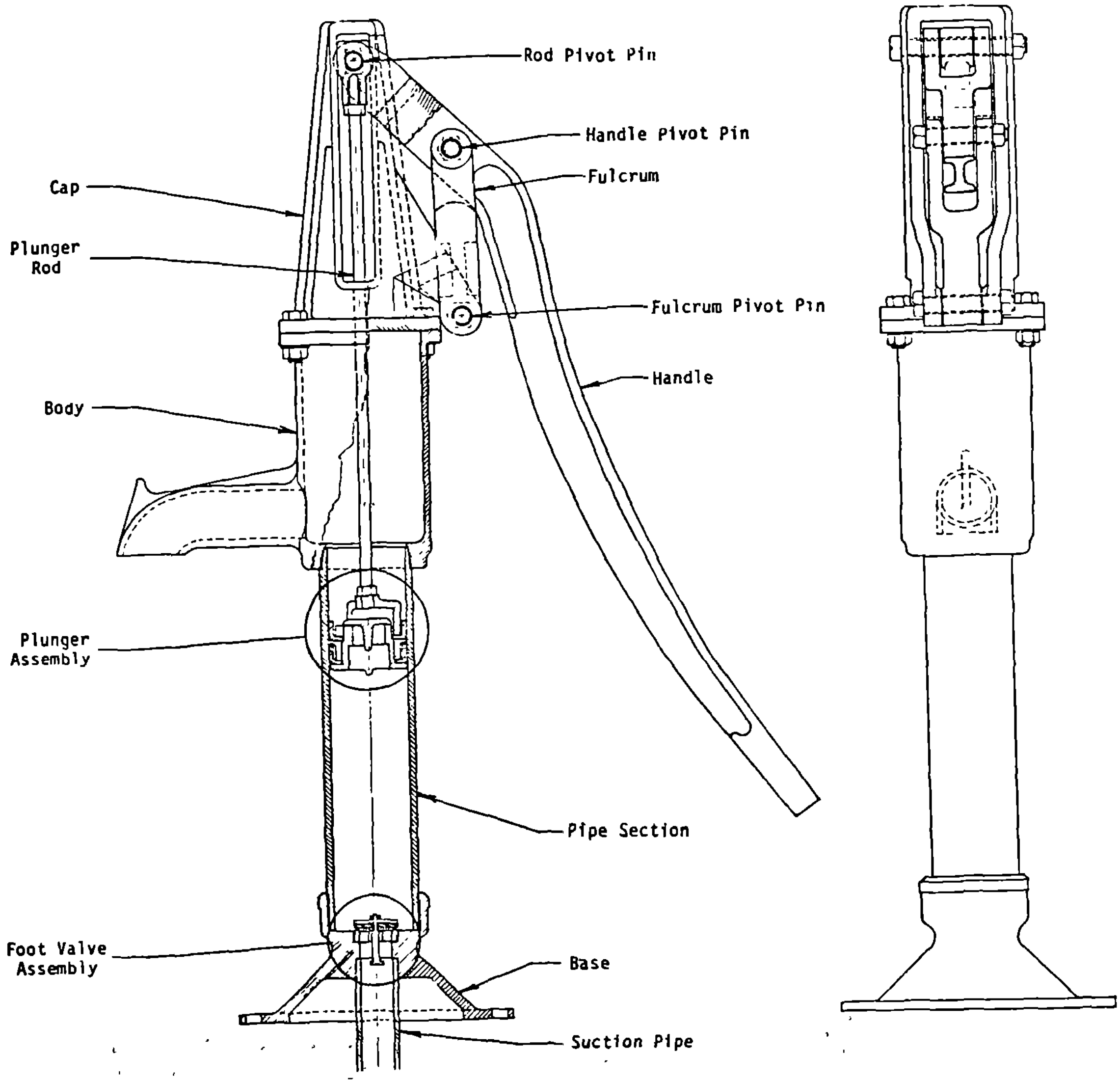


Figure 1 . Shallow Well Pump

9. On each successive downstroke step D is repeated, and on each successive upstroke step F is repeated. Thus the pump delivers water on each upstroke.

Shallow set pumps do not "pull" or "draw" water from the source. Rather the pump reduces the atmospheric pressure on the water in the suction pipe. The atmospheric pressure on the water outside of the suction pipe pushes the water up and into the pump. Because of vacuum leaks around the plunger cups and through the plunger valve, the use of shallow-well pumps is limited to conditions where the water table during pumping is within 8 meters of the cylinder even though "standard atmospheric pressure" is about 10.3 meters (34 feet).

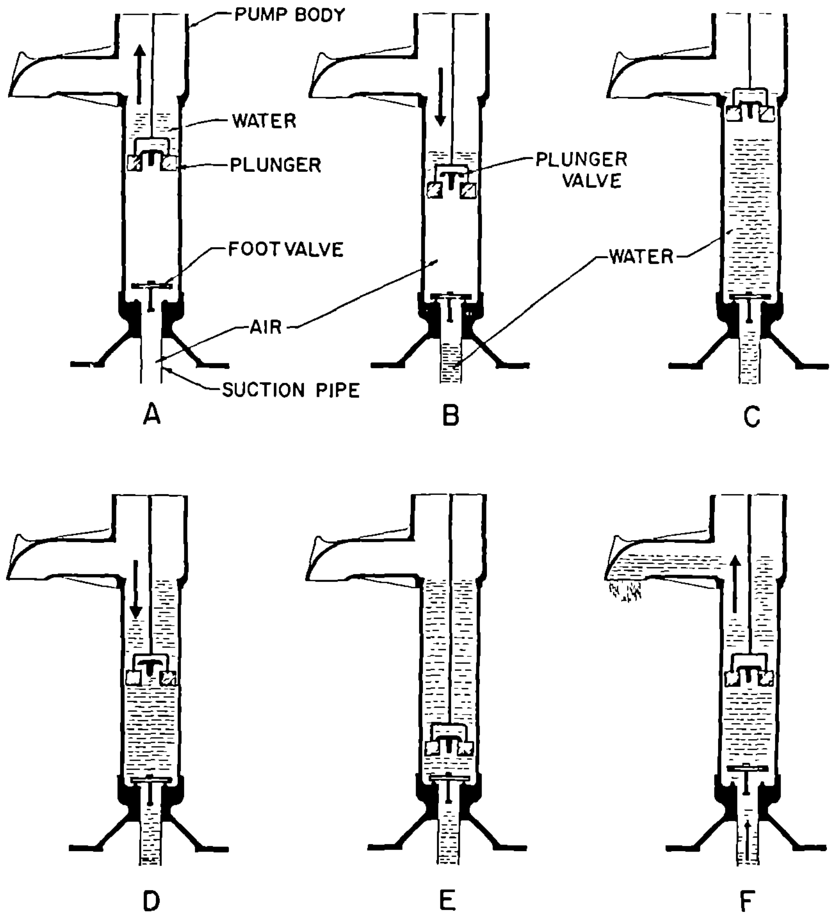


Figure 2 . Shallow Well Pump Operation

Water for the World

Means of Disease Transmission
Technical Note No. DIS. 1.M.1

Water- and sanitation- related diseases are major causes of illness and death among people in both rural and urban areas in many developing countries. The health and well being of people cannot be improved without understanding these diseases and knowing how they are transmitted from one person to another.

This technical note describes what causes these diseases, how they are spread and the factors influencing their transmission. Methods for preventing the transmission of the water- and sanitation- related diseases can be found in the technical note, "Methods of Improving Environmental Health Conditions," DIS.1.M.2.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

BACTERIA - One-celled microorganisms which multiply by simple division and which can only be seen with a microscope.

FECES - The waste from the body moved out through the bowels.

LARVAE - Young forms that come from the eggs of insects and worm parasites.

PARASITES - Worms, insects or mites which live in or on animals or people.

There are about 30 diseases that are related to water and sanitation. Table 1 lists the 21 which are most important. Each of them affects from millions to hundreds of millions of people every year. All of these diseases are caused by living organisms that must spend much of their life in or on a human body. They include viruses so tiny that they can pass through the finest filter, bacteria and protozoa that can be seen only with the aid of a microscope, tiny mites that are barely visible to the eye and worms that may be a meter long.

The transmission of all of these diseases is related in some way to water supply and sanitation, usually to inadequate disposal of human wastes and to contaminated water supplies. The diseases are transmitted through contact with or consumption of water, contact with infected soil, the bites of insects that breed in or near water and poor personal and family hygiene. Man is usually the source of the organisms that cause these diseases and human activity is an important factor in the transmission of them.

Following the order shown in Table 1, the transmission of the diseases will be discussed for each of the five categories.

Waterborne Diseases (Water Quality Related)

In the waterborne diseases, the microorganisms which cause the disease are swallowed with contaminated water. All but one, Guinea worm, are caused by organisms found in human excreta, the source of the contamination. The infective stage of Guinea worm is not from fecal contamination, but is from a tiny larva that develops in a water-flea after the larva is discharged into the water. The larva comes from a blister on the skin of a person infected with the meter-long adult worm.

Cholera and typhoid fever are the waterborne diseases which are most feared because, when untreated, they have high death rates. However, the diarrheas and dysenteries are more important because of the infant deaths and huge numbers of illnesses they cause. In the developing countries,

Table 1. Water and Sanitation-Related Diseases

Category	Disease: Common name	Disease: Medical name	Type of Organism	Transmission
Waterborne (Water quality related)	Cholera Typhoid fever Paratyphoid fever Bacillary dysentery Amebic dysentery Diarrhea Diarrhea Jaundice Guinea worm	Cholera Typhoid Paratyphoid Shigellosis Amebiasis Salmonellosis Giardiasis Hepatitis Dracunculiasis	Vibrio Bacteria Bacteria Bacteria Protozoan Bacteria Protozoan Virus Worm	By consuming (drinking) fecally contaminated raw water containing an infective dose of the vibrio, bacterium, protozoan or virus; except Guinea worm where transmission is by swallowing water flea infected with worm larva that was shed from skin blister on infected human.
Water-washed (Water quantity; and accessibility related)	Bacillary dysentery Diarrhea Viral diarrhea Trachoma Pink eye Itch	Shigellosis Salmonellosis Enteroviruses Trachoma Conjunctivitis Scabies	Bacteria Bacteria Virus Intracelluar bacteria Bacteria Mite	Anal-oral or skin-to-skin direct contact transmission resulting from poor personal cleanliness and hygiene caused from lack of water for sufficient washing, bathing and cleaning.
Water-contact (Body-of-water related)	Blood fluke disease	Schistosomiasis	Worm	Eggs in feces or urine hatch larvae in water, penetrate suitable snail, multiply greatly in snail, free-swimming larvae leave snail, penetrate skin when person has contact with infected water.
Water-related insect vectors (carriers) (Water-site related)	Yellow fever Malaria Filarial fever Sleeping sickness River blindness	Yellow fever Malaria Filiariasis Trypanosomiasis Onchocerciasis	Virus Protozoa Worm Protozoa Worm	Mosquitoes, tsetse flies and blackflies, which breed in or near water, pick up disease organisms when they bite infected person; organisms grow in vectors and are inoculated into another person when insect bites.
Sanitation-related (Fecal polluted soil related)	Hookworm Roundworm	Ancylostomiasis Ascariasis	Worm Worm	Eggs or larvae become infective when feces are deposited on soil; eggs are eaten from contaminated hands or vegetables, or larvae penetrate skin that comes in contact with infected soil.

the diarrheas and dysenteries cause hundreds of millions of illnesses and millions of infant deaths each year.

The basic transmission of waterborne disease is person to person. The microorganisms for infected people contaminate water which is consumed by other people. Figure 1 shows a common way that water becomes contaminated. The contamination of water supplies occurs:

1. Where latrines and privies are located uphill from or very close to a water source such as a spring, stream, pond or well. Liquids carrying the organisms seep from the latrines into the water supply.

2. Where privy pits, soakage pits, or sewage absorption systems penetrate the water table of an aquifer located near the surface and shallow wells and springs whose water comes from the aquifer are contaminated.

3. Where wells and springs are unprotected so that surface run-off enters these water sources. The run-off after rainfall carries disease-causing organisms into the water source.

4. Where sanitation is poor. If people defecate on the ground or in bodies of water rather than in safe latrines or privies, disease-causing organisms can get into water supplies.

5. Where Guinea worm occurs, water is contaminated when the skin of an infected person with a blister caused by the worm is immersed in water and great numbers of larvae are released into the water. Some of the larvae are eaten by tiny water fleas (Cyclops). The larvae in the water fleas grow, shed their skins, and become infective. When a water flea containing an infective larva is drunk with water from the contaminated source, the little worm is transmitted to a new person where it grows to maturity under the skin.

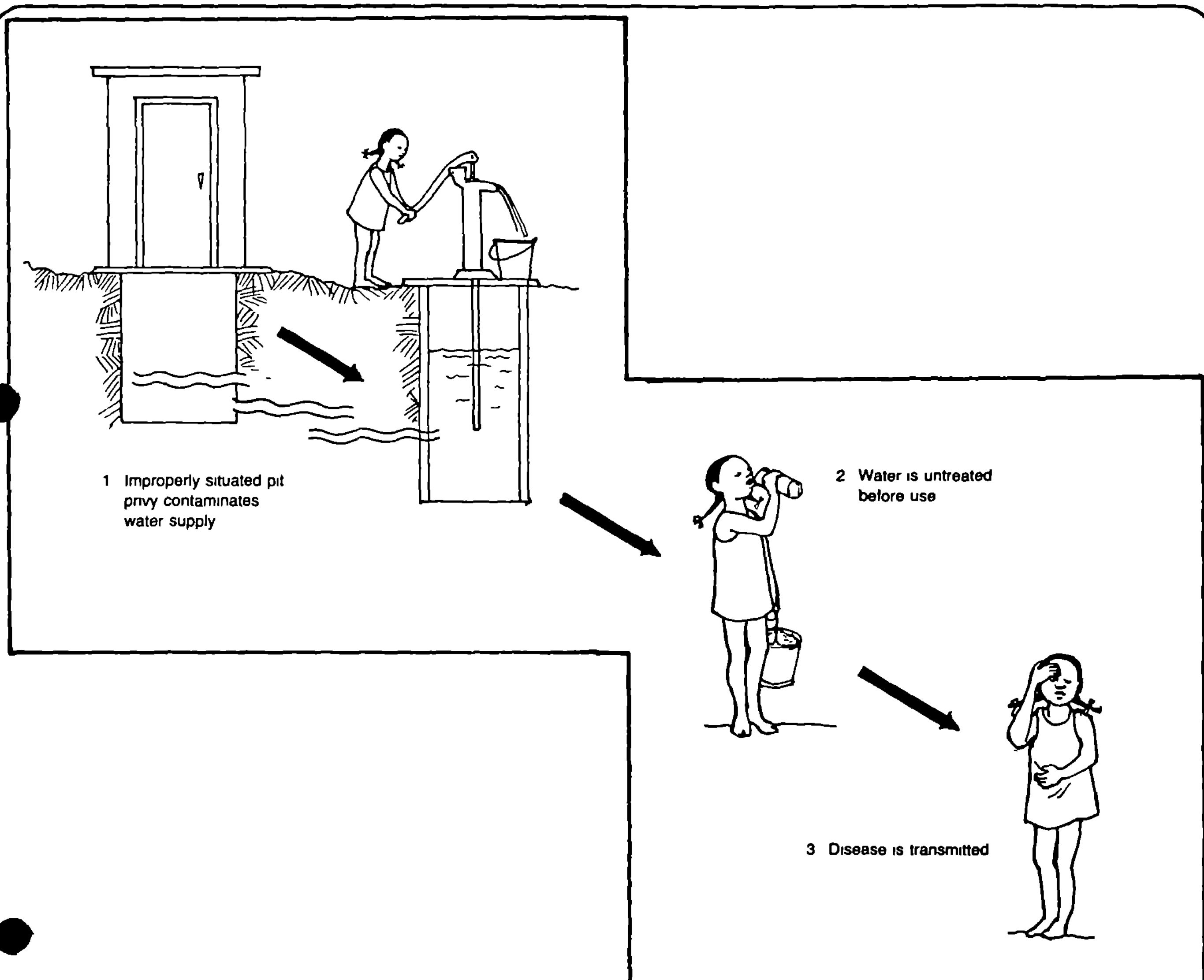


Figure 1. Transmission of Waterborne Disease

Water-Washed Diseases (Water Quantity and Accessibility Related)

Water-washed diseases are diseases whose transmission results from a lack of sufficient clean water for frequent bathing, hand washing before meals and after going to the toilet, and for washing clothes and household utensils. Several common diseases fall into this category. Shilgellosis (bacillary dysentery), salmonellosis (food poisoning), trachoma, and scabies are all diseases that can be passed by direct contact between people or by the direct contamination of food by dirty hands or flies. Figure 2 shows one way water-washed diseases are spread. The diseases in this group are transmitted:

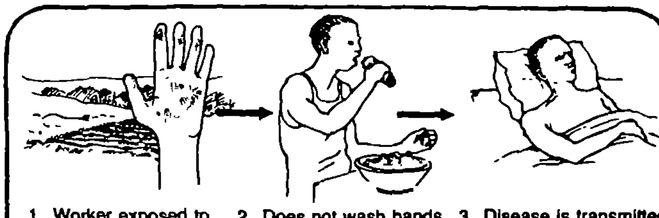


Figure 2. Transmission of Water-Washed Diseases

1. When a water supply produces insufficient quantities to meet peoples' needs or when the water supply is located at a distance from the users. The availability of only small amounts of water makes the practice of good personal and household hygiene difficult, or even impossible.

2. When feces are not disposed of in a sanitary way. Uncovered or unprotected latrines or stools passed on the ground are breeding places for flies and sources of bacteria. Bacteria and viruses are passed from feces to people by flies, contaminated fingers and food. Food contamination with salmonella quickly grows great numbers of the bacteria. When eaten, the food causes food-poisoning diarrhea with life-threatening consequences, especially for small children.

3. When people are ignorant of the need for personal hygiene and, for whatever set of reasons, either do not bathe frequently or use the same water and towels to wash more than one person, then trachoma and conjunctivitis are passed around within a family or other groups living together and scabies get passed from the skin of one person to the skin of another.

Water-Contact Diseases (Body-of-Water Related)

Water-contact diseases are diseases which are transmitted when people have contact with infected water. The single most important water-contact disease is Schistosomiasis (blood fluke disease). It is very widespread in Asia, Africa and South America with hundreds of millions of people at risk of getting the disease and millions suffering from it. Figure 3 shows how schistosomiasis is transmitted. Briefly, transmission is as follows: Schistosome eggs passed in urine or feces fall into water where a first stage larva hatches. The first stage larva, to survive, must find and penetrate a specific type of snail. In the snail, the first stage larva changes into a large number of sacs in which many thousands of forked-tailed second stage larva are produced over a period of months to years. Each day, several hundreds of these second stage larvae escape from the snail to swim about in the water seeking the warm skin of a human hand or food into which to penetrate. Once through the skin, the little worm enters the person's blood stream, grows to maturity (worms are about a centimeter long), works its way into the blood vessels of the intestine and urinary bladder, and lays its eggs in the wall of those organs. The eggs then cut their way through the tissues to the inside of the intestine or bladder and are passed with the feces or urine. So the transmission cycle continues.

Schistosomiasis is transmitted in areas:

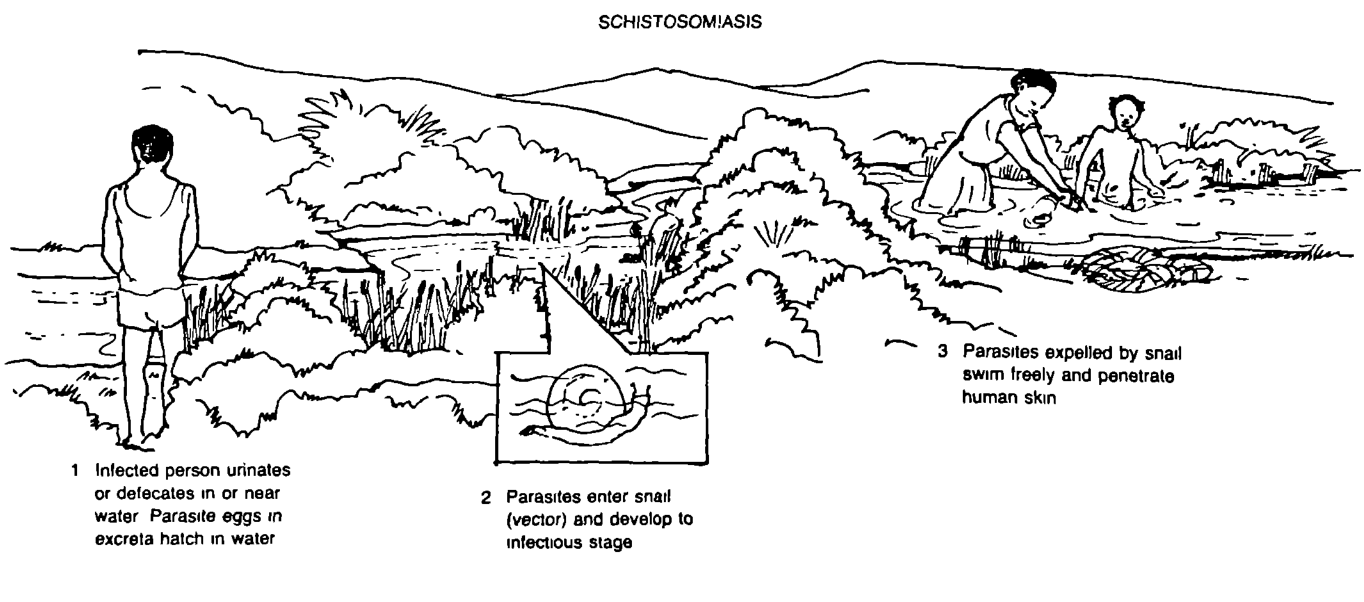


Figure 3. Transmission of Water-Bused/Water-Contact Diseases

1. Where poor sanitation is practiced so that feces or urine find their way into bodies of water that contain snails, or where rats or wild animals get the worms and keep the snails infected.

2. Where the appropriate type of snail is abundant and can become infected.

3. Where people enter infected water to bathe, wash clothes, dip up water, cultivate crops or swim.

4. Where irrigation projects or man-made lakes have extended the bodies of water in which snails can grow and have the chance to be infected from man or wild animals.

Water-Related/Insect Vector (Carrier) Diseases (Water Site Related)

Water-related insect vector diseases are those that are transmitted by insects which breed in or near water. Transmission occurs when the insect becomes infected with the disease organism from biting a person or animal, and then bites another person. The parasites are injected into the skin or bloodstream by the insect bite. The insects breed in water that is used as water supplies (streams and rivers) and, in the case of mosquitoes, in water storage jars, and water tanks, or in shaded high humidity areas near streams or lakes.

The most common diseases in this category are:

• African trypanosomiasis (sleeping sickness) which is transmitted by the tsetse fly which thrives on high humidity and breeds in river areas under lush vegetation growing at water sites.

• Onchocerciasis (river blindness) which is transmitted by blackflies which breed while attached to rocks and vegetation in fast-flowing rivers and streams. Figure 4 shows how onchocerciasis is transmitted.

• Malaria which is transmitted by female anopheline mosquitoes which breed in a wide variety of water collections.

• Arboviruses (yellow fever) which is also transmitted by mosquitoes. The type of mosquitoes that carries this disease is different from that which carries malaria. Mosquitoes that carry yellow fever breed in highly polluted stagnant water and usually rest in areas far from their breeding places.

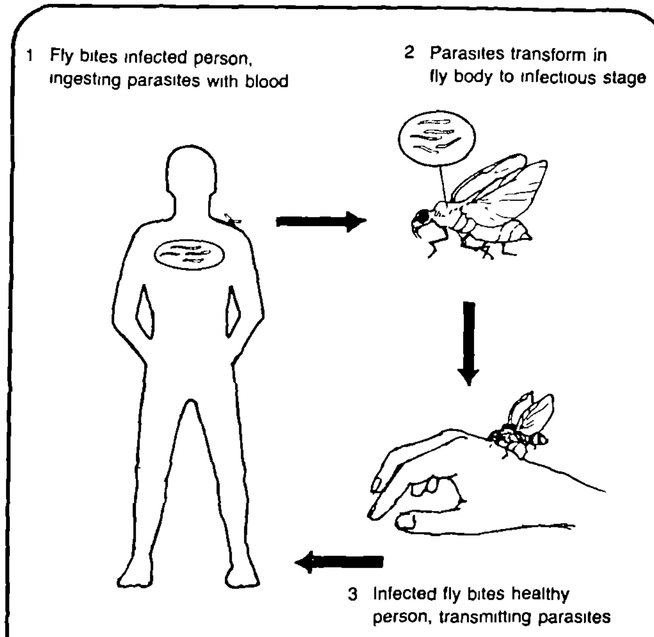


Figure 4. Transmission of Water-Related (Insect Carried) Diseases

• Filariasis which is a worm infection spread by mosquitoes. The mosquitoes that carry the parasite breed in any stagnant pond or pool or in water in cans, coconut husks, dishes, gutters or wherever water is standing.

The transmission of water-related insect vector diseases occurs in many types of situations in which the insect vectors are able to breed in large numbers, can bite persons infected with the protozoan or worm that causes the disease, and later, after the parasites have developed in them, have the opportunity to bite other people. In many situations, the water supply site where people come to get their water, is the place where the insects get their opportunity to bite both infected and other people. The household environment is also a place where some of these diseases are transmitted.

Sanitation-Related Diseases (Fecal Polluted Soil Related)

Sanitation-related diseases are specifically those that are transmitted by people lacking both sanitary facilities for waste disposal and knowledge of the need to dispose of wastes in a sanitary manner. The infective stage of the worm which causes those diseases develops in fecally contaminated soil. The most common diseases in this category are hookworm and roundworm.

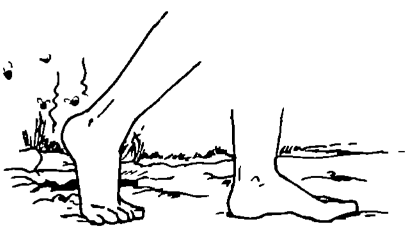
Hookworm larvae develop and live in damp soil that has been contaminated with feces containing hookworm eggs. They penetrate the bare feet of people walking or standing on the infected soil. See Figure 5. Entrance can also occur through the hands or other skin areas.

Roundworm or ascariasis is transmitted by swallowing eggs which have become infective by developing on polluted soil. The eggs are eaten by children who play on the infected soil, drop food on the soil and then eat it, or eat from dirty hands or eat contaminated raw vegetables.

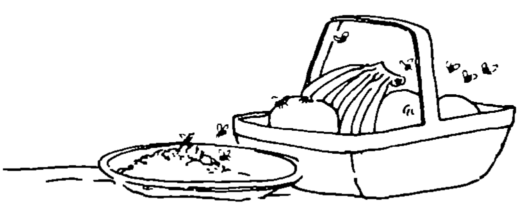
Both diseases occur:

1. Where there are not latrines and the soil is polluted, where latrines are not sanitary or where they are not used.

2. Where fresh untreated feces are used as fertilizer.



a Hookworm is transmitted through the feet of people walking barefoot in contaminated soil



b Roundworm is often transmitted by contaminated flies which land on food

Figure 5. Transmission of Sanitation-Related Diseases

3. Where people are not educated to wash their hands before eating.

Summary

This technical note has discussed several diseases which are common in many countries. They are all directly related to local environmental conditions and are all passed from person to person. The cycle, or chain of transmission, involves both direct transmission of the disease or else depends on an agent, or vector, for the transmission.

Once the chain of transmission is understood, means to break the chain should be adopted. Generally, relatively simple environmental measures need to be developed to stop the spread. The methods of doing this are discussed in "Methods of Improving Environmental Health Conditions," DIS.1.M.2.

Notes

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes see the introductory Note in the series, titled "Using 'Water for the World' Technical Notes " Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D C , 20523, U S A.

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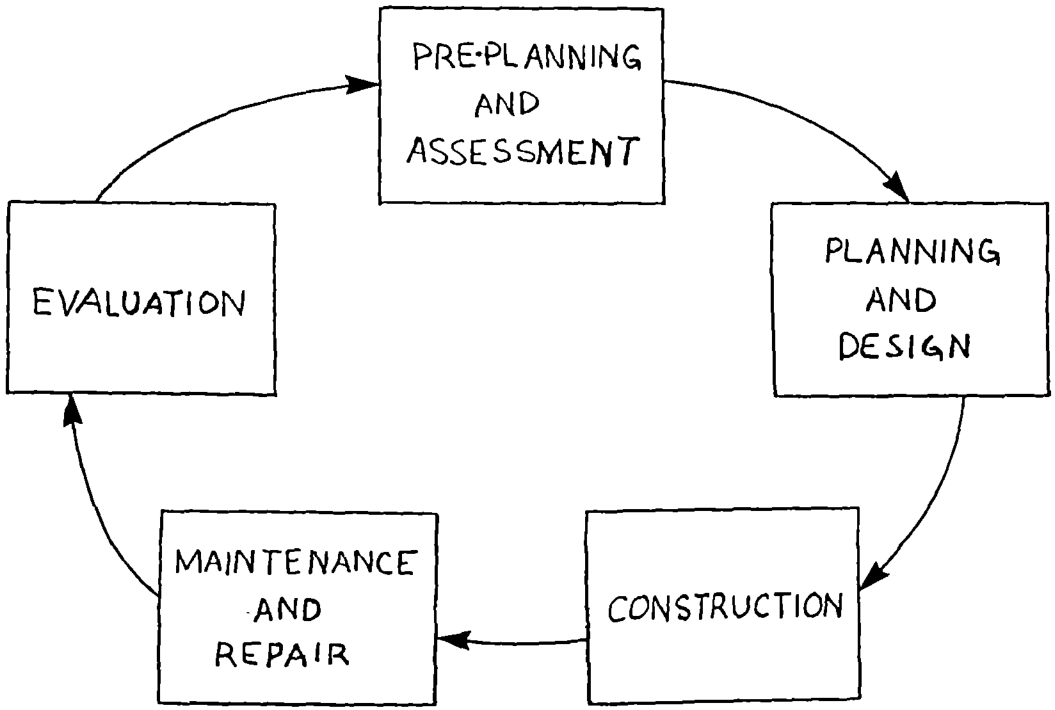
THE PROJECT CYCLE



PRE-PLANNING AND ASSESSMENT

- Meet with and explain handpump project to village leadership.
- Identify with community basic resources needed for a handpump project.
- Conduct with community initial village assessment for project feasibility, determine well recharge rate.
- Obtain commitment to handpump project from village.
- Make commitment to village regarding support.

PLANNING AND DESIGN

- Meet with local users to find out their concerns and desires regarding a handpump project.
- Rough design apron slab.
- Find material quantities and develop cost estimate for proposed wells.
- Present cost estimate for each well to village leadership, facilitate decision to proceed.
- Finalize apron design.
- Develop with community work plan for construction including materials, tools, labor and what to do with well users during construction.
- Facilitate procurement of materials, tools and labor (make sure everyone does their job to get ready for construction)

CONSTRUCTION

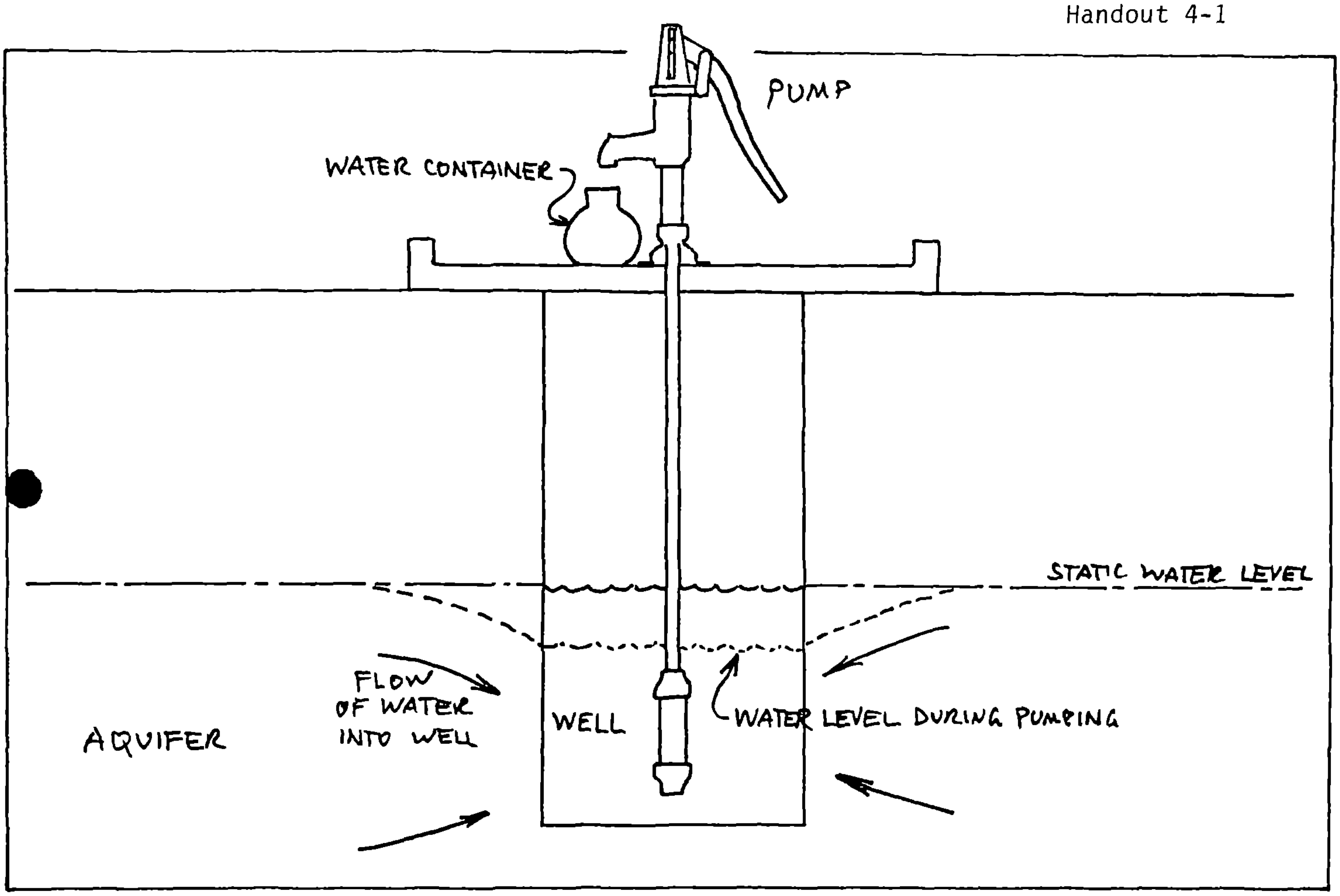
- Organize work force, assign responsibilities, explain construction tasks.
- Reline the well.
- Construct the apron, allow three days for curing.
- Finish the well site.
- Install pump.
- Disinfect well.

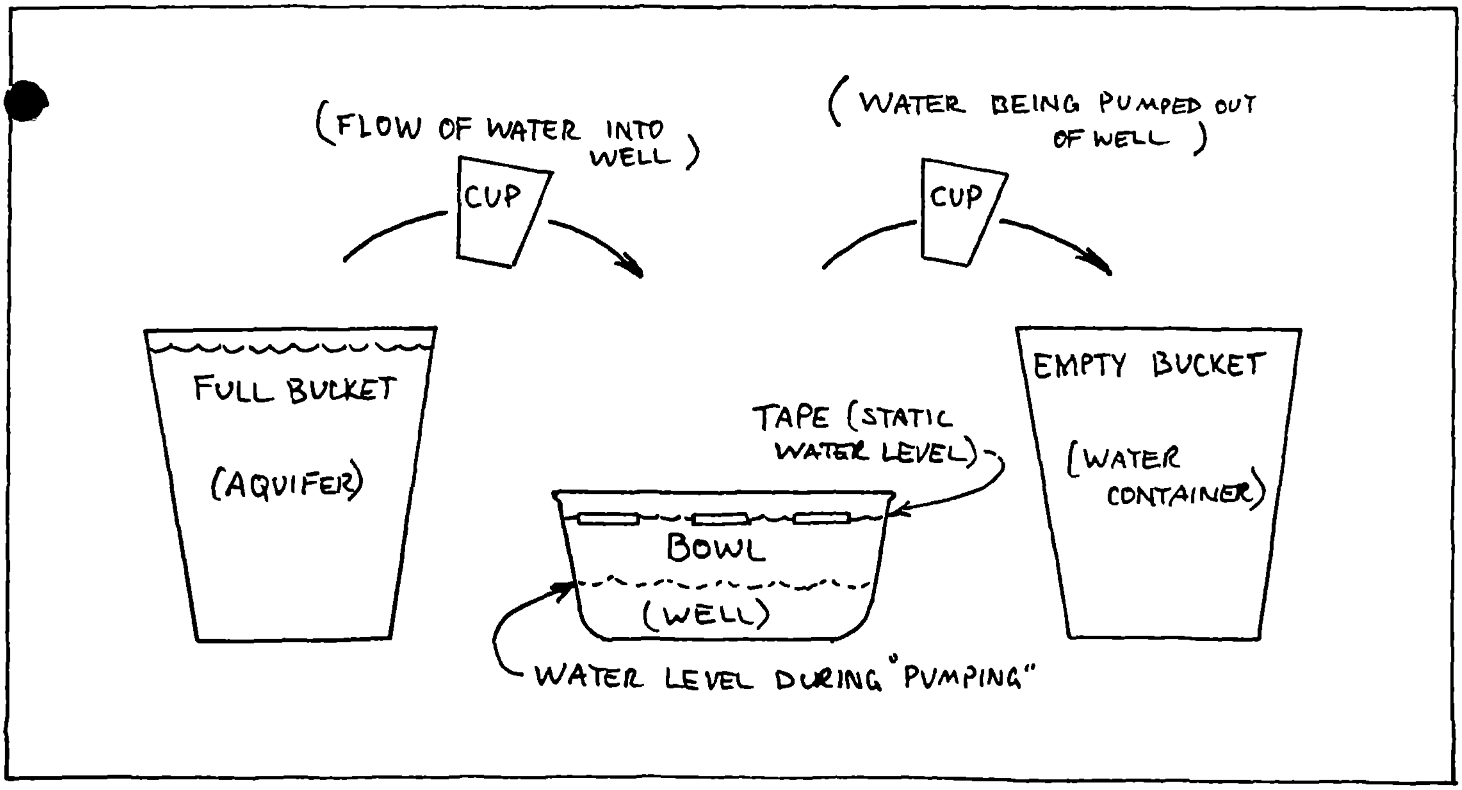
MAINTENANCE AND REPAIR

- Select caretakers with community.
- Train caretakers in maintenance, repair and disinfection.
- Design/implement with community necessary maintenance schedule.
- Train users in proper handling and storage of water, other user education.
- Be prepared to solve any operational problems that arise or make repairs.

EVALUATION

- Reflect on project with community, noting what changes should be made before beginning next handpump project.
- Determine ways to integrate handpump projects into other community health and sanitation programs.
- Identify future work for improving village water resources.





HOW RECHARGE DEMONSTRATION CORRESPONDS TO WELL

Water for the World

Selecting a Well Site
Technical Note No. RWS. 2.P.3

Selecting a well site properly is important to ensure that the well will tap into a reliable source of good quality ground water, and to ensure that the water will not be contaminated in the future. Selecting a site involves considering existing wells, local geography, quality and quantity of ground water, possible sources of contamination, accessibility to users, and proposed methods of well construction.

This technical note describes the main considerations in selecting a well site. Read the entire technical note before beginning the selection process.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

CONTAMINATE - To make unclean by introducing an infectious (disease-causing) impurity such as bacteria.

DRAWDOWN - The distance between the water table and the water level in a well during continued pumping.

GROUND WATER - Water stored below the ground's surface.

IMPERMEABLE - Not allowing liquid to pass through.

PERMEABILITY - The ability of soil to absorb liquid.

POROSITY - A soil's ability to store water.

WATER TABLE - The top, or upper limit, of an aquifer.

General Information

If possible, the well site should be selected by a qualified engineer who has made a thorough field investigation. This investigation may be expensive and time-consuming, but it is one of the most important steps in developing a source of ground water. The investigation, or part of it, may have been done during the earlier planning stages. See "Planning How to Use Sources of Ground Water," RWS.2.P.1.

Whether an engineer or someone else selects the site, a map of the village and surrounding area should be obtained or produced. Add to the map all relevant features discussed in this technical note. See Figure 1.

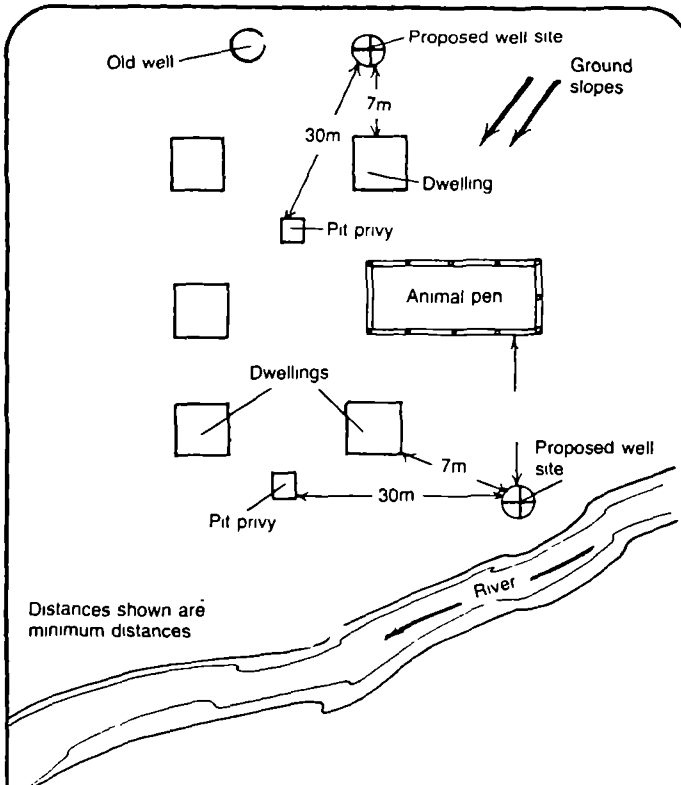


Figure 1. Location Map

Existing Wells

The primary objective when sinking a new well is to sink it where ground water is likely to be found. Existing wells are the best indication of the presence of ground water. Where possible, sink a new well near an old one--ground water will probably be reached at about the same depth. The history of the old well will provide information on seasonal changes in the water table, which may indicate that the new well should be deeper than the old one.

If the new well is to be used in addition to the old one, care must be taken not to sink it too close to the existing well. Otherwise, the yield of one or both wells may be adversely affected. This is due to the effect that a well has on the surrounding water table.

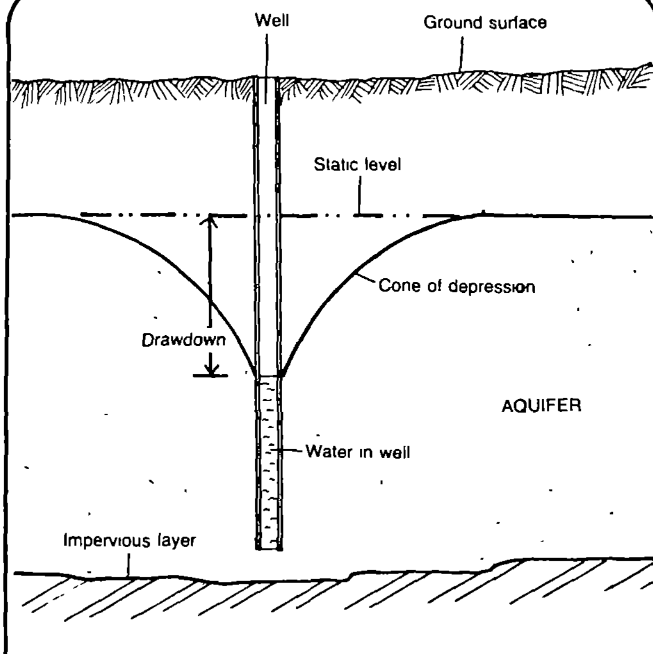


Figure 2. Cone of Depression

When water is pumped or lifted out of a well, the water level in the well falls below the original level, called the static level, until it stabilizes at a new level, called the pumped level. The distance between the static level and the pumped level is the drawdown. The water table surrounding a well curves down to the pumped level, forming a cone of depression. See Figure 2. If the cones of depression of two wells overlap, the pumped level in one or both wells will be lowered and the yield will be decreased. Draw all existing wells on your map, similar to Figure 1.

Local Geography

If no wells exist, the presence of ground water can be indicated by surface water, topography, and certain types of vegetation.

<u>Surface water</u>. A successful well can generally be sunk near a river because the river will replenish the ground water and reduce changes in the water table. Water taken from such a well is usually cleaner and cooler than water taken from the river. If the well is deep, water may be available even when the river is temporarily dry.

<u>Topography</u>. Ground water gathers in low areas. Therefore, the lowest ground is generally the best place to sink a well. In hilly areas, valley bottoms are the best places for wells. An exception to this could be where there is a spring on the side of a hill. The spring may indicate lateral movement of ground water over a layer of impermeable soil. If so, a successful well could be sunk uphill from the spring. This may have the advantage of bringing the source of water closer to the community or dwelling.

On your map, draw all rivers, springs, and topographical features.

<u>Vegetation</u>. Certain types of vegetation can indicate that ground water lies near the surface. The most useful indicators of ground water are perennial plants (those present year-round), especially trees and shrubs. Annual plants, such as grasses, are not good indicators, because they come and go with the seasons. The dry season is probably the best time to survey vegetation for indications of ground water.

Quality of Ground Water

Once ground water is located, its quality must be tested before constructing permanent wells. The water must be clean, clear, and good-tasting, and be free from disease-causing organisms. For information on testing water, see "Determining the Need for Water Treatment," RWS.3.P.1, and "Analyzing a Water Sample," RWS.3.P.3. If the ground water is contaminated, another source may have to be found.

Quantity of Ground Water

The quantity of a groundwater source is nearly as important as its quality. Unfortunately, the only way to test the yield of an aquifer is to dig a well and pump it. See "Testing the Yield of Wells," RWS.2.C.7. You can, however, make a rough estimate of the yield by identifying the sediment and rock which compose the aquifer.

The two most significant elements of an aquifer are its porosity and permeability. Porosity governs the amount of water that an aquifer can contain. Permeability governs the amount of water that can be brought to the surface. For example, some aquifers may contain large quantities of water, but their rate of yield is too slow to suit the needs of the user. Porosity and permeability depend on a number of factors including particle size, arrangement and distribution.

Table 1 shows the estimated yields of aquifers composed of different types of sediment. The table should not be used for exact calculations but only for indications of yield.

Table 1. Estimated Yields of Aquifers

Sediment Composing the Aquifer	Estimated Yield (liters per minute)
Sand and gravel	11400; could be less based on pump and well design
Sand, gravel, and clay	1900-3800
Sand and clay	1900
Fractured sandstone	1900
Limestone	38-190; more if near stream, or if there are underground caverns
Granite or hard rock	38 or less
Shale	less than 38

If the quantity of ground water is insufficient, another well site will have to be found. The new site may replace or supplement the old site.

Possible Sources of Contamination

A well should not be dug in areas where the ground water is likely to be contaminated. A well site should be uphill and at least:

50m from a seepage pit or cesspool;
30m from a subsurface absorption system;
30m from a pit privy;
30m from animal pens, barns, or silos;
15m from a septic tank;
7m from a drain, ditch, or house foundation.

The well site should not be subject to flooding during the wet season or any other time. This will be of greatest concern where the well is in a low area or near a river that yearly overflows its banks. The site can be protected from flooding by building small dams or ditches to prevent flooding the well. If not, another site should be considered.

Draw all possible sources of contamination on your map, as in Figure 1.

Accessibility to Users

The well site should be as close as possible to the village or dwelling. As the distance between the well and the user increases, the per capita water consumption decreases. This is shown in Table 2. The table should not be used for exact calculations but only for indications of consumption.

Political considerations may influence accessibility. There may be pressure to put the well near the dwelling of the village chief or other influential member of the community. A compromise may be necessary.

Methods of Well Construction

The proposed method of well construction must be suitable to the soil conditions at the well site. If not, another site must be found or another method of construction must be considered. Table 3 shows some of the limitations of well construction methods based on soil conditions. For more information, see "Selecting a Method of Well Construction," RWS.2.P.2.

Table 2. Water Consumption and Distance to Water Source

Distance to Source	Estimated Consumption (liters per person per day)
More than 1000m	7
500-1000m	12
Less than 250m	20-30
In the yard of the dwelling	40

Table 3. Well Construction Methods and Soil Conditions

Construction Method	Unsuitable Soil
Hand Dug	Hard rock, large boulders
Driven	Hard rock, heavy clay, boulders, coarse gravel
Jetted	Hard rock, boulders
Bored	Hard rock, boulders larger than auger
Cable Tool	None

Summary

When all alternative well sites have been determined, draw them on your map, as in Figure 1. Then select the best site. When examining a site, you will no doubt find that even though it may rate well in some ways, it rates poorly in others. Selecting the best site is often a matter of judgment and experience. You must weigh the relative advantages and disadvantages of each site. Figure 3 is a simplified example of four alternative sites from which a village must select one.

Site #1 would allow easy access to ground water because the water table lies close to the surface of the ground. However, limited water would be available because the layer of impermeable rock also lies near the ground surface. Thus, slight fluctuations in the water table would drastically affect the availability of water.

Site #2 is the site closest to the village, and therefore has the greatest accessibility. However, the water table is quite deep and may be difficult to reach. The aquifer cannot be penetrated too deeply, because of the position of the impermeable layer.

At Site #3, the aquifer can be reached without digging very far down. The aquifer can be deeply penetrated. This would ensure a reliable water source. However, the site is some distance from the village, and below the homes.

At Site #4, the most water can be reached with the least difficulty. The site is at the greatest distance from the village. It is in a low spot that may be subject to flooding.

Each site has advantages and disadvantages. The project director, the villagers, and the village leaders must decide which site is best for the community.

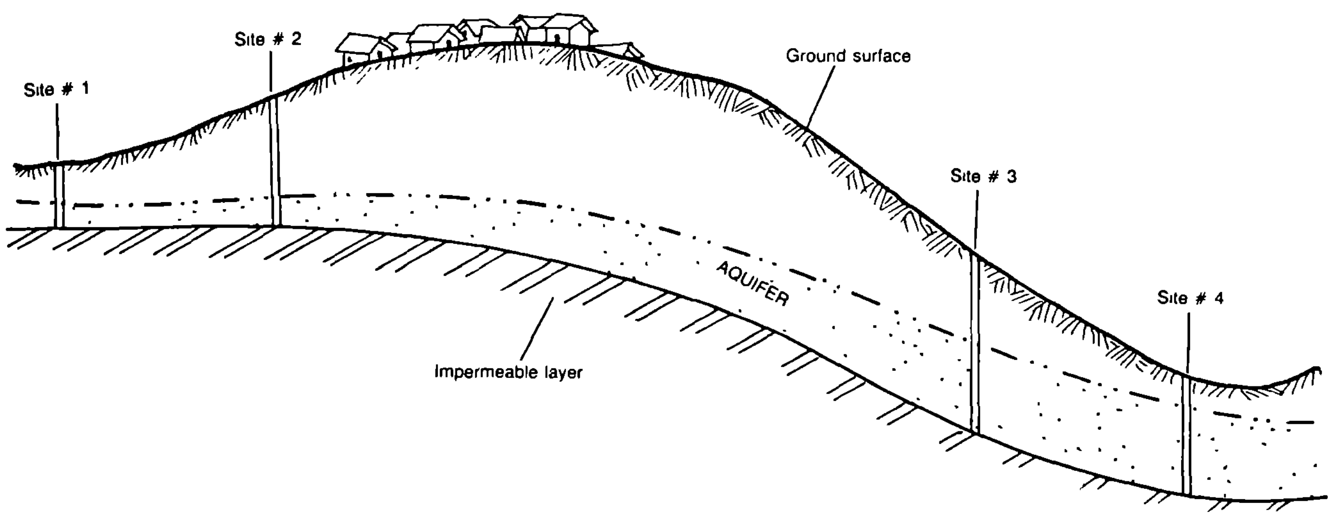


Figure 3. Alternative Well Sites

Notes

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service *Technical Notes* are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the *series, titled* ' Using 'Water for the World' Technical Notes " Other parts of the ' Water for the World ' series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency *for International* Development, Washington, D C , 20523, U S A

Well Recharge Rate

Drilled Wells

Well Diameter, Millimeters	Well Recharge Rate (Liters/Minute)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
80	20	40	60	80	100	120	140	160	180	200	220	240	260	280
100	13	25	38	51	64	76	90	100	110	130	140	150	160	180
150	6	11	17	23	28	34	40	45	51	56	62	68	73	79
200	3	6	9	13	16	19	22	25	29	32	35	38	41	44
250	2	4	6	8	10	12	14	16	18	20	22	24	26	28
300	2	3	4	5	7	8	10	11	13	14	15	17	18	20

Distance water rose in well in one minute (To nearest cm)

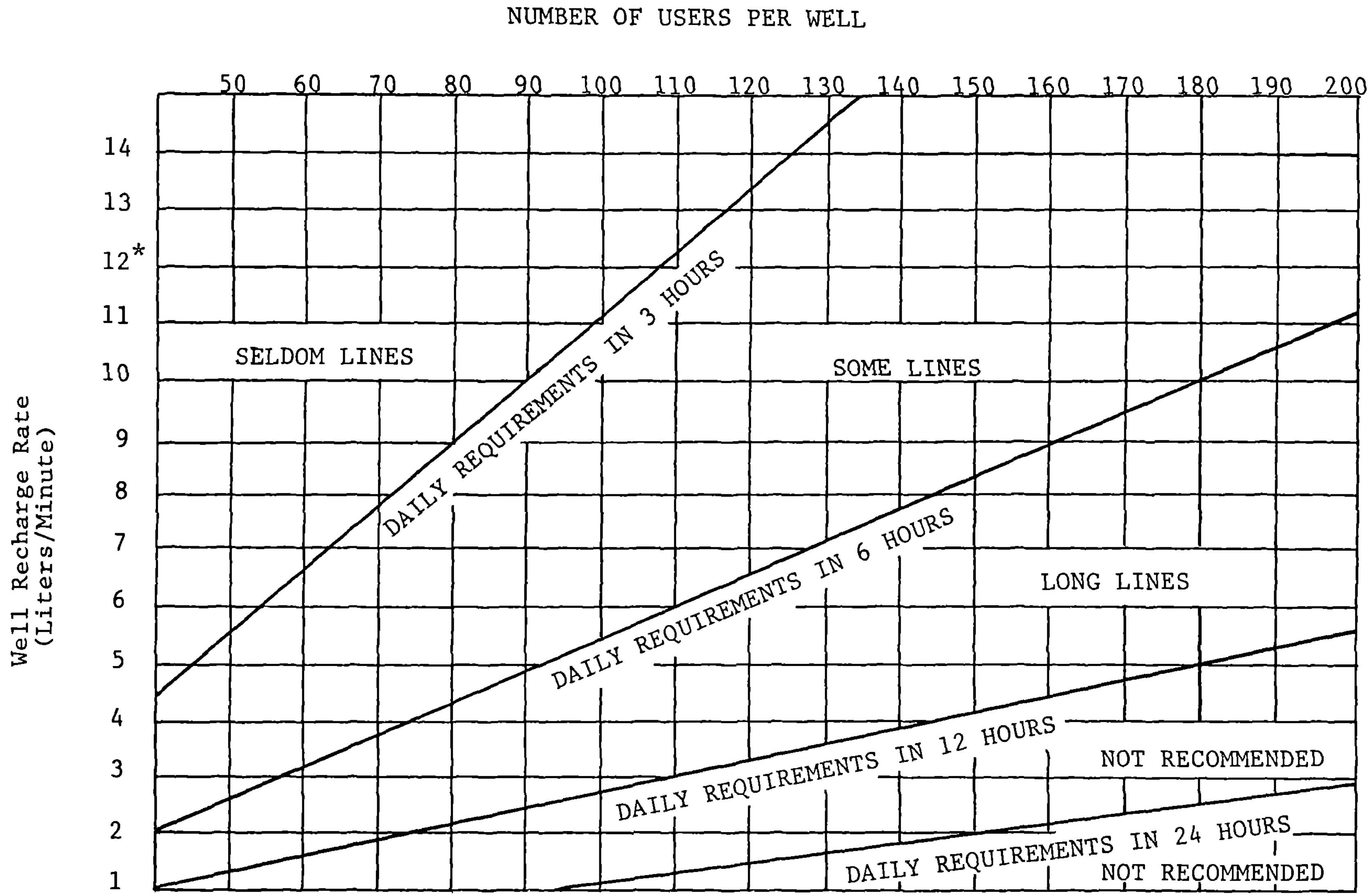
Dug Wells

Well Diameter, Meters	Well Recharge Rate (Liters/Minute)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	1	2.5	4	5	6.5	7.5	9	10	11.5	13	14	15	16.5	18
1.25	-	1.5	2.5	3	4	5	6	6.5	7	8	9	10	10.5	11.5
1.5	-	1	2	2.5	3	3.5	4	4.5	5	5.5	6	7	7.5	8
1.75	-	-	1	1.5	2	2.5	3	3.5	3.5	4	4.5	5	5.5	6
2.0	-	-	1	1.5	1.5	2	2	2.5	3	3	3.5	4	4	4.5
2.5	-	-	-	-	1	1	1.5	1.5	2	2	2	2.5	2.5	3
3.0	-	-	-	-	-	-	1	1	1.5	1.5	1.5	1.5	2	2

Distance water rose in well in 10 minutes (To nearest 1/2 cm)

SUITABILITY OF WELL RECHARGE RATES FOR VARIOUS NUMBERS OF USERS

(Based on 20 Liters/Person/Day With Minimal Water Storage in Well)



*Above 12 liters/minute the rate at which water can be pumped into containers becomes an influential factor in the formation of lines.

Problems of Determining Well Recharge Rate

1. An 80 mm diameter drilled well is pumped for 360 strokes. After pumping the well water was allowed to rise for one minute. The static water level was 6 meters below the surface. When pumping stopped, the water level was 62 meters below the surface. The water level rose to 59-1/2 meters in the minute immediately after pumping stopped. What is the well recharge rate? Two hundred people will use the pump. Is the recharge rate sufficient?

2. The static water level of a 1.25 meter diameter dug well is 2.10 meters (210 cm) below the surface. A pump is installed and pumped for 360 strokes. The water level immediately after pumping was 2.73 meters (273 cm) below the surface. In the ten minutes after pumping the water rose 6 centimeters. What is the recharge rate? If the users will only tolerate short waits at the well for water, what is the maximum number of people who can use the pump?

3. A village of 100 has a 20-year-old drilled well on which the pump has broken. It is 200 mm in diameter and the static water level is at 30 meters. A pump is temporarily installed on the well and pumped for 360 strokes. The water level is recorded at 41.45 meters after pumping and recorded again at 41.32 meters one minute later. Should the village use this well as their primary water source? What will happen if they do?

4. A 1-1/2 meter diameter dug well is pumped with a handpump for 360 strokes. The water level drops 4 cm from the static water level of 3.35 meters by the end of the 360 strokes. After 10 minutes, the water level is again 3.35 meters from the surface. What is the well recharge rate?

Answers to the Problems of Determining Well Recharge Rate

Problem #1:

The water in the well rose 2 1/2 meters (250 cm) during the minute following pumping. Judging from the recharge rate chart, the recharge rate for an 80 mm diameter well with the above rise in water level is about 12-1/2 liters/minute. The recharge rate is sufficient for 200 people.

Problem #2:

The recharge rate for a 1.25 meter diameter well with a rise after pumping of 6 centimeters is 7 liters/minute. With less than 120 users, some lines will occur at the pump site while the well recharges. For over 120 users, lines wil probably occur frequently.

Problem #3:

The difference in water levels from the end of pumping until one minute later is 13 cm. For a 200 mm diameter well the recharge rate is 4 liters/minute. The village of 100 should expect long lines while the well is recharging. The village should look into further developing the well or drilling it deeper.

Problem #4:

The charts do not apply to this problem because the water level rose more than two-thirds of the distance back to the static water level in the period after pumping stopped. The recharge rate is therefore sufficient for at least 200 people if the pump used to test the recharge rate is the same as will be installed on the well.

Water for the World

Constructing Hand Dug Wells
Technical Note No. RWS. 2.C.1

Proper construction of a hand dug well is important to ensure a year-round supply of water and to protect the water from contamination. Construction involves assembling all necessary personnel, materials, and tools; preparing the site; excavating the well shaft; and lining the shaft. Finishing the well is discussed in "Finishing Wells," RWS.2.C.8.

There are several good methods to construct a hand dug well; if you are familiar with a specific method, use it. This technical note describes one method of construction, using locally available materials, that has been employed successfully in a number of countries. Read the entire technical note before beginning construction.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

CONTAMINATE - To make unclean by introducing an infectious (disease-causing) impurity such as bacteria.

GROUND WATER - Water stored below the ground's surface.

KIBBLE - A large bucket for lifting materials when sinking a shaft; also called a hoppit or sinking bucket.

POROUS - Having tiny pores, or spaces which can store water or allow water to pass through.

WATER TABLE - The top, or upper limit, of an aquifer.

Materials Needed

The project designer must provide three papers before construction can begin:

1. A <u>location map</u> similar to Figure 1.

2. A <u>design drawing</u> similar to Figure 2.

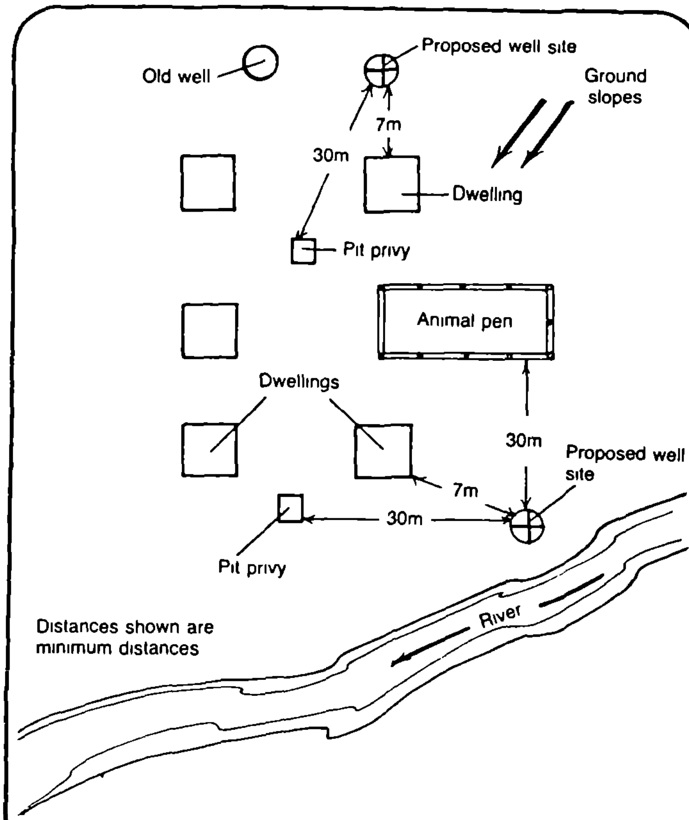


Figure 1. Location Map

3. A materials list similar to Table 1.

After the project designer has given you these documents and you have read this technical note carefully, begin assembling the necessary workers, supplies, and tools.

Construction Schedule

Depending on local conditions, availability of materials, and skills of workers, some construction steps will require only a few hours, while others may take a day or more. Read the construction steps and make a rough estimate of the time required for each step based on local conditions. You will then have an idea of when specific workers, materials, and tools must be available during the construction process. Draw up a work plan similar to Table 2 showing construction steps.

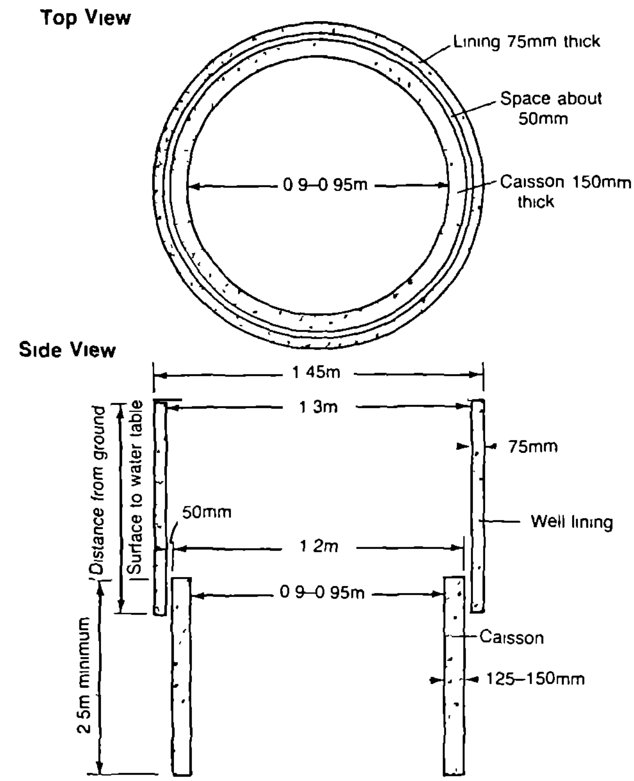


Figure 2. Design of Well Lining and Caisson

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Personnel	Foreman	1	____
	Worker, skilled in sinking well	1	____
	Worker, experienced with concrete	1	____
	Workers, unskilled	2-4	____
Supplies	Cement (Portland)	____kg	____
	Sand (clean; fine to 6mm)	____m3	____
	Gravel (clean; 6-36mm)	____m3	____
	Water (clean and clear)	____	____
	Re-rod for lining: 8mm diameter	____m	____
	Re-rod for caissons: 15mm diameter	____m	____
	Materials for storage shed	____	____
Equipment	Headframe	____	____
	Rope for caissons; 100m x 12mm diameter, steel wire with fiber core, tensil strength 7kg/cm^2	____	____
	Rope for kibbles: 100 x 6mm diameter	____	____
	Rope for trimming rods: 100m x 3mm diameter	____	____
	Steel shutters (1.3m diameter x 0.5m high) with wedges and bolts	____	____
	Steel shutters (1.3m diameter x 1.0m high) with wedges and bolts	____	____
	Steel molds for caisson rings (1.2m outside diameter, 0.95m inside diameter, 0.5m high)	____	____
	Templates for molds	____	____
	Stretcher for caissons	____	____

Total Estimated Cost = ____

Table 2. Sample Work Plan for a Hand Dug Well

Time Estimate	Day	Task	Personnel	Materials/Tools
1 day	1	Locate and prepare well site, assemble materials	Foreman (present during entire construction), 2-4 workers	Measuring tape; drawings, tools and materials for building shed
1 day	2	Erect headframe; set center point and offset pegs; build mixing slab	2-4 workers	Headframe; plumb bob, re-rod; cement, sand, gravel, water; trowel
4 hours	3	Dig shallow excavation; install temporary lining	2-4 workers	Shovels, shutters (1.3m diameter, 1.0m high) spirit level
7 days	3-9	Excavate and trim first lift	4 workers	Shovels; picks; mattock, kibble; top plumbing rod; trimming rods
2 hours	10	Install first set of shutters	4 workers	Shutters (1.3m diameter, 0.5m high); spirit level, trimming rods, shovel
6 hours	10	Install vertical and horizontal re-rods	4 workers	Lengths of re-rod, binding wire; spacing blocks and holding hooks; wire cutters
1 day	11	Install second set of shutters; pour concrete; build curb	4 workers	Oiled shutters (1.3m diameter, 1.0m high), cement, sand, gravel, water, tamping rod, re-rod, burlap covering, mattock
1 day	12	Install third and fourth sets of shutters; pour concrete	4 workers	Sets of oiled shutters, cement, sand, gravel, water
2 days	13-14	Widen top of well; add re-rods; install fifth and sixth sets of shutters; pour concrete, bend back rods and cover with layer of weak mortar	4 workers	Burlap covering; mattock, re-rod; binding wire, sets of oiled shutters, cement, sand, gravel, water
---	---	Construct second and third lifts and lining as needed	4 workers	Materials and tools as needed
1 day	15	Build caisson rings	4 workers	Molds, re-rods, oiled pipes; templates, cement, sand (none if porous concrete), gravel, water
10 days	16-25	Cure caisson rings	----	Wet burlap or straw
2 days	26-27	Install caisson rings	4 workers	Stretcher; spacers, heavy planks, wrench, mortar; trowel
2 days	28-29	Sink caissons into aquifer	4 workers	Shovels, kibble
2 hours	30	Install base plug	4 workers	Precast base plug

Caution!

1. Workers in the well shaft should wear hard hats for protection.

2. Workers at ground level must be careful not to accidentally drop or kick tools or other materials into the well shaft.

3. A kibble, rather than a bucket or basket, should be used to hoist soil out of the shaft.

4. The well must be dug at the exact location specified by the project designer.

Construction Steps

1. Using the location map and a measuring tape, locate the well site. Clear the area of any vegetation or debris that might interfere with work.

2. Assemble all laborers, materials, and tools needed to begin construction and arrange the materials in a fashion similar to Figure 3. A proper layout will save time and effort during later construction steps. A shelter should be built to protect tools and some materials from the weather, theft, or being misplaced.

Because the caisson rings must be cured for at least 10 days before they can be lowered into the well shaft, build them first even though they will not be needed until later in the construction process. See step #26.

3. Erect the headframe over the site of the well. The headframe must be sturdy enough to support the caisson rings, which may weigh over 350kg. One type of headframe that has been used successfully is shown in Figure 4. It is made of angle iron and equipped with a winch and brake. The four feet of the headframe must rest on solid ground--place stone slabs or pour concrete under them if necessary. It is important that the headframe not be moved once it is in position and the center point of the well has been fixed.

4. Build a slab for mixing concrete by first leveling an area about two meters square. Spread 50mm of well-tamped gravel, cover with a layer of cement mortar (4 parts sand to 1 part cement), and smooth with a trowel. Form a lip around the outer edge, cover the slab with wet burlap or straw, and keep moist for two or three days.

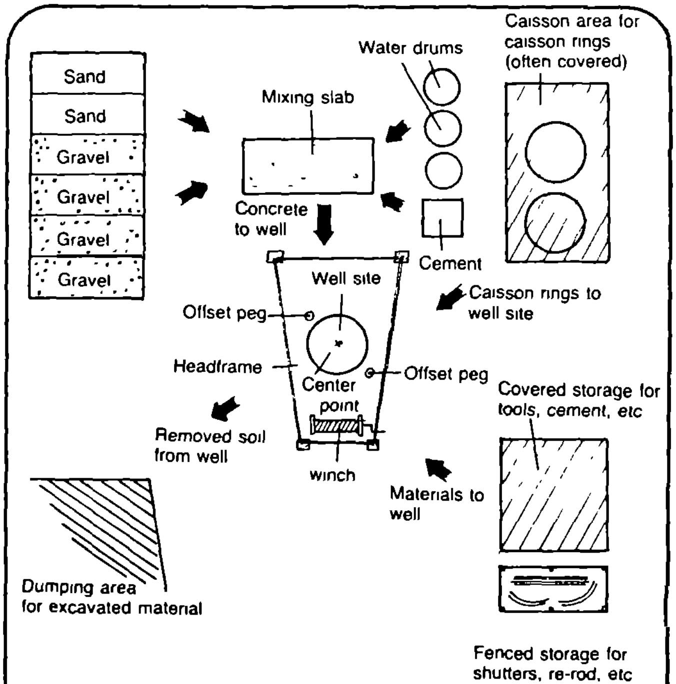


Figure 3 Layout of Well Site

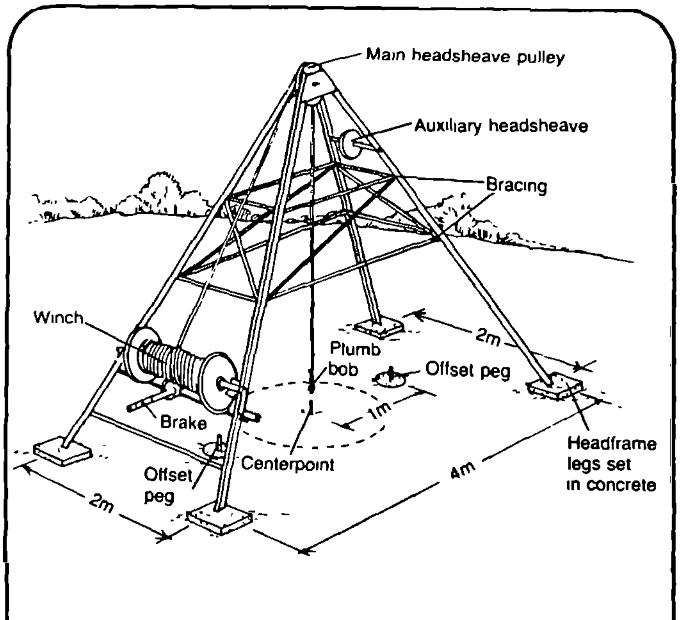


Figure 4. Headframe

5. Establish the center point of the well by lowering a plumb bob from the headsheave pulley on the side opposite the winch; that is, the side from which the main hoisting rope will descend. Mark this point on the ground with a short length of re-rod. Set offset pegs on opposite sides and exactly 1.0m from the center point. Make the top of these pegs at least 150mm above ground level to make allowance for the temporary lining that will be installed. These pegs should be set in concrete and positioned so that the top plumbing rod will fit over them as in Figure 4. Allow the concrete to set for several days before using the pegs.

6. Mark a circle of 650mm radius around the center point. Carefully excavate within this circle to a depth of 0.9m. Position a set of steel shutters 1.3m in diameter and 1.0m high inside this hole with 100mm projecting above ground to act as a temporary lining. See Figure 5. Be certain tha the shutters are exactly in place and that the top is level. Firmly tamp soil around the outside. These shutters will prevent the top of the shaft from crumbling, and they will reduce the risk of tools or materials being accidentally kicked into the shaft.

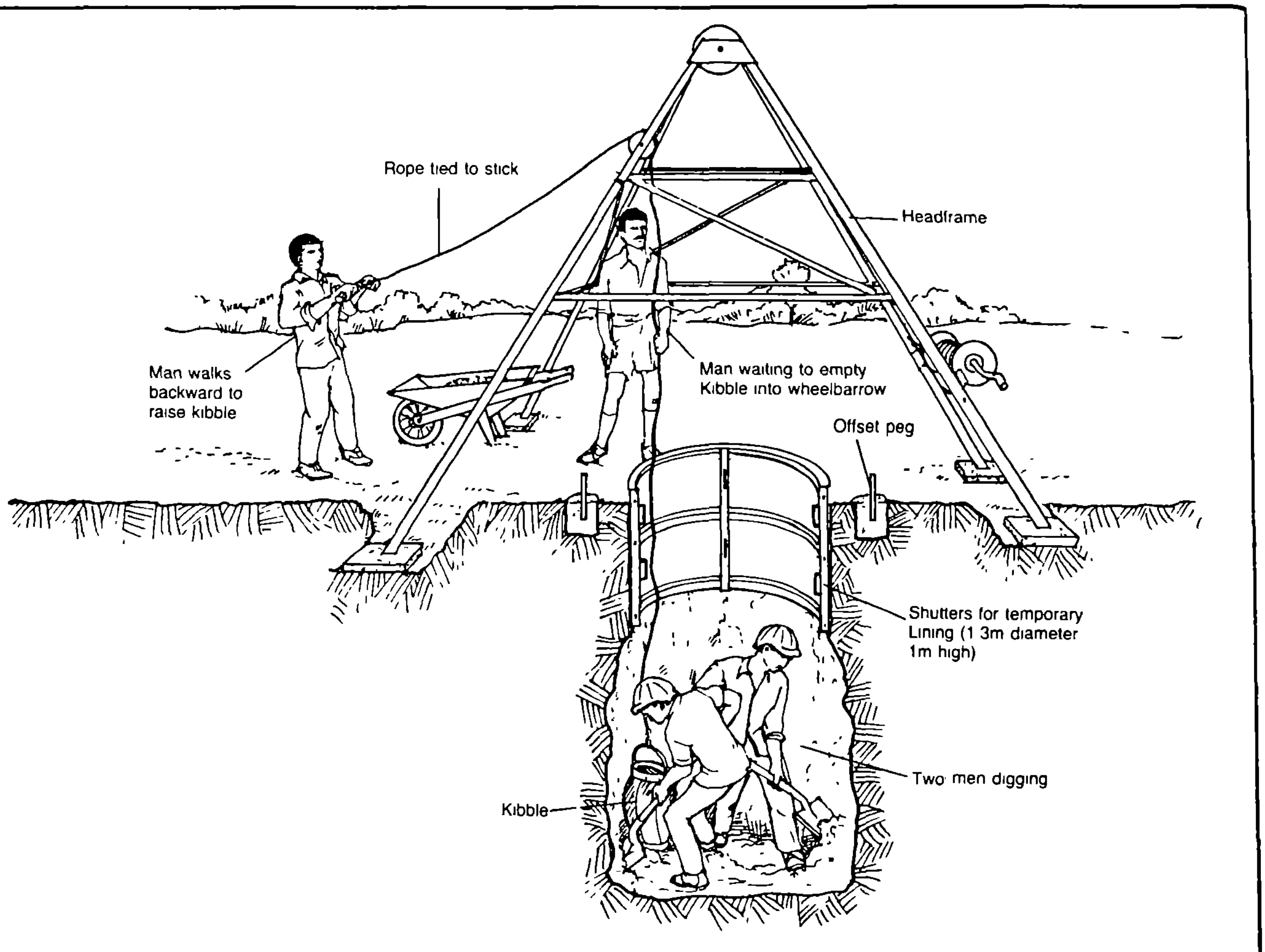


Figure 5. Excavating the Shaft

7. Begin excavating the first lift of the well. Normally, two workers using miner's picks and bars and short-handled shovels excavate the soil in layers about 100mm deep, and they keep the bottom of the excavation fairly level at all times. Soil is removed by hoisting it up in a kibble, as shown in Figure 5. The shaft is dug somewhat less than its finished diameter of 1.45m.

Every meter or so the long trimming rods, 1.45m long, are suspended from the top plumbing rod. The workers carefully trim the walls of the shaft so that the trimming rods can freely turn with their ends just missing the shaft walls, as shown in Figure 6. It is important that the trimming be done with extreme care, for even a small addition to the thickness of the lining will increase the amount of concrete used.

Depending on the condition of the soil, the first lift can be dug as deep as 5.0m, 4.1m below the bottom of the temporary lining. If the soil is crumbly or tends to cave in, the lift must be shallower. If water is struck, stop the excavation and proceed to step 25.

8. A set of shutters, 1.3m in diameter and 0.5m high, is oiled and then lowered to the bottom of the shaft. Set the shutters precisely in place by suspending the short trimming rods 1.3m long and lining up the edges of the shutters directly beneath the ends of the rods. Use a spirit level to be certain that the shutters are level. It is essential that these shutters be exactly in place and perfectly level, or else the entire lining will be out of line. See Figure 7.

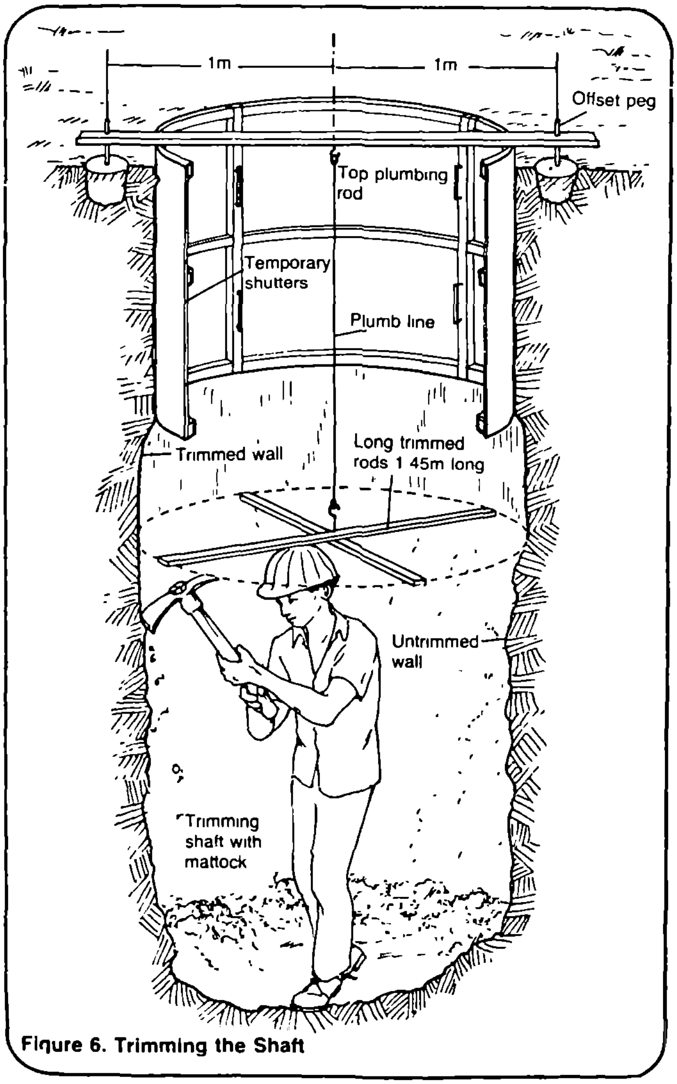


Figure 6. Trimming the Shaft

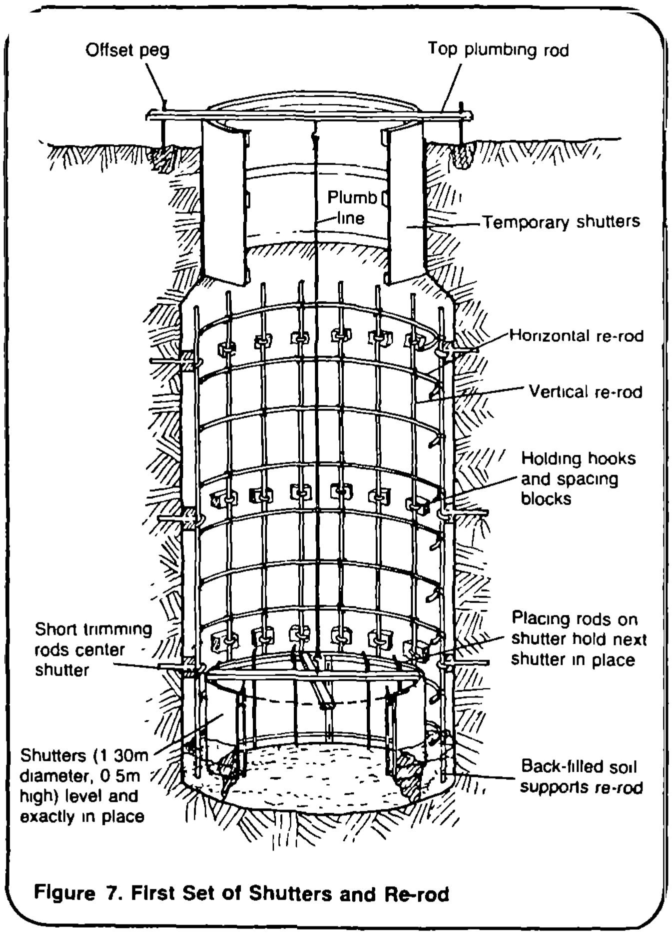


Figure 7. First Set of Shutters and Re-rod

9. Position 20 lengths of vertical re-rod, each length 4.0m long and 8mm in diameter, behind the shutters and around the shaft walls. Fix the rods to the walls about 200mm apart using spacing blocks and holding hooks. Backfill behind the shutters with soil to help hold the rods in place, as shown in Figure 7.

10. On the surface, shape horizontal re-rods into circles 1.38m in diameter. You will need three or four horizontal re-rods for each meter of depth. Lower the re-rods and fasten them to the inside of the vertical re-rods about 250-300mm apart, as shown in Figure 7. They will make the reinforcement cage strong and secure. Use a wire brush to remove all dirt from the re-rods.

11. Oil a set of shutters, 1.3m in diameter and 1.0m high, lower it into the shaft, and position it on top of the first set. Center the shutters with the short trimming rods, 1.3m long, check them with a spirit level, and bolt them in place, as shown in Figure 8.

12. Mix concrete on the mixing slab. Use one part cement, two parts sand, four parts gravel, and enough water to make a workable mix. Lower the concrete in a concrete bucket tied to a rope over the auxiliary headsheave. The main headsheave and a bosun's chair will be used later to raise and lower the workman pouring concrete. When lowering the bucket, be careful that it does not catch on any projection and spill its contents on the workers below.

Pour the concrete behind the shutters as shown in Figure 8. Pour it evenly and in shallow layers to prevent overloading one side. Tamp with a length of re-rod. Fill the space between the shutters and the shaft walls until the concrete is 10-20mm from the top of the shutters, and leave the top of the concrete rough. This will ensure a good bond with the next pour.

13. Temporarily cover the concrete with burlap or other material to keep off soil. Carefully excavate a triangular-shaped groove, 200mm deep and 200mm high at the well face, around the shaft walls just above the shutters. Set re-rod pins into the groove and fasten to the vertical re-rods. Remove the temporary cover. Fill in the groove with concrete as shown in Figure 8. This forms a curb which wil help hold the lining in place and prevent it from slipping.

14. Oil the third set of shutters, 1.3m diameter and 1.0m high, lower it into the shaft, and position it on top of the second set. Center the shutters with the short trimming rods, check them with the spirit level, and bolt them in place. Pour concrete as before, and tamp to be certain all voids are filled with concrete.

15. Oil a fourth set of shutters and repeat the process of lowering and positioning them and pouring concrete as shown in Figure 8.

16. The top of the fourth set of shutters will be about 600mm below the bottom of the shutters being used for temporary top lining. Cover the concrete with burlap to keep off soil and remove the temporary lining. Excavate the sides of the well to a diameter of 1.6m from the surface of the ground down to the top of the fourth shutter. Attach lengths of vertical re-rod to the re-rod already in place. Bend the ends of all re-rods into hooks and overlap the lengths by

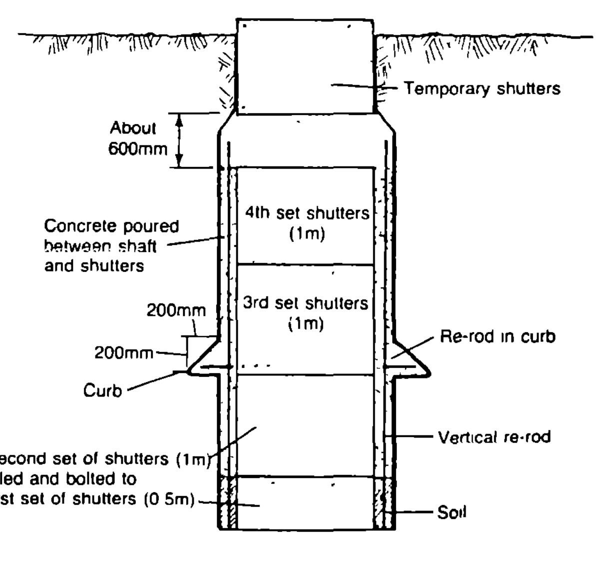


Figure 8. Shutters and Curb

at least 200mm as shown in Figure 9. The new re-rods should protrude above ground about 200mm. Position circles of horizontal re-rods 250-300mm apart and fasten them to the vertical re-rods. Remove the burlap from the concrete.

17. Oil the fifth and sixth sets of shutters in turn, set them in place, check their positioning with trimming rods and a spirit level, and bolt them together. Pour concrete as before, and carefully fill in the space behind the shutters up to ground level as shown in Figure 9. The extra thickness of concrete in the top 1.5m of the lining will provide a solid base for the wellhead. See "Finishing Wells," RWS.2.C.8.

18. Bend back the protruding vertical rods until they are level with the ground. Make a weak mortar mix (1 part cement to 15 parts sand), and use it to cover the re-rods and form a lip around the well as shown in Figure 9. This mortar layer will help keep surface water and debris out of the well, and it can be easily broken away when it is time to build the wellhead.

The first lift is now complete. Leave the shutters in place for about seven days to allow the concrete lining to cure. If you have more shutters, you can begin the second lift at once, leaving the first lift shutters in place. If not, you will have to wait seven days before beginning the second lift.

19. To begin the second lift, remove the earth-filled shutter at the bottom of the first lift, and clean the re-rods with a wire brush.

20. Excavate the second lift to a depth of 4.65m below the bottom of the concrete lining of the first lift. If ground water is encountered before you reach this depth, stop the excavation and proceed to step 25.

21. Position the vertical re-rods in the same manner used in the first lift. Bend the top ends of these re-rods into hooks and leave the bottom ends of the re-rods protruding down from the concrete. The lengths should overlap by about 200mm. Fasten them together with wire. Position and fasten circular sections of horizontal re-rods in place.

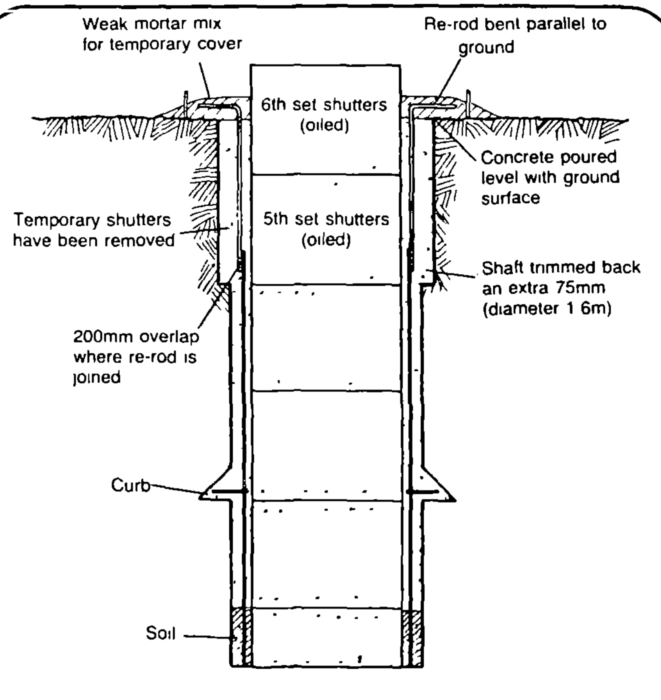


Figure 9. Completing the First Lift

22. Begin lining the second lift in the same manner as the first. Remember the first set of shutters is 0.5m high and backfilled with soil, and a concrete curb is built just above the second set of shutters.

23. There will be a gap of about 150mm between the top of the fourth set of shutters and the bottom of the concrete lining of the first lift, as shown in Figure 10. To pour concrete into this set of shutters you will need a funnel or scoop made from scrap metal. This will prevent spilling concrete.

24. The gap between lifts should be left open until the entire well is excavated and lined in case there is any movement or shifting of the lining.

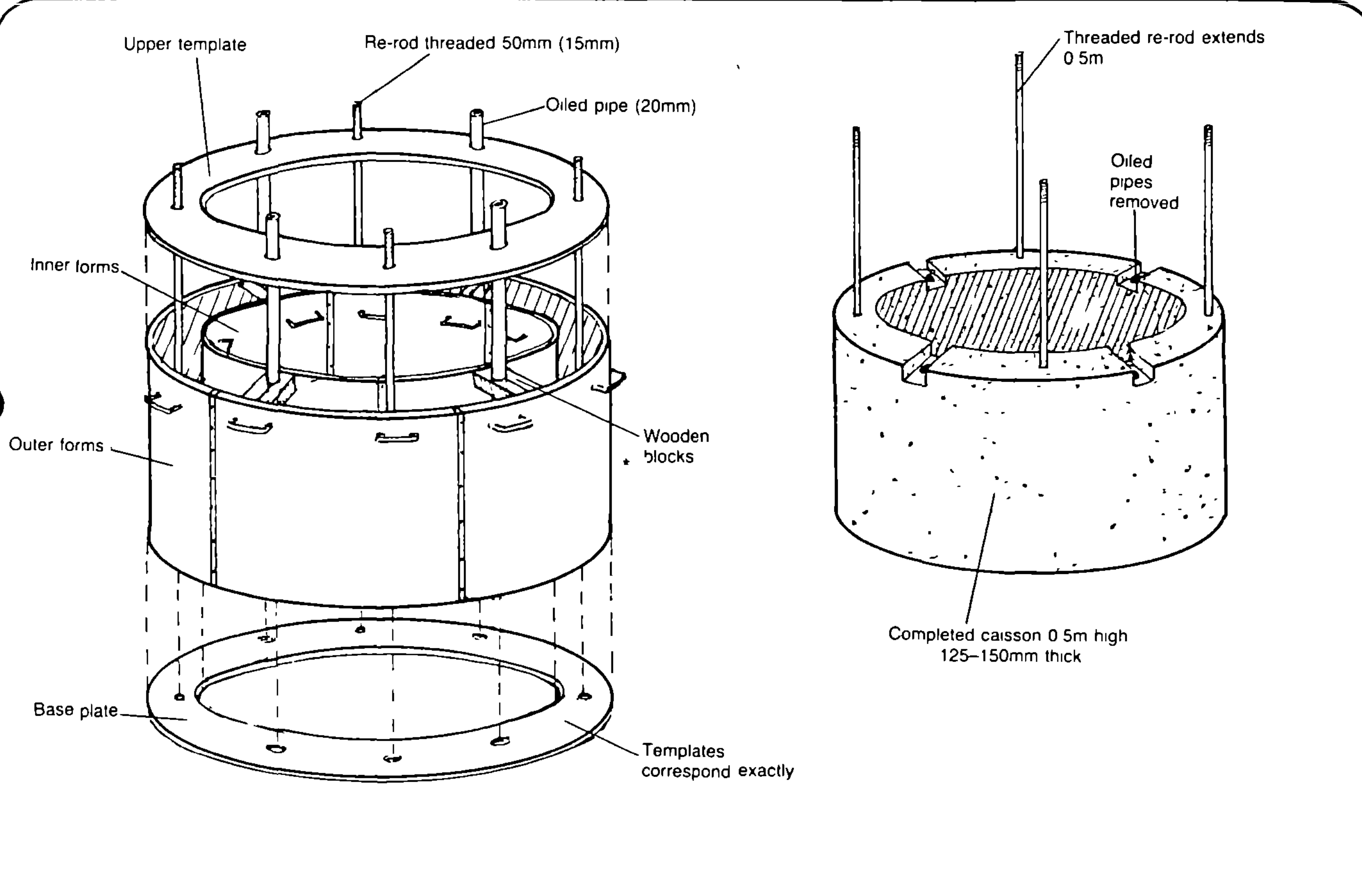


Figure 10. Casting Caissons

These gaps can be used to attach the pipe for a pump or the supports for an access ladder.

When it is time to fill the gaps, use concrete mortar and bricks or stones. Thoroughly seal the entire gap with a coating of plaster to prevent possible contamination by entry of surface water.

25. Continue the process of digging and lining until ground water is reached. If you encounter difficult ground or if the water table is reached before a full lift is excavated, the lift can be made as shallow as 650mm, 500mm for a small set of shutters and 150mm for the gap below the previous lining.

When the aquifer is reached, dig down into it to examine its composition and depth. An auger is a useful tool for this work. If the aquifer is a shallow perched layer, you must sink the well through it to a deeper aquifer. If you have indeed reached a main aquifer, line this last section of the shaft as before and build an extra-deep curb as shown in Figure 10.

26. The remainder of the well will be sunk using the caisson method. Before you can begin, the lining must be given time to harden so that you can remove the shutters. See Figure 2 for the way in which caisson rings fit into the lining.

The caisson rings may already have been cast as described in step 2. The type of rings used depends on the composition of the aquifer. The rings can be made of porous concrete, standard concrete, or standard concrete perforated with seepage holes.

26a. Cast all types of rings in a mold 0.5m high, with an outside diameter of 1.2m and an inside diameter of 0.90-0.95m. See Figure 10. If standard concrete is to be used, it can be the same mix as was used for the lining. If the rings are to have seepage holes, you must use special molds with perforations. If porous concrete is to be used, it should be made by mixing one part cement to four parts washed gravel and no sand. The mix must not be overly wet; use only enough water to make it workable. The gravel must be quite clean and of the correct size. It must all pass through a 20mm screen but none of it must pass through a 10mm screen.

26b. To ensure that the caisson rings will fit together when placed in the well shaft, equip each ring with four evenly-spaced re-rods, 15mm diameter and 1.0m long, and four evenly-spaced holes 20mm in diameter. When the rings are set one on top of the other, the re-rods from one ring will fit into the holes of the other. The holes are made with well-oiled pipes, and the pipes and re-rods are held in position by a template. A small block of wood with a hole for the pipe to pass through is positioned to form a recess in the caisson ring for a bolt which will be secured onto the end of each re-rod. Each re-rod is threaded at the top 50mm and has a hole drilled 25mm from the bottom end through which a nail or piece of thick wire is placed. This will prevent the rod from pulling out when weight is placed on it.

26c. Cast the caisson rings in the shade. Insert the re-rods and the pipes that will form the holes. If the rings are to have seepage holes, place rods or wooden pegs through the holes in the sides of the mold.

26d. When the concrete has been in the mold for 12-24 hours, remove the pipes for the holes and, if necessary, the rods or pegs for the seepage holes.

26e. The molds should not be removed for three days, and the caisson rings should not be moved during this time. If porous concrete is being used, the molds should be left in place for seven days.

26f. Remove the caisson rings from their molds. Cure the rings by keeping them moist and in the shade for seven days. If they are made from porous concrete, the rings should be cured for 14 days.

27. Roll the first caisson ring beside the well shaft and tip it on end so that the re-rods are pointing up. Lower the stretcher over two re-rods on opposite sides of the ring. The stretcher must be made of steel or wood and be capable of supporting the weight of the caisson rings, each of which may weigh over 350kg. Fit lengths of 20mm diameter pipes and washers over the re-rods so that the stretcher can be tightly bolted down as shown in Figure 10.

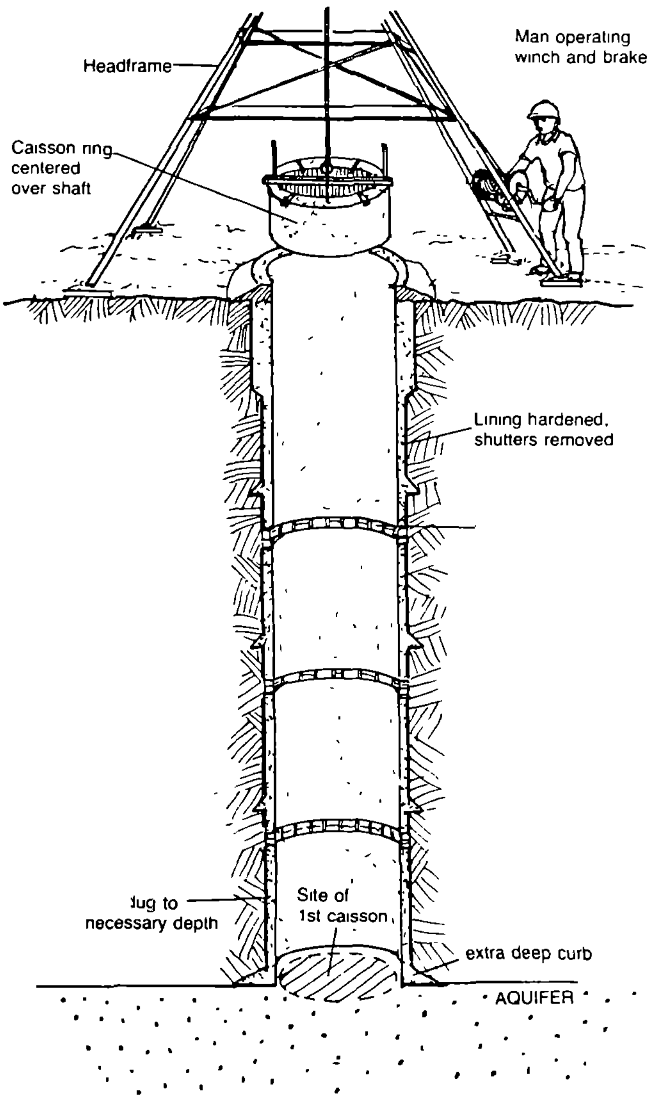
28. Cover the opening of the well shaft with stout logs or planks. Attach the main lowering rope to the U-bolt in the center of the stretcher. Carefully maneuver the caisson ring up onto the logs or planks until it is centered, raise it about 100mm, and remove the planks.

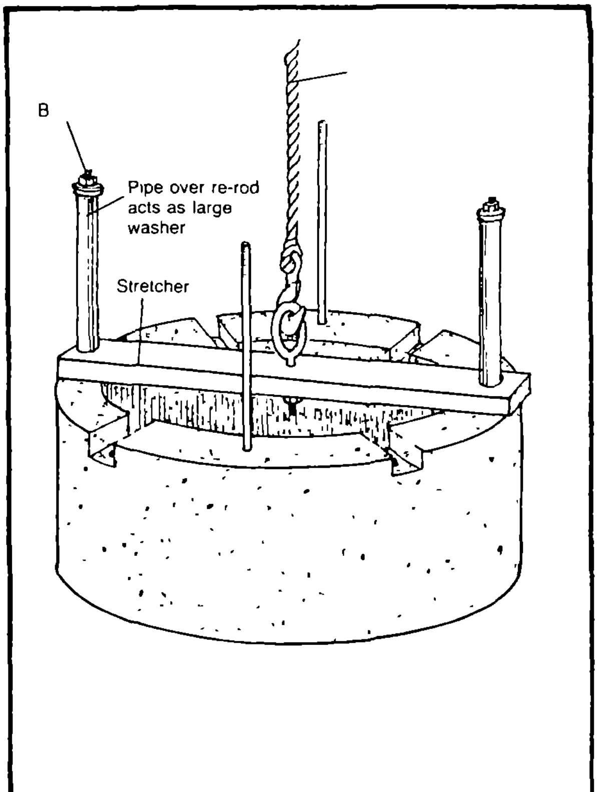
29. Slowly and carefully lower the ring to the bottom of the shaft. The ring must be level and perfectly centered, or you will have difficulty fitting on the other caisson rings. If necessary, raise the ring just off the bottom and wedge pieces of wood underneath until it is level and in position. Only then should you unbolt the stretcher. See Figure 11.

30. Lower the second ring in the same manner as the first. Just before it reaches the projecting re-rods of the first ring, a worker, perhaps sitting on the stretcher, must turn it so that its holes match the projecting re-rods. Partly lower the ring onto the re-rods, then spread a 10mm layer of cement mortar on the top edge of the first ring. Lower the second ring until it rests on the first. The rods of the first ring will project up into the recesses on the top edge of the second ring. Fix bolts on the threaded ends of the re-rods and tighten until the second ring is secure and level. Fill in the recesses and cover the bolt with cement mortar.

31. Continue lowering rings and fitting them together until there are five or six rings in the shaft. See Figure 11.

32. Probe the bottom of the shaft with a pointed length of re-rod to check for hard or soft spots. When excavation starts, there may be a





Method of Lowering Caisson into Well

Figure 11. Installing Caissons in Completed Lining

danger that the ground will suddenly give way and that several caisson rings will drop below the bottom of the lining. This is all right as long as the top ring does not drop below the lining.

33. Begin excavating in shallow layers, first in the center of the shaft and then under the ring. Dig evenly around the ring to prevent it from sinking out of line. As you excavate, the well shaft and the caisson rings will gradually sink into the aquifer and the shaft will begin to fill with water. Dig until the water becomes too deep for working, or until you are satisfied that the well will yield sufficient water. See Figure 11.

If you wish to remove water from the shaft while excavating, bail it out with a kibble. Do not pump out water with a mechanical pump, for that can cause the aquifer to collapse.

34. Set a base plug in the bottom of the shaft as shown in Figure 12. The plug can be made of porous concrete precast at ground level, or it can be made from layers of sand and gravel. If it is precast, it should have handles for lifting and removing it. The purpose of the plug is to prevent aquifer materials from rising into the well.

35. Unless the caisson rings have been sunk during the dry season, you may have to deepen the well during

the dry season. If so, you should add more caisson rings at that time.

36. Fill the space between the caisson rings and the concrete lining with small-sized gravel.

37. To build the wellhead and finish the well, see "Finishing Wells," RWS.2.C.8.

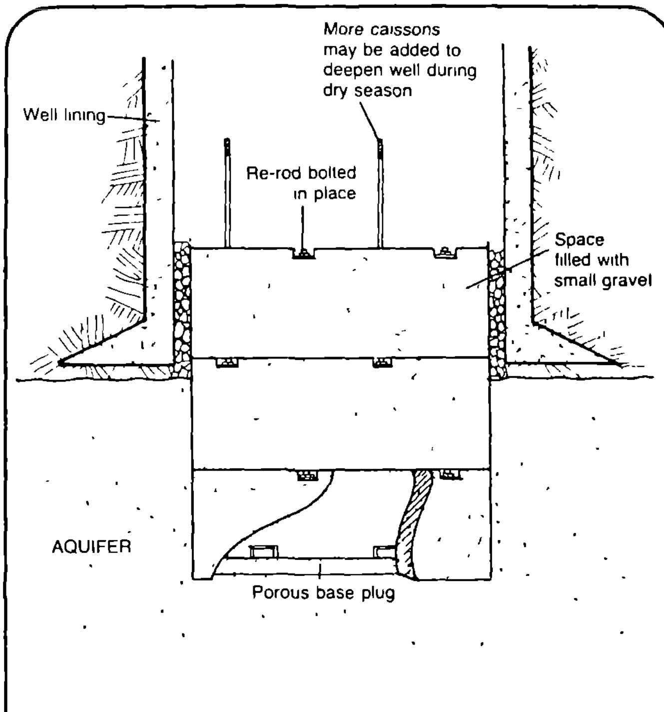


Figure 12. Caissons Sunk into Aquifer

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled Using Water for the World Technical Notes " Other parts of the 'Water for the World" series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D C , 20523, U S A

1982

Lining an Existing Well

1. Set up tripod over well
2. Place platform in well
3. Remove existing retaining wall
4. Excavate to desired diameter
5. Cut and place rebar
6. Place collapsable mold on platform
7. Pour first lining ring
8. Wait at least 24 hours before removing mold
9. Set mold for next lining ring
10. Pour next lining ring
11. Continue pouring lining rings until well relined to surface
12. Plaster lining as needed
13. Remove platform
14. Remove debris from well

Repairing the Lining of an Existing Well

- Determine if well lining can be repaired or should be replaced by a new lining.

- Construct scaffolding

  . Why? - to provide a firm surface from which to work on sides of the well

  . Key points to remember:
    - be careful when near an open well without a headwall
    - don't work inside well without an assistant above ground and a safety rope around waist

- Remove headwalls

  . Why? - easier to seal the well against surface contamination without headwalls, and it is easier to draw water when the users don't have to climb up or reach up to operate the pump

- Remove decaying lining

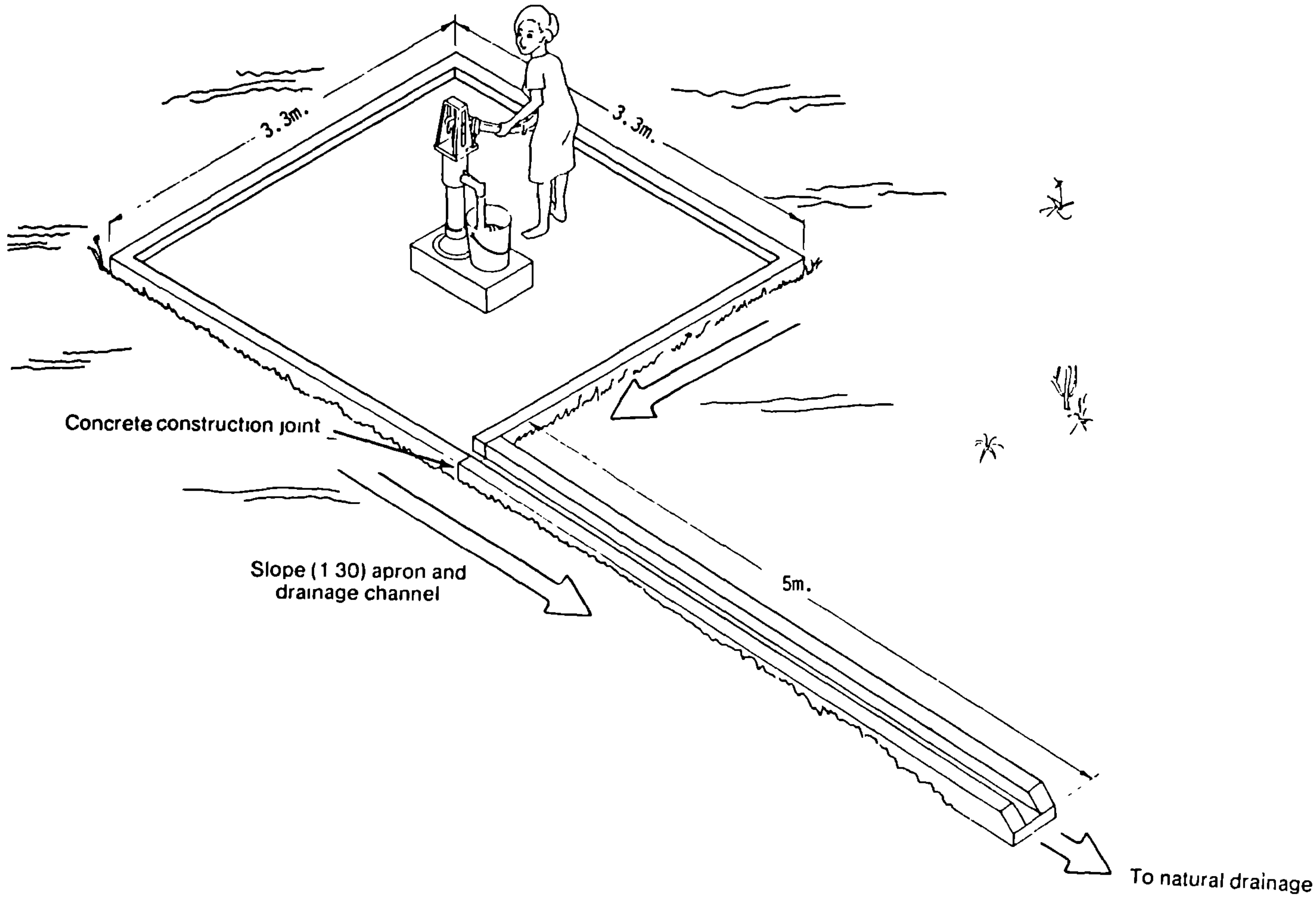
  . Why? - to provide a solid base on which to put the new lining. New lining placed over old lining will soon crack or chip off and could allow contaminated water to enter the well
  . Key points to remember:
    - don't work inside well without an assistant above ground and a safety rope around waist

- Reline the well

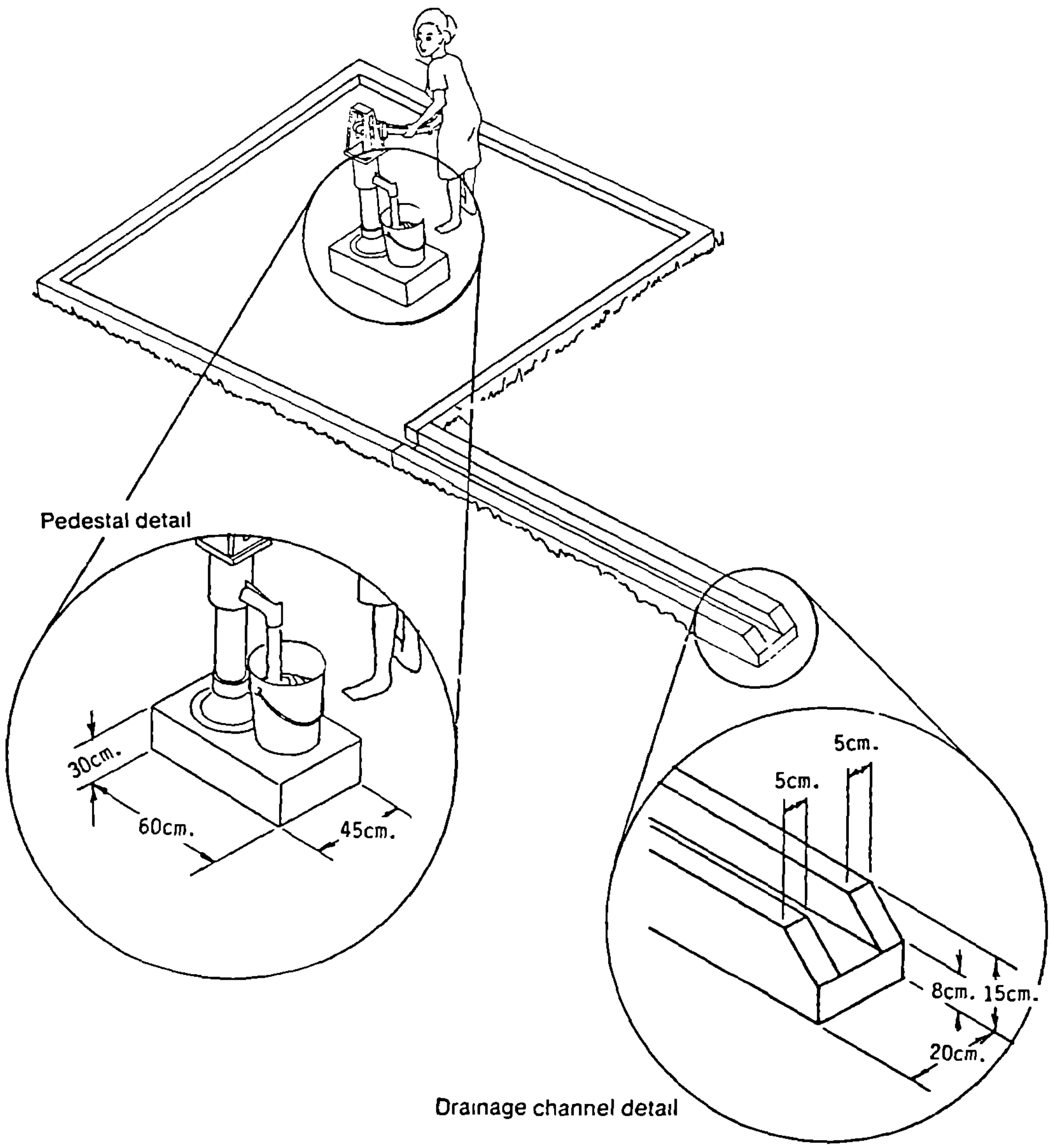
  . Why? - to prevent surface water from entering the well through the lining
  . Key points to remember:
    - don't work inside well without an assistant above ground and a safety rope around waist
    - wet wall before applying plaster
    - sling plaster onto wall for good bond and smooth out plaster with screed

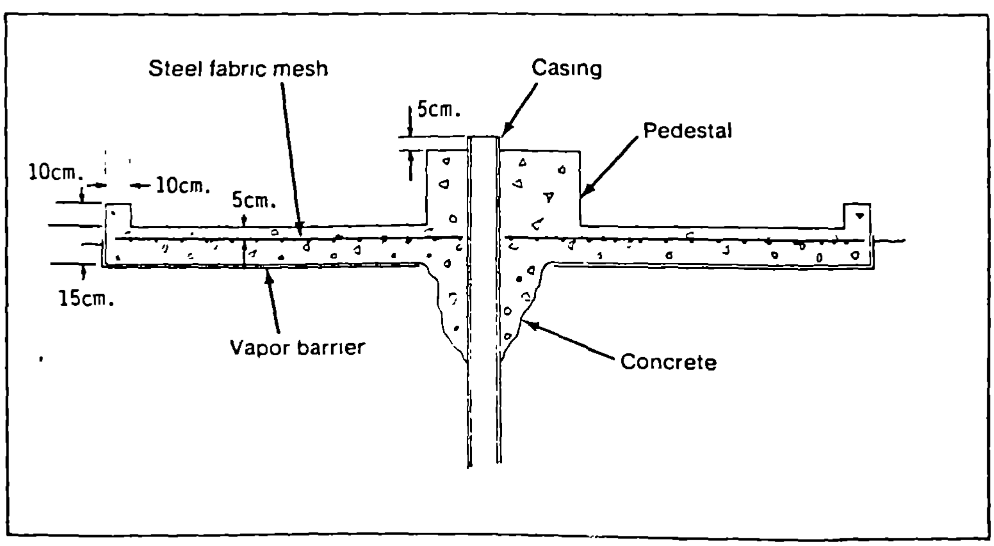
- Clear debris from the well

  . Why? - to restore the storage capacity of the well
  . Key points to remember:
    - don't work inside well without an assistant above ground and a safety rope around waist

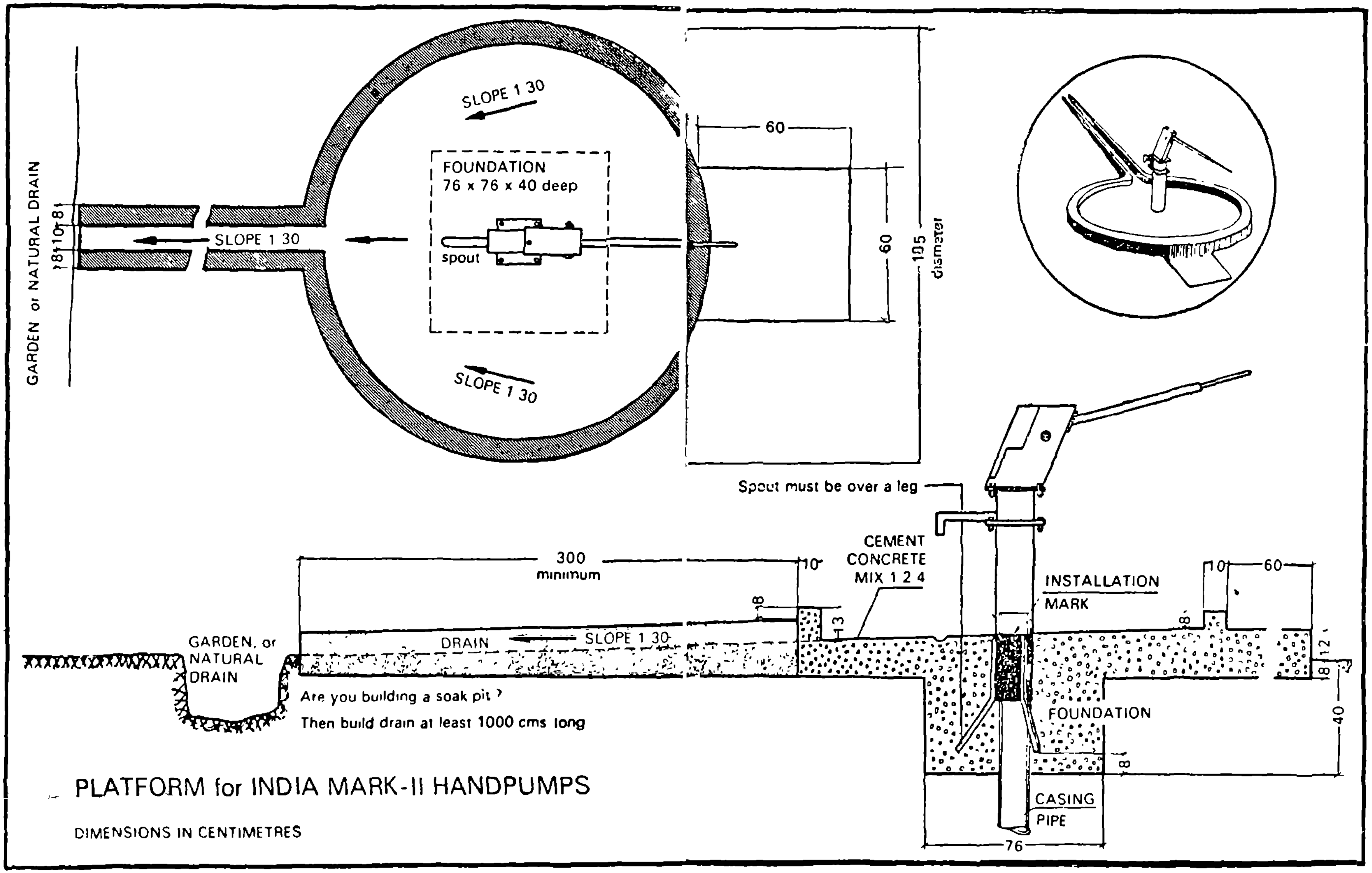


POSSIBLE APRON DESIGN, TYPE I





Apron cutaway detail



POSSIBLE APRON DESIGN, TYPE 2

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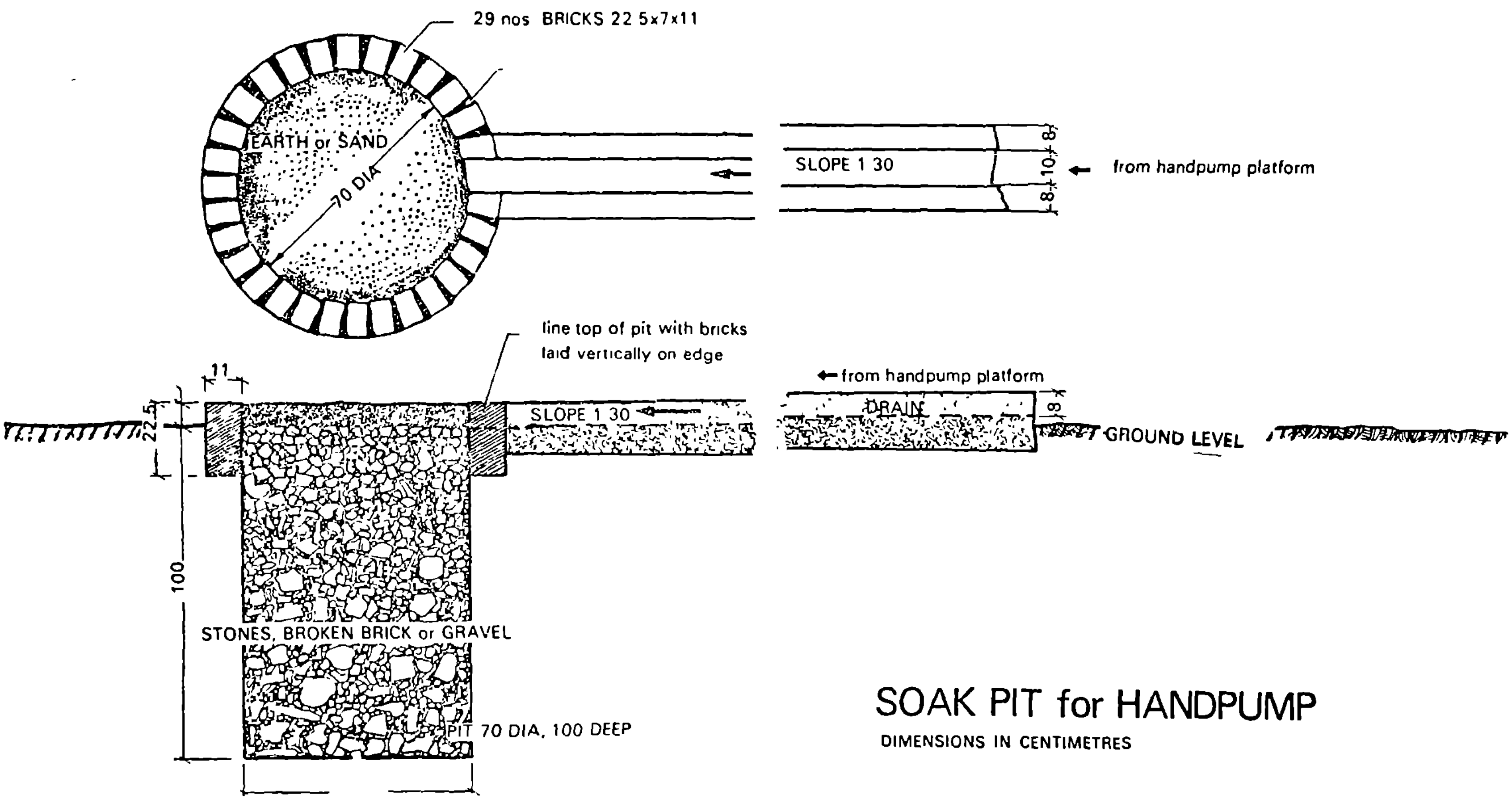


SOAK PIT for HANDPUMP

DIMENSIONS IN CENTIMETRES

Steps for Constructing an Apron for a Dug Well

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
  - remove all vegetation
  - remove all loose soil
  - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
  - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
  - most large forms will be built in place
  - assemble other form on flat surface to minimize warpage during assembly

D) Cut and place planking over well opening:

- Why? - to support concrete while it hardens and cures
- Key points to remember:
  - planking must be adequately supported
  - planking must be easy to remove when apron has cured

E) Locate and place pipe section and access hatch form:

- Why? - pipe section provides water barrier and acts as form for concrete to make hole for suction or drop pipe; access hatch form used to make hatch opening
- Key points to remember:
  - must be sufficient space between pipe section and access hatch for cover to fit on finished well
  - both access hatch opening and pipe section located over well
  - pipe section placed over deepest part of the well

F) Cut hole under pipe section:

- Why? - for cylinder or suction pipe to pass through

G) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
  - apron form tilted to provide slope for apron

- lowest side faces toward drain
- place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

H) Cut, place and tie rebar:

. Why? - to give tensile strength to concrete (so it won't crack when in tension)
. Key points to remember:
  - rebar extends 10-15 cm past sides of well
  - rebar raised about 2 cm above the planking
  - rebar clean and free of rust

I) Place anchor bolts:

. Why? - to hold pump securely on apron
. Key points to remember
  - bolts placed so pump spout will not be over access hatch
  - use pump base as template for placing bolts if template unavailable

J) Construct access hatch cover:

. Why? - to keep people from falling in the well and to prevent contaminants from entering well through the access hatch
. Key points to remember:
  - Steps:
    - make forms
    - cut, bend, place and tie rebar
    - forms constructed to proper size so hatch fits opening
    - rebar placed 2 cm from bottom
    - rebar clean and free of rust

K) Mix and place concrete for apron:

. Why? - makes durable, relatively inexpensive apron
. Key points to remember:
  - factors that influence concrete strength
    - quantity of water
    - quality of water, aggregate
    - mixture of cement, sand and concrete
    - dropping vs. placing concrete
  - mark depth of concrete on inside of forms
  - tamp concrete so it fills out forms and flows around rebar
  - level low spots in concrete

L) Mix and place concrete for access hatch cover:

. Why? - make durable, relatively inexpensive cover that can be made with materials already at site
. Key points to remember:
  - factors that influence concrete strength same as for apron

- fill forms to top
- tamp concrete so it fills out form and flows around rebar

M) Cover concrete for curing:

- Why? - concrete continues to gain strength as long as it is wet
- Key points to remember:
  - do not walk on concrete until it has cured 24 hours

Steps for Constructing an Apron for a Drilled Well

A) Clear and level the apron site:

- Why? - to give firm foundation to apron
- Key points to remember:
  - remove all vegetation and loose soil
  - slope the area toward the drain with a 1:30 slope
  - tamp the soil

B) Measure and cut form material:

- Why? - so finished concrete apron will be desired size and shape
- Key points to remember:
  - cut all edges square

C) Assemble forms:

- Why? - to hold wet concrete in place
- Key points to remember:
  - assemble form on flat surface to minimize warpage during assembly

D) Place apron forms:

- Why? - to give shape to concrete
- Key points to remember:
  - place apron form first, pour concrete for apron, place curb and pedestal forms and pour concrete for curb and pedestal

E) Place anchor bolts:

- Why? - to hold pump securely on apron
- Key points to remember
  - bolts placed so pump spout will face toward drain
  - use pump base as template for placing bolts

Team Work Plan Guide #1

(Dug Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A:	• clear and level site	30 minutes
Apron Form Group	• measure and cut apron forms	40 minutes
	• assemble forms	20 minutes
	• cut, place and tie rebar for apron (Help Group B)	1 hour
Group B:	• cut and place planking over well	1 hour
Planking	• construct access hatch opening form	15 minutes
	• locate and place pipe section and access hatch	10 minutes
	• cut hole under pipe section	10 minutes
	• cut, place and tie rebar for apron (primary responsibility)	1 hour
	• place anchor bolts	10 minutes
Group C:		
Hatch Cover Group	• construct access hatch cover forms	15 minutes
	• cut, place and tie rebar for hatch cover	1 hour
	• cut, place and tie rebar for apron (Help Group B)	1 hour

Team Work Plan Guide #1

(Drilled Well - Ground Level Apron Design)

Group	Task	Approximate Time
Group A: Clear and Slope Group	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	30 minutes
	• place anchor bolts	5 minutes
Group B: Form Group	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes

Team Work Plan Guide #1

Group	Task	Approximate Time
Group A:	• clear apron area of loose soil and vegetation	10 minutes
	• slope area toward drain	20 minutes
	• excavate pit	20 minutes
	• place pump pedestal	15 minutes
Group B:	• measure and cut apron form materials	15 minutes
	• assemble forms	10 minutes
	• place forms	10 minutes
	• mix and place concrete for pedestal	30 minutes

Team Work Plan Guide #2

(Dug Well - Ground Level Apron Design)

Group	Task	Time
Group A	• mix and place concrete for apron	
Apron Group	- clear mixing site	10 minutes
	- bring sand, gravel, cement water	ongoing
	- mix concrete	ongoing
	- transport concrete to apron area	ongoing
	- place and tamp concrete	ongoing
	- place secondary forms (to make lips around access hatch and apron's outer edge)	10 minutes
	- finish concrete surface	20 minutes
	- cover concrete for curing	10 minutes
Group B	• mix and place concrete for access hatch cover	
Hatch Cover Group	- clear mixing site	5 minutes
	- bring sand, small gravel, cement water	15 minutes
	- mix concrete	20 minutes
	- transport concrete to hatch cover	ongoing
	- place, tamp and finish concrete	20 minutes
	- cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

Team Work Plan Guide #2

Task	Approximate Time
clear mixing site	10 minutes
bring sand, gravel, cement, water	ongoing
mix concrete	ongoing
transport concrete to apron area	ongoing
place and tamp concrete	ongoing
place secondary forms (to make lip around apron)	10 minutes
finish concrete surface	20 minutes
cover concrete for curing	10 minutes

The ongoing tasks should be rotated among team members to give all the participants experience in the task.

Special Preparations

Steel Reinforcing - Reconditioned Dug Wells

Cover the well opening with wooden planks as shown in Figure 1. If the well is over one (1) meter in diameter, supporting joints should be placed under the wooden platform. The top of the platform should be level with the surface of the surrounding earth.

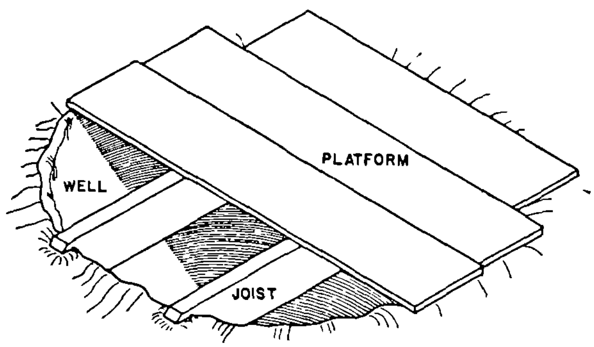


Figure 1. Platform Construction for Dug Wells

Sometimes it is desirable to have an access hatch for reconditioned wells, especially if the site is remote and the well is the only source of water in the vicinity of the community. The hatch also allows access for periodic reconditioning. See Handout 5-8,p.3 entitled "Access Hatch" for details of construction.

If an access hatch is not required, mark the location of the pump on the wooden platform. Two items should be considered in locating-the pump: a) the drop pipe or suction pipe should be in the deepest part of the well and b) the drop pipe of the medium-set and deep-set pumps should be straight even if the well is crooked to minimize wear by the plunger rod on the drop pipe. Cut a fifty-five (55) millimeter (mm) hole in the platform for shallow-set pumps or an eighty-five (85) mm hole if a medium-set or deep-set pump cylinder is to pass through.

Cut a section of ninety (90) mm (3 inch) PVC pipe and place it over the hole in the platform as in Figure 2. For shallow-set and medium-set pumps, the pipe section is thirty-five (35) cm long and for deep-set pumps it is fifty (50) cm long. The pipe section serves as a concrete form during construction and a water barrier during operation. If well casing is used, the PVC pipe section is unnecessary.

Adapted from Pashkevich and Gass

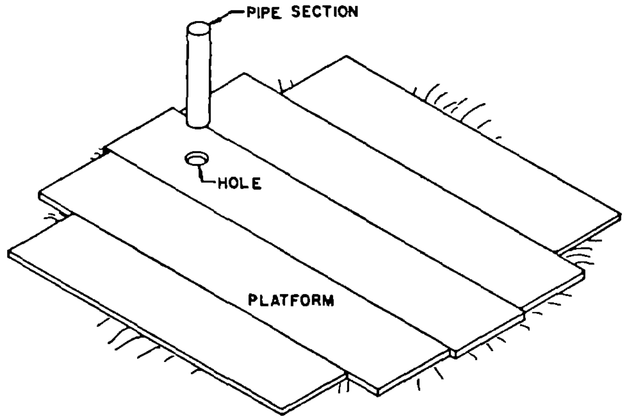


Figure 2. Locating Pipe Section

Lay out ten (10) mm diameter reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. After the bars have been cut to length and placed on center, tie them together with 16-gauge tying wire. The bars are then raised 1-1/2 to 2 cm above the planking by placing small rocks under the reinforcing bar framework. The well should now look like Figure 3.

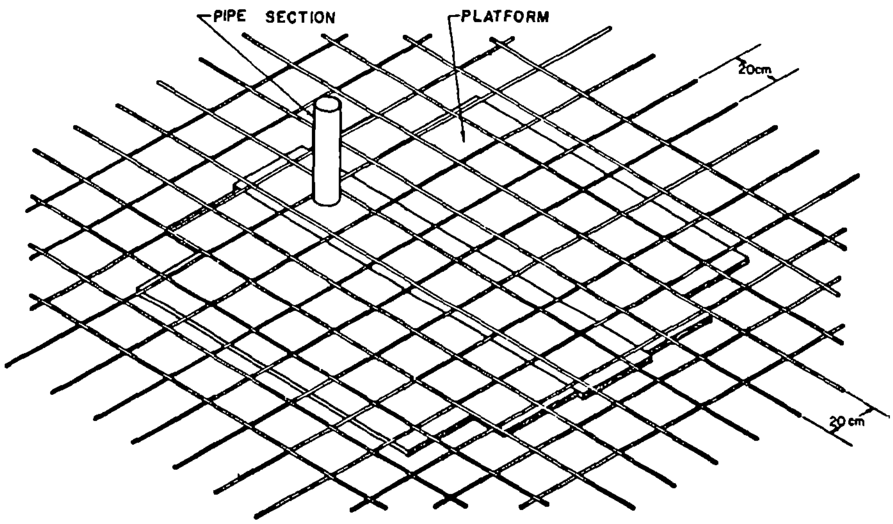


Figure 3. Reinforcement for Dug Wells

Steel Reinforcing - Filled Dug Wells

In some instances, it is advisable or more cost effective to refill a dug well. Some examples would be a very old dug well whose sides require extensive and prohibitively costly repair or a new dug well where casing the well with 90 mm (3 inch) pipe is less expensive than with concrete rings or bricks. However, an unfilled dug well has the advantage of providing a larger containment area or reservoir.

After installing the casing and gravel packing, fill and pack the well until it is level with the surrounding area cleared for the apron. As the fill may settle causing the apron to crack, it is necessary to use steel reinforcment in the apron slab.

Lay out ten (10) mm diameter reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. After the bars have been cut to length and placed on center, tie the bars together with 16-gauge tying wire. The bars are then raised 1-½ to 2 centimeters above the ground by placing small rocks under the reinforcing bar framework. The well should now resemble Figure 4.

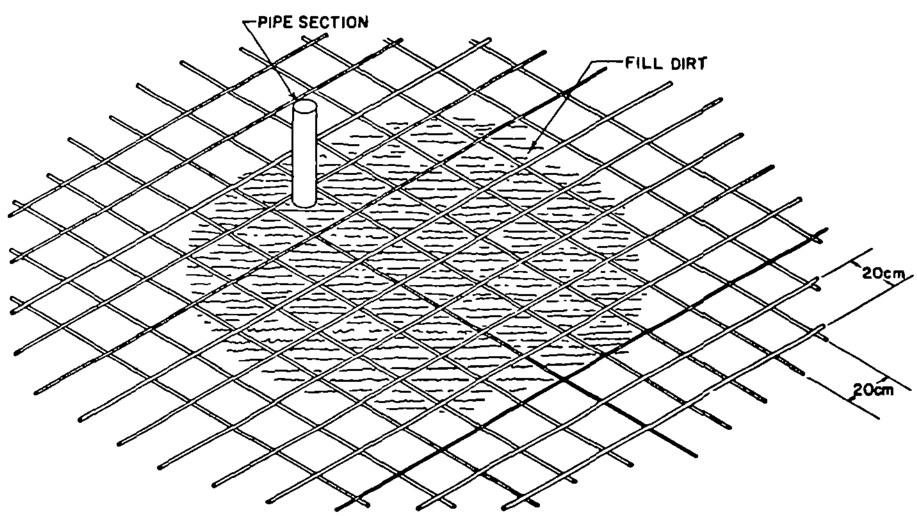


Figure 4. Reinforcement for Filled Dug Wells

Access Hatch

The location of the access hatch needs to be carefully selected. It should be on the opposite side of the pump from the drain and the pump spout should point away from it so that waste water will not be running around or on the hatch cover.

The hatch must be at least fifty (50) cm by fifty (50) cm in size to allow a man or bucket to pass inside. Having selected the hatch location, mark the location of the suction or drop pipe thirty (30) cm from the edge of the hatch opening. Be sure that the hatch and drop pipe will both be over the well opening.

Cut a hole for the suction or drop pipe in the wooden platform as described in the two preceding sections.

Construct the hatch opening form as described in Handout 5-8, p. 12-15 Place the opening form and the 90 mm pipe section in their respective locations on the wooden platform as shown in Figure 5. There should at least be twenty-five (25) cm between the pipe section and the opening form so that the hatch cover will later fit properly.

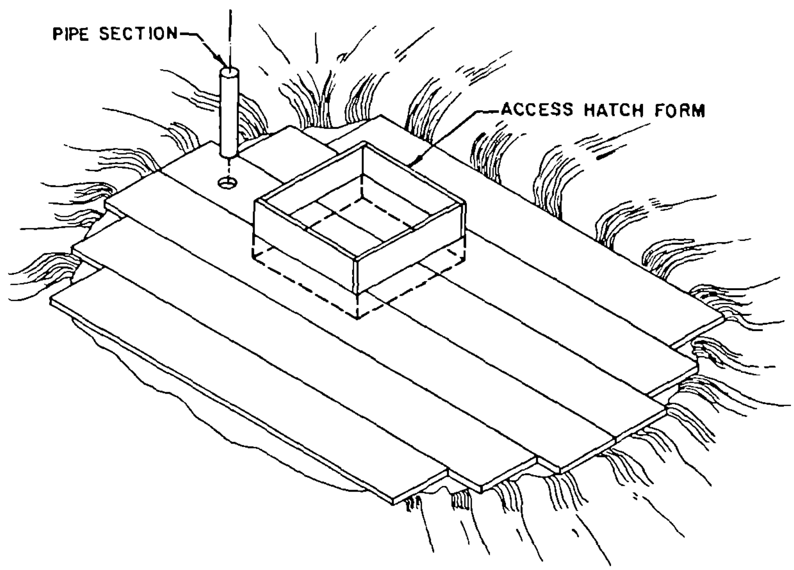


Figure 5. Locating Pipe Section and Access Hatch

Next, lay out ten (10) mm reinforcing bars on twenty (20) cm centers. The bars should extend fifty (50) cm beyond the edge of the well on either side. As shown in Figure 6. four bars should be laid out in a diamond shape around the hatch opening for additional strength. Tie the bars together with 16-gauge tying wire. Raise the bars 1½ to 2 cm above the platform by placing small rocks under the reinforcing bar framework.

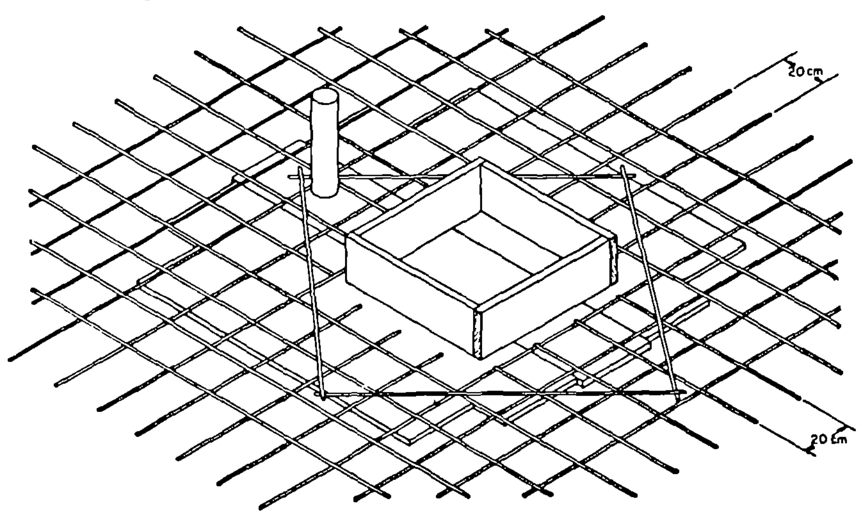


Figure 6. Reinforcement Around Access Hatch

Level a one (1) meter by one (1) meter area near the well site. Construct the hatch cover forms as described in Handout 5-8, p.12. Lay the small cover form in the center of the leveled area. Fill the inside of the form with dirt and pack it firmly. Cover the form with wet cement bags or damp newspaper. Shape them until they conform to the contour of the small cover form (Figure 7).

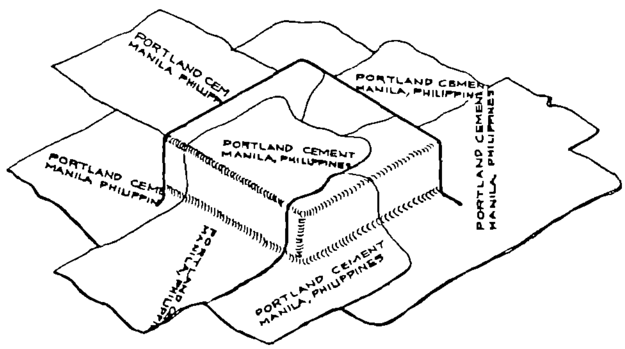


Figure 7. Inside Form for Hatch Cover

Center the large cover form around the small cover form. Place and tie 10 mm (3/8 inch) reinforcing bars on fifteen (15) cm centers. Bend one piece of bar as shown to make a handle. Pour the hatch cover when pouring the concrete for the apron. The completed cover should resemble Figure 8.

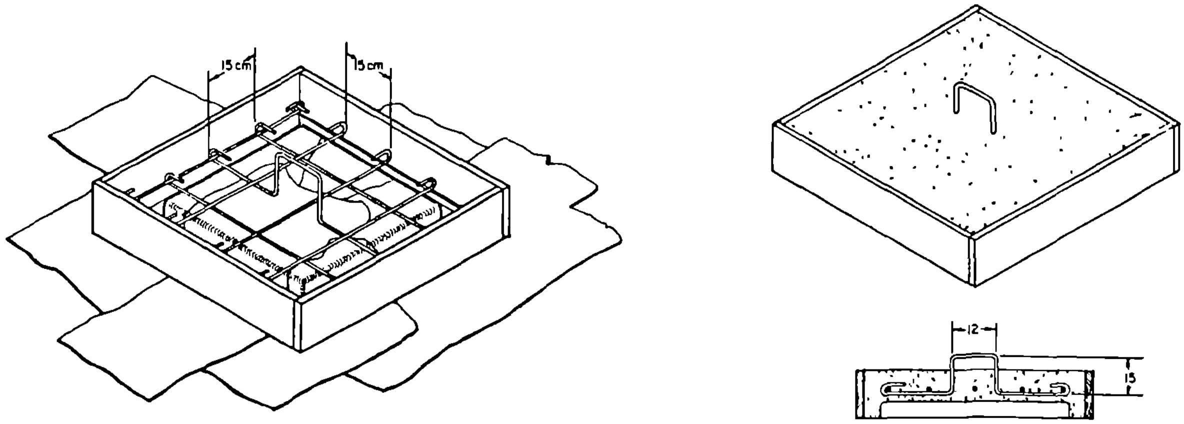


Figure 8. Hatch Cover Handle Detail

Construct a curb around the hatch opening as shown in Figure 9. using the hatch curb form described in Handout 5-8, p. 13. The curb should be five (5) cm in height and width. Plaster over the curb with a one (1) cm thick 1:3 cement/fine sand rendering.

After the concrete has set and cured for at least ten (10) days, cut out the hatch opening in the platform with a keyhole saw or similar tool.

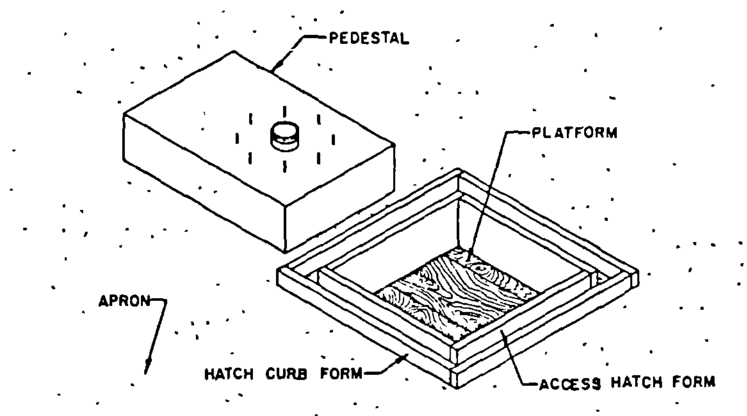


Figure 9. Constructing Hatch Curb

Site Preparation

The well should be located on a local high spot. The slight rise in elevation above the surrounding area is conducive to good drainage and the prevention of well contamination.

Remove the vegetation and loose top soil to ensure that the base for the apron slab will be well-compacted earth. The well casing should be exposed to a length of at least 35 cm above the ground. If 35 cm are not exposed, remove more top soil from the entire area.

If the pump is to be installed on a dug well, refer to Handout 5-8, p.1 ("Special Preparations") for steel work and access hatch instructions.

Place the apron form on the cleared area (see Handout 5-8, p.12-15) for the details of the apron form). Determine the apron orientation and select the location of the concrete drain. Construction is easier and drainage better if the concrete drain is located at a corner. Center the apron form around the well.

Drive stakes at the four corners of the apron form as shown in Figure 10 . The apron form is then tilted in the direction of the drain to facilitate drainage. Mark on the stake nearest the drain fifteen (15) cm above the ground. A mark is then placed on the opposite stake ten (10) cm above the first mark. Use a level or water-filled clear hose to obtain exact heights. The other two stakes are marked at points five (5) cm above the first mark. Line up the top of the apron form with the marks and nail the form to the stakes. Gravel and sand are used as fill to build up to the bottom of the raised apron form.

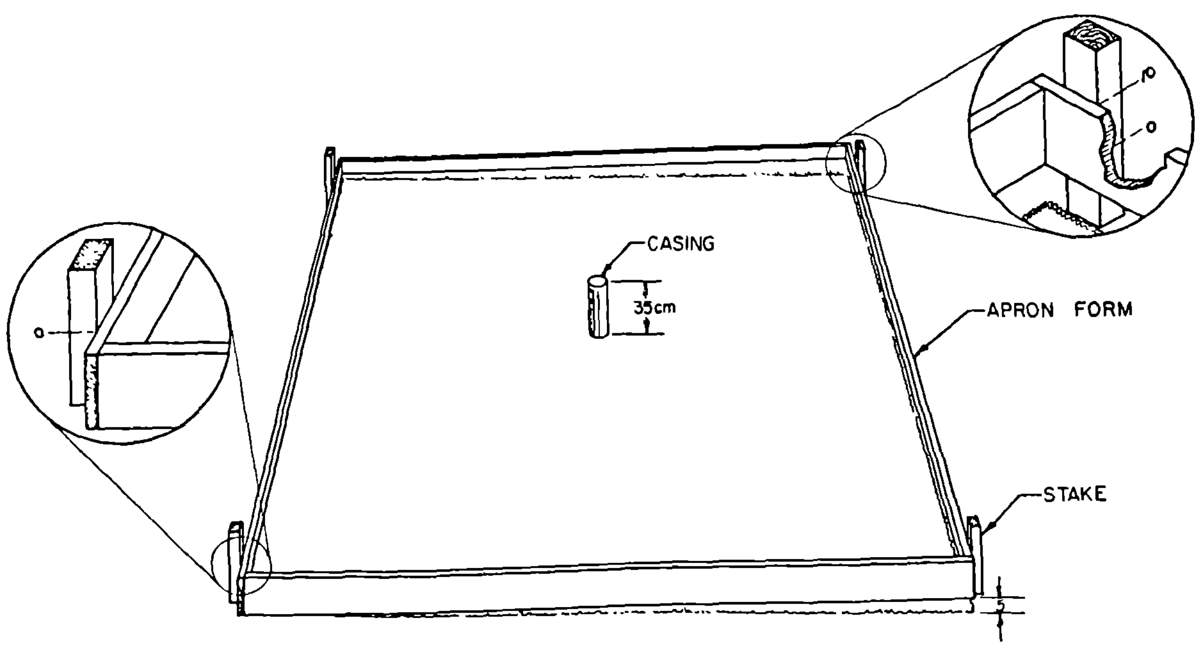


Figure 10. Sloping The Apron Form

Concreting the Apron

Shallow-Well and Medium-Set Pumps

Measure ten (10) cm up from the bottom of the apron form and place a mark on the form. Repeat this in several places around the form. Prepare a 1:2:4 concrete mixture and fill the apron form to the height of the marks. Level the concrete with a long board (Fig. 11) and fill any low spots that will prevent water from draining off the apron. Smooth the concrete because cement rendering will not be applied to the apron.

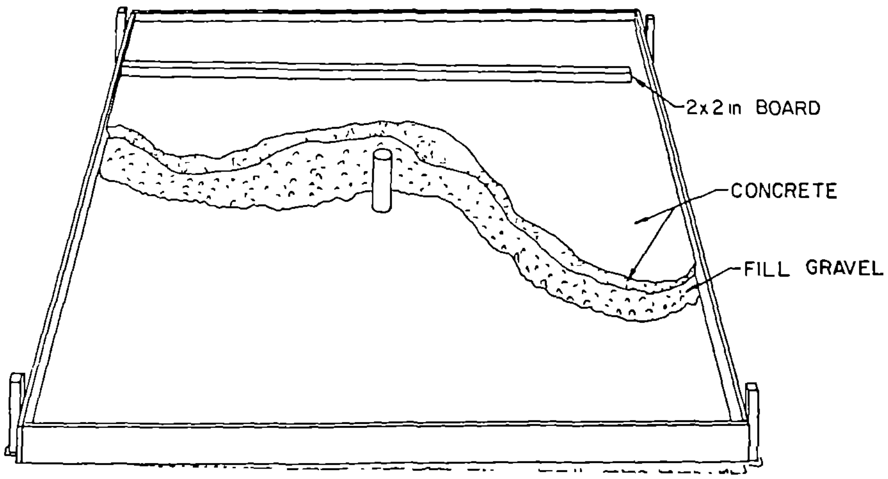


Figure 11. Pouring the Apron Slab

Prepare the anchor bolts for placement by bolting them onto the pump base. The use of the base positions the bolts both vertically and in relation to one another. The anchor bolts should be toed out as in Figure 12.

Measure up 25 cm on the casing from the apron slab. Cut off the casing at this point. Place the pedestal form (Handout 5-8, p. 13) around the casing. Center it carefully so that a bucket can be placed on the pedestal beneath the pump spout (Figure 13).

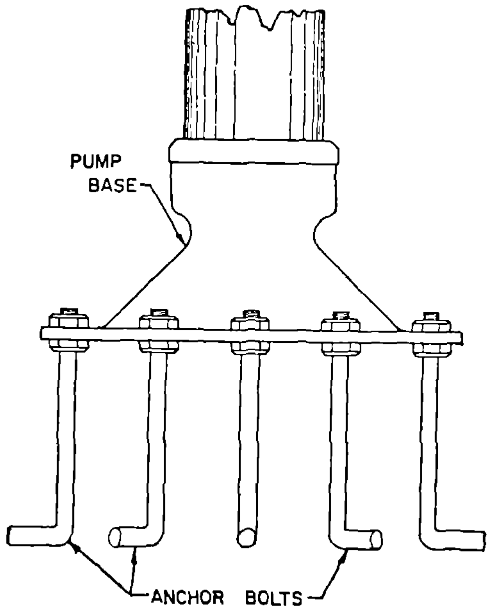


Figure 12. Preparation of Anchor Bolts for Installation

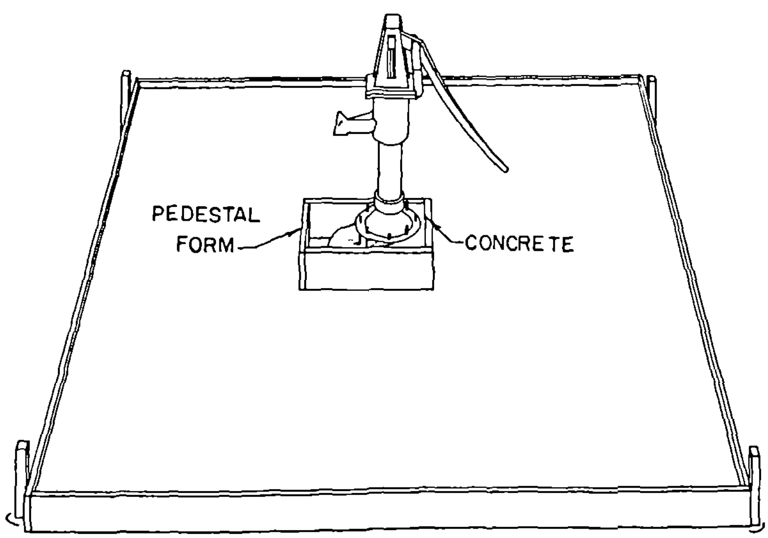


Figure 13. Pouring The Pedestal

Place the pump on the well casing. Ensure that the base is level so that the installed pump will not be tilted.

Placing the pump base on the casing before concreting the anchor bolts in place creates a water barrier to prevent rain or pumped water from entering the well (Figure 14.) However, this is not a water seal and the well could become contaminated if flood waters cover the base.

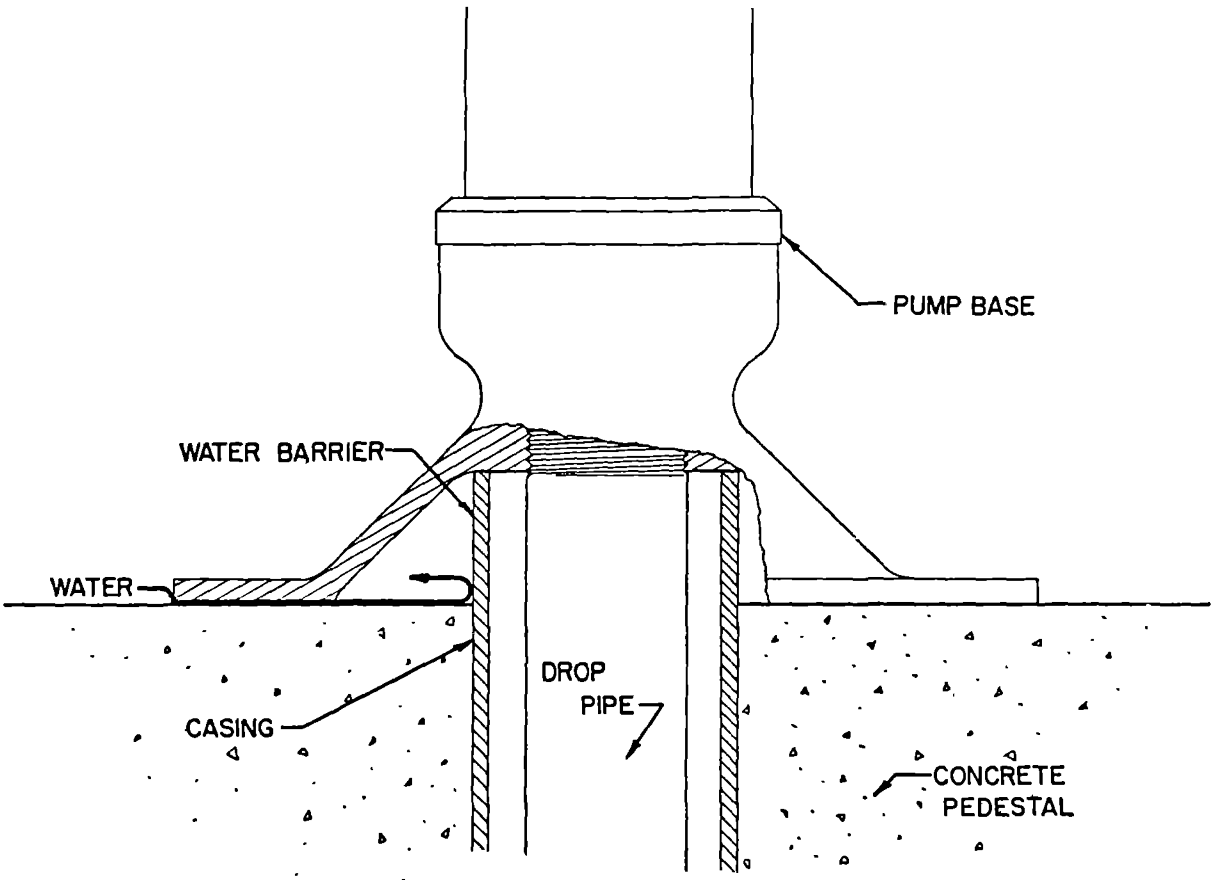


Figure 14. Casing as Water Barrier

Slowly fill the pedestal form with concrete to the bottom of the pump base, packing the concrete firmly between the anchor bolts. It is not necessary to fill the form to the top but only to the bottom of the pump base. Any cement that is splashed onto the bolt threads should be wiped off before it hardens. After the concrete has set, remove the pump base and the pedestal forms and plaster the pedestal with a one (1) cm thick 1:3 cement/fine sand rendering. Fill any voids left around the well casing as waste water may enter the well at this point.

Leaving space for the drain, construct a five (5) cm high by ten (10) cm wide water curb around the perimeter of the apron. Use the curb form (Handout 5-8, p. 13) as shown in Figure 15. After removing the apron and curb forms, plaster the curb with a 1:3 cement/fine sand rendering.

Allow the apron and pedestal to cure for at least one week before installing the pump so that the concrete can harden sufficiently (see Handout 5-9, Concrete Primer, for curing procedures).

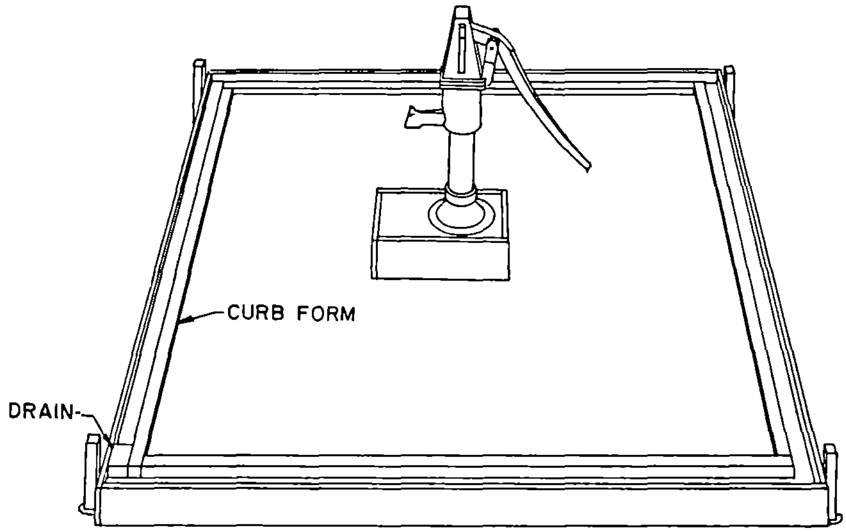


Figure 15. Constructing The Apron Curb

Form Work and Reinforcement

It has been found that the use of removable, reusable forms is more convenient and economical than other methods of concrete construction. This is particularly true of the deep-set pump column. The following section assumes the use of reusable forms. Form material is Tangili wood unless otherwise noted.

Apron Forms

Apron Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length:403 cm
No. of pieces:4

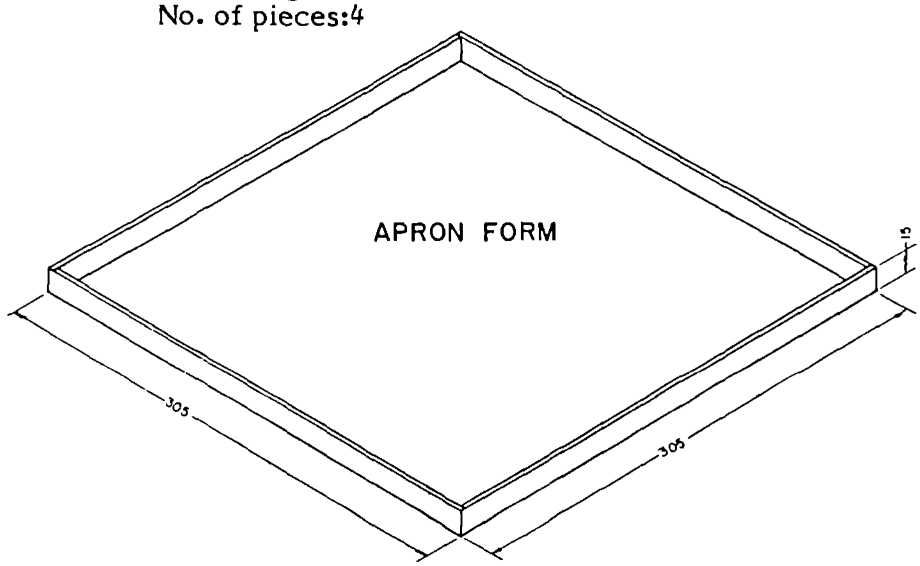


Figure 16.

Apron Curb Form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 377 cm
No. of pieces: 4

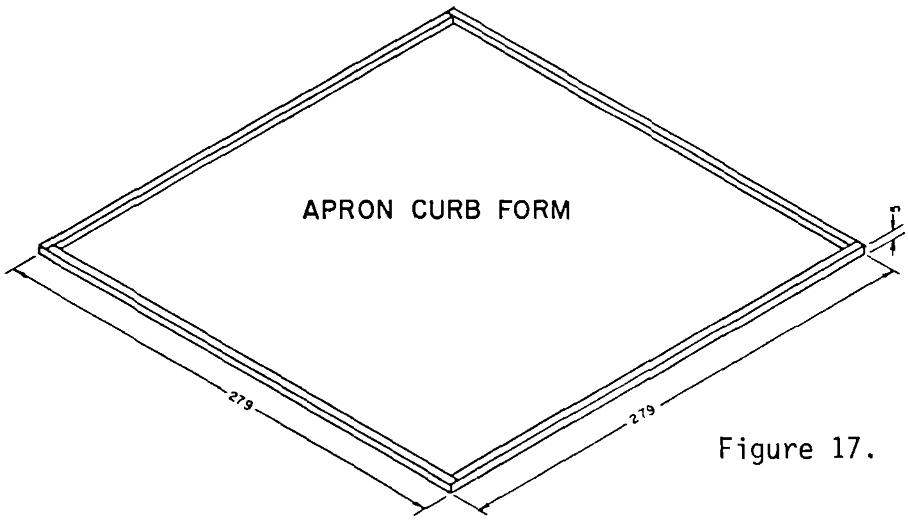
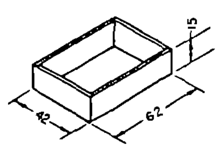


Figure 17.

Pedestal Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 60 cm No. of pieces: 2
Req'd length 40 cm No. of pieces: 2



PEDESTAL FORM

Figure 18.

Access Hatch Forms

Opening form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 48 cm
No. of pieces: 4

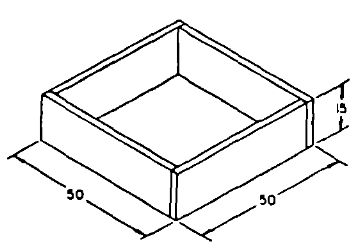


Figure 19. Opening Form

Opening curb form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 62 cm
No. of pieces: 4

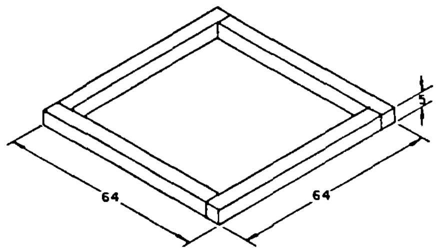


Figure 20. Opening Curb Form

Small Cover Form
Size: 5 x 5 cm (2 x 2 inch)
Req'd length: 58 cm
No. of pieces: 4

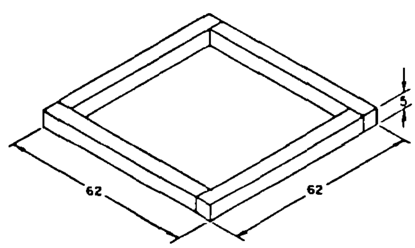


Figure 21. Small Cover Form

Large Cover Form
Size: 2.5 x 15 cm (1 x 6 inch)
Req'd length: 74 cm
No. of pieces: 4

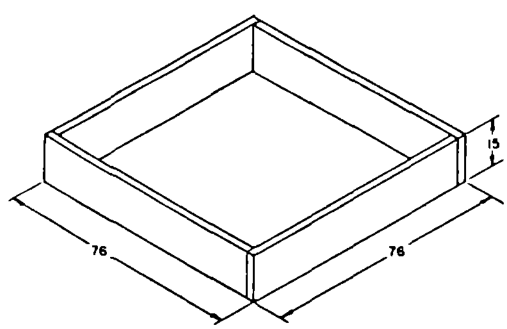


Figure 22. Large Cover Form

Assembly for above forms:

1. Cut the lumber to the required lengths as specified above.
2. Nail the boards together as shown in Figure 23. The dimensions given above are for this method of assembly. Assemble the forms on a flat area so that they won't have a warp.

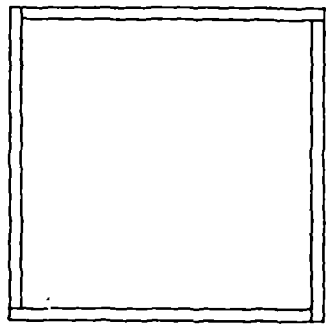
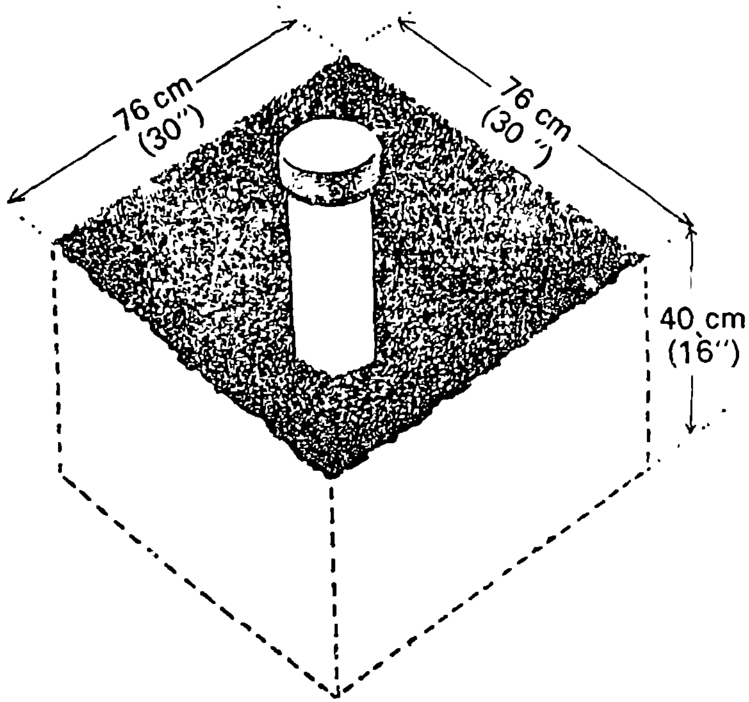


Figure 23. Recommended Assembly of Forms

1

(1) Cover casing pipe

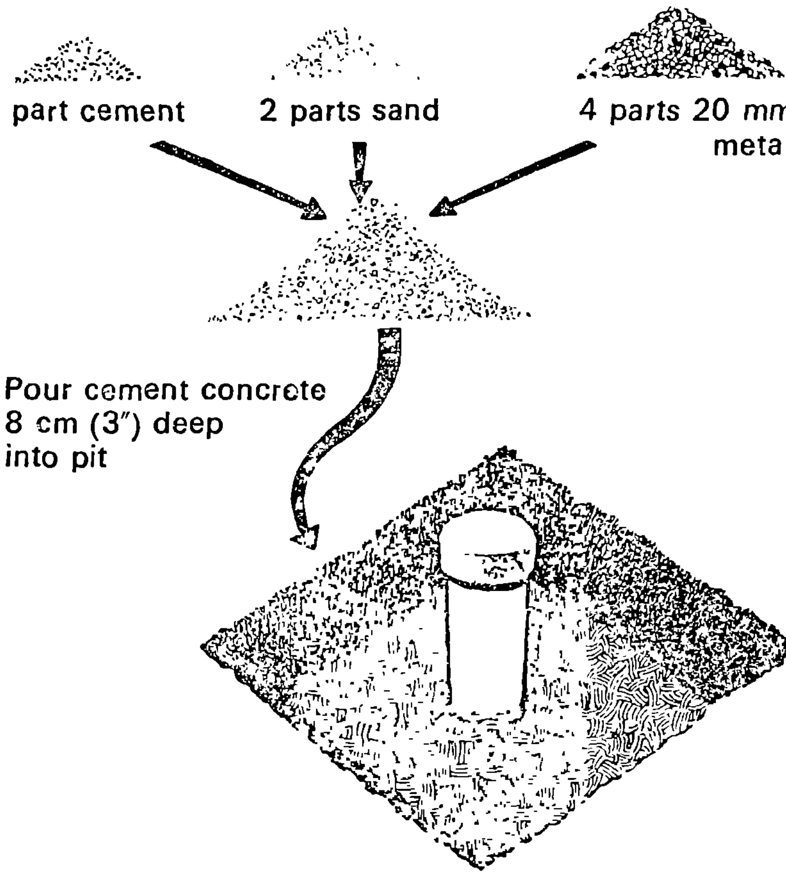
(2) Dig a square pit around casing pipe 40 cm (16") deep



From INALSA

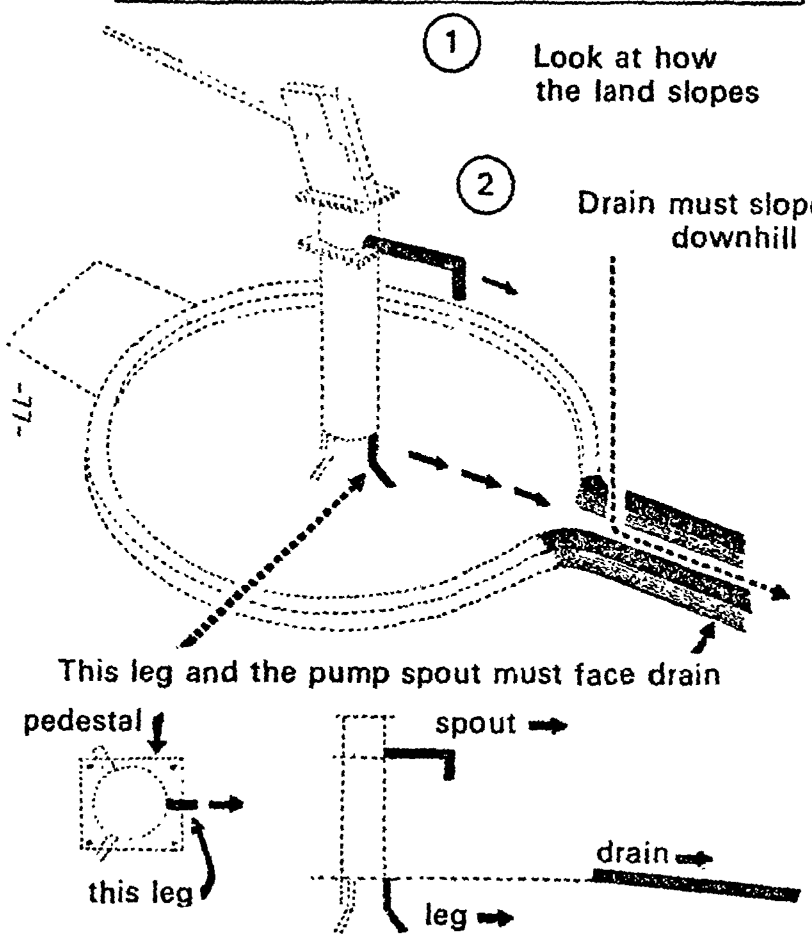
2

Prepare cement concrete mix

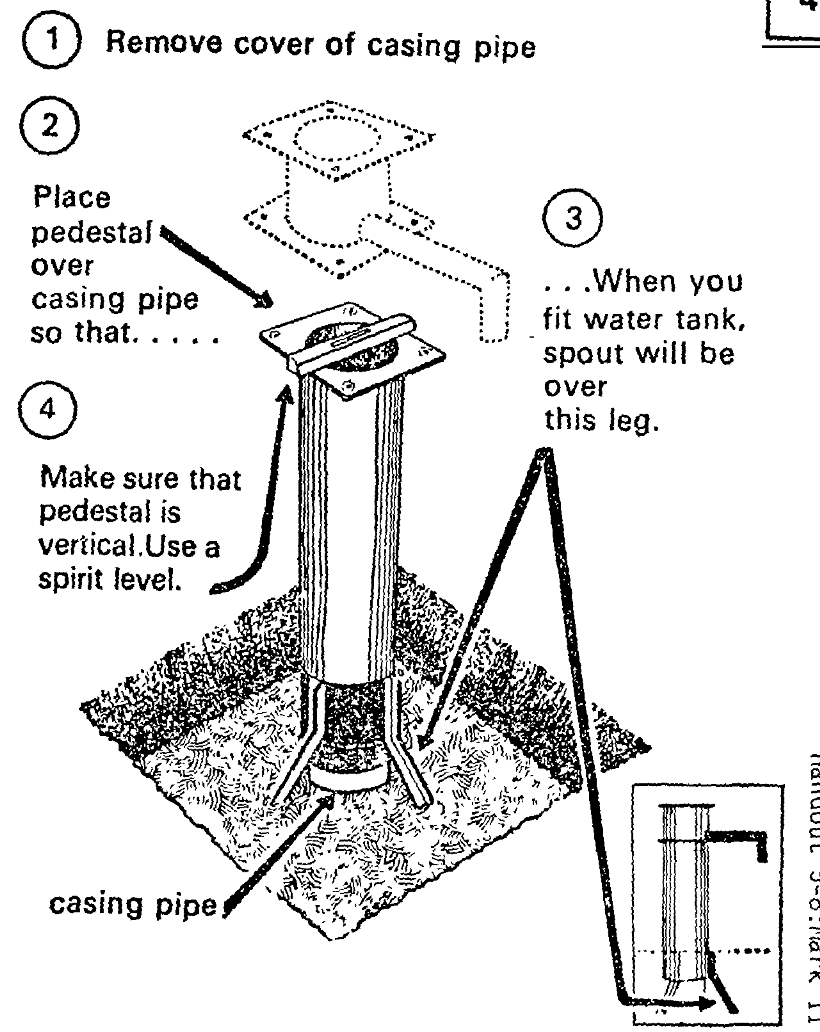


3

Decide now where you will make the drain



4

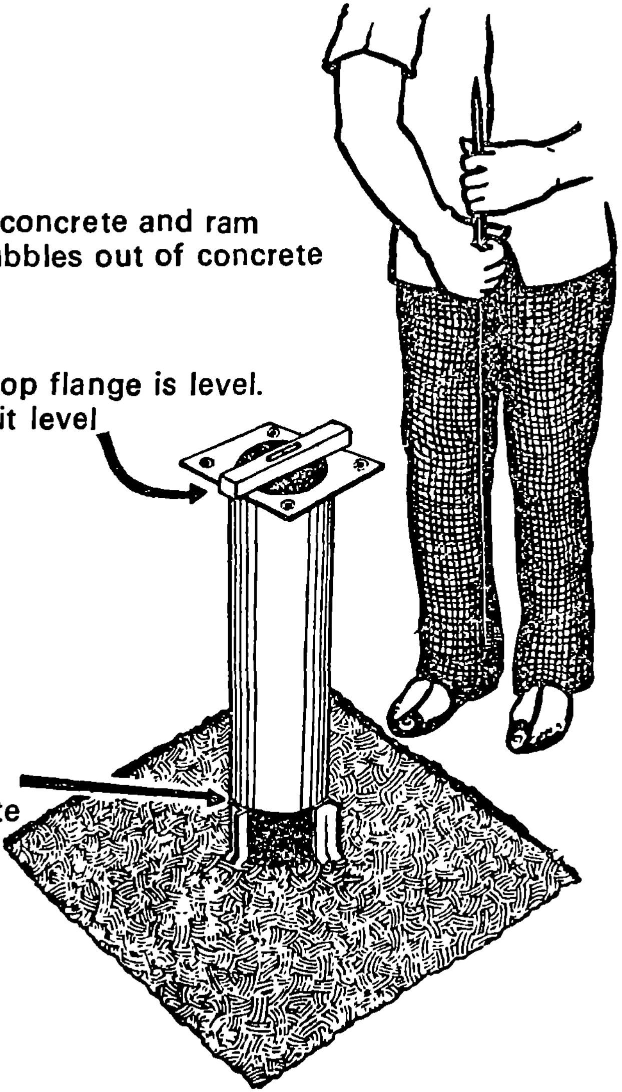


5

1. Fill pit with concrete and ram to get air bubbles out of concrete

2. Check that top flange is level. Use the spirit level

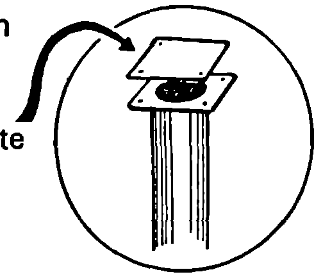
3. Construct platform o top of leg while concrete s still wet



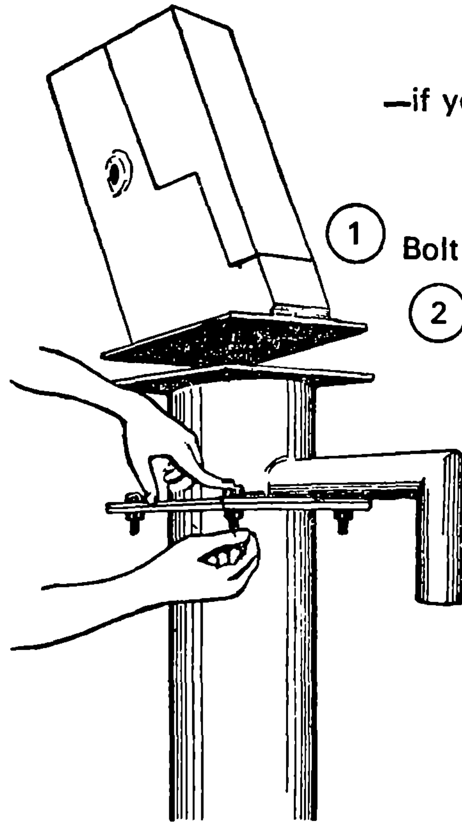
6

Cover pedestal so that children can't put stones in the well

— if you have a cover plate use it



—if you don't have a cover plate. . . .

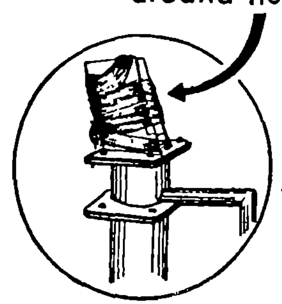


1. Bolt on water tank

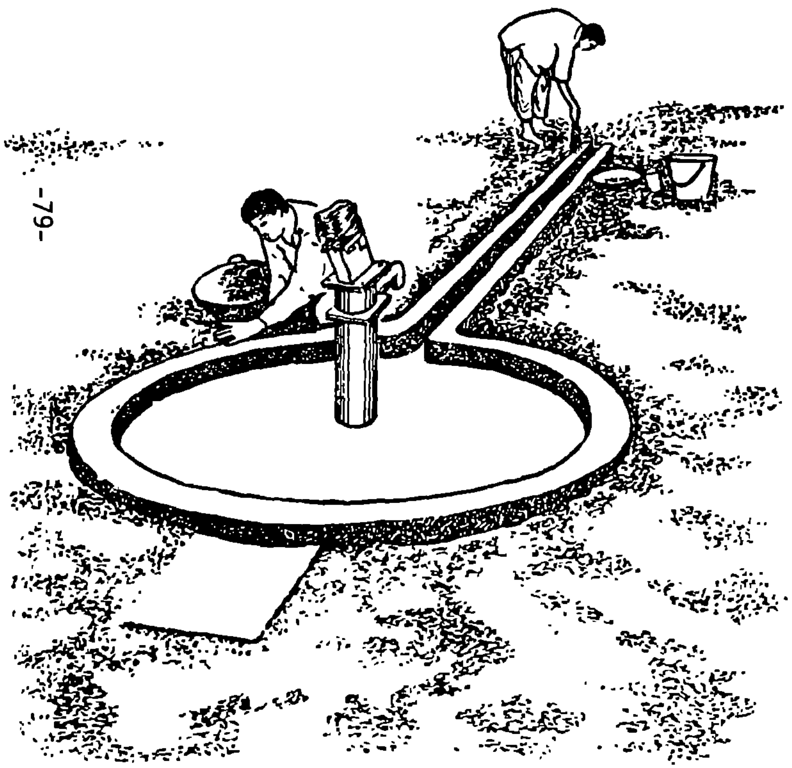
2. Remove handle from head

3. Bolt on head

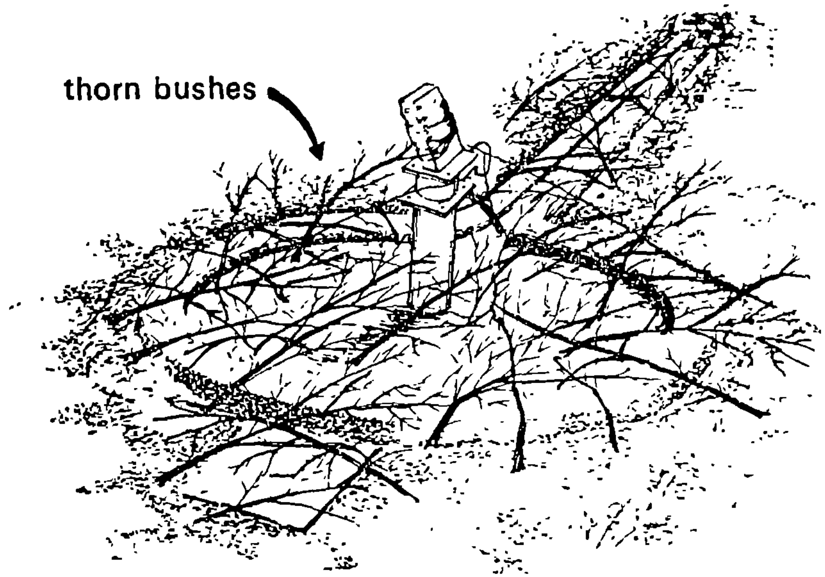
4. Wrap cloth around head



Construct platform and drain.
Use plan on pages 8 and 9.



To cure concrete, block drain and fill platform with water. Ask villagers to keep away from installation.



ALLOW CONCRETE TO SET FOR 7 DAYS

CONCRETE PRIMER

A. Introduction to Cement

Cement is one of the most useful materials in well construction. It can easily be mixed with sand and water to make mortar or with gravel, sand and water to make concrete. Both mortar and concrete are among the strongest and most durable materials used for all types of construction around the world. Mortar is normally used as the bonding agent between bricks or rocks while concrete is normally reinforced with steel bars and molded to the desired size and shape.

For well work, mortar or concrete is usually the best material for the lining, headwall, platform and cover of dug wells, and the platform and seal around the top three meters of casing in drilled wells.

Cement is available in almost every country in the world. Sand and gravel are usually available locally. Occasionally it will be difficult to get cement for well construction either because there are other higher priority demands for the cement or because it is too expensive. It is impossible here to say how or even whether cement can be obtained in such a circumstance.

Of the two cement compounds, mortar and concrete, concrete is the stronger. This is because the rock that makes up the gravel itself is stronger than the concrete and so contributes to its strength. Sometimes the two can be used interchangeably where lack of materials or working conditions demand it. Remember that concrete is the stronger product and should be used where possible.

NOTE: The rest of the discussion in this appendix will deal specifically with concrete. The same procedures can and should be followed if mortar is used instead.

B. Ingredients of Concrete

Concrete is made from cement, sand, gravel and water. These ingredients are combined in certain proportions to achieve the desired strength. The amount of water used to mix these ingredients is by far the most important factor in determining the final strength of the concrete. Use the least amount of water that will still give you a workable mix. Sand and gravel, which are sometimes referred to as fine and coarse aggregate respectively, should be clean and properly graded. Cement and water form a paste which, when mixed, acts as a glue to bind the aggregates together in a strong hard mass.

1. Proportions:

- There are four major ingredients in concrete: cement, sand, gravel, and water.
- Dry ingredients are normally mixed in certain proportions and then water is added. Proportions are expressed as follows: 1:2:4, which means that

From WASH Field Report No. 54, Philippine Hand Pump Program, 8/82 to one part cement you add two parts sand and four parts gravel. A "part" usually refers to a unit of volume. Example: A 1:2:4 concrete mix could be obtained by mixing 1 bucket full of cement with 2 buckets of sand and 4 buckets of gravel.

- Proportions are almost always expressed as cement: sand: gravel, and they are usually labelled that way.

- There are many minor variations in the proportions used for mixing concrete. The most commonly used are 1:2:4, 1:2:3, 1:2.5:5. For purposes of well construction, all work equally well.

  NOTE: A 1:2:4 mix will go a little farther than the 1:2:3 mix and allows a little more room for using less than the best grade of sand or gravel than a 1:2.5:5 mix.

- Normal range for amount of water used to mix each 50 kg bag of cement is between 20 liters and 30 liters (94 lb. bag of cement is between 4.5 gal. and 7 gal.)

- The water-tightness of concrete depends primarily on the water/cement ratio and the length of moist curing. This is similar to concrete strength in that less water and longer moist-curing promote water-tightness.

2. Choice of Ingredients

- Cement: The descriptions and properties given in this appendix are specifically of Portland cement. This is the type most commonly used and hereafter will be referred to only as cement.

  When used, it should be dry, powdery and free of lumps. When storing cement, try to avoid all possible contact with moisture. Store it away from exterior walls, off damp floors, and stacked close together to reduce air circulation. If it could be kept completely dry it could be stored indefinitely. Even exposed to air it will gradually draw moisture, thus limiting even the covered storage time to between 6 months and 1 year depending on conditions.

- Water: In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement.

- Aggregates: Fine and coarse aggregates together occupy 60% to 80% of concrete volume.

  - Fine aggregate: Sand should range in size from less than .25 mm to 6.3 mm. Sand from sea shores, dunes or river banks is usually too fine for normal mixes. (You can sometimes scrape about 30 cm of fine surface sand off and find coarser, more suitable sand beneath it.)

  - Large Aggregate: Within the recommended size limits mentioned later, the larger the gravel you use the stronger and more economical the concrete will be.

- The larger the size of the gravel the less water and cement will be required to get the same strength concrete.

- The maximum gravel size should not exceed:

  - one-fifth the minimum dimension of the member;
  - three-fourths the clear space between reinforcing bars or between reinforcement and forms. (Optimum aggregate size in many situations is about 2.0 cm.)

The shape and surface texture of aggregates affect properties of freshly mixed concrete more than they affect hardened concrete. Rough textured or flat and elongated particles require more water to produce workable concrete than do rounded or cubical aggregates and more water reduces the final strength of the concrete.

It is extremely important to have the gravel and sand clean. Silt, clay, or bits of organic matter, even in low concentrations, will ruin concrete. A very simple test for cleanliness makes use of a clear widemouth jar. Fill the jar about half full of the sand and small aggregate to be tested, and cover with water. Shake the mixture vigorously, and then allow it to stand for three hours. In almost every case there will be a distinct line dividing the fine sand suitable for concrete and that which is too fine. If the very fine material amounts to more than 10% of the suitable material, then the concrete made from it will be weak.

This means that other fine material should be sought, or the available material should be washed to remove the material that is too fine. This can be done by putting the sand (and gravel if necessary) in some container such as a drum. Cover the aggregate with water, stir thoroughly, let stand for a minute, and pour off the liquid. One or two such treatments will remove most of the very fine material and organic matter.

Another point to consider in the selection of aggregate is its strength. About the only simple test is to break some of the stones with a hammer. If the effort required to break the majority of aggregate stones is greater than the effort required to break a similar sized piece of concrete, then the aggregate will make strong concrete. If the stones break easily, then you can expect that the concrete made of these stones will only be as strong as the stones themselves.

In very dry climates several precautions must be taken. If the sand is perfectly dry, it packs into a smaller space. If 20 buckets of dry sand are put in a pile and two buckets of water stirred in, you could carry away about 27 buckets of damp sand. If your sand is completely dry, add some water to it or else measure by weight instead of volume. The surface of the curing concrete should be kept damp. This is because water evaporating from the surface will remove some of the water needed to make concrete properly. Cover the concrete with building paper, burlap, straw, or anything that will hold moisture and keep the direct sun and wind from the concrete surface. Keep the concrete moist by sprinkling as often as necessary; this may be as often as three times per day. After the first week of curing, it is not necessary to keep the surface damp continuously (see "Curing Concrete" below).

3. Estimating Quantities of Materials Needed

   1. Calculate the volume of concrete needed.

   2. Multiply the volume of concrete needed by 3/2 (1.5) to get the total volume of dry loose material needed. The cement and sand do little to add to the volume of the concrete because they fill in the air spaces between the gravel.

   3. Add 10% (1/10) for losses due to handling.

   4. Add the numbers in the volumetric proportion that you will use to get a relative total. This will allow you later to compute fractions of the total needed for each ingredient (1:2:3 = 6).

   5. Determine the amount of cement needed by multiplying the volume of dry material needed (from step 2) by the proportional amount of the total mix (e.g., amount cement needed = 1/6 x volume dry materials).

   6. Divide by the unit volume per bag, 33.2 liters per 50 kg bag cement or 1 cubic foot per 94 lb. bag cement. When figuring the number of cement bags round up to nearest whole number.

   NOTE: This calculation, even with the 10% addition for handling losses, rarely leaves any extra concrete, particularly for small jobs requiring less than 5 hand-mixed bags of cement.

C. Construction with Concrete

1. Outline of Concrete Work:

   - Build form (8C.5.2)
   - Place rebar (8C.5.3)
   - Mix concrete (8C.5.4)
   - Pour concrete (8C.5.4)
   - Remove forms (8C.5.4)
   - Finish surface (8C.5.4)
   - Cure concrete (8C.5.4)

2. Materials for Forms

   The following materials are used to construct interior forms:

   - Steel: forms made of steel are durable and strong but are heavy, awkward, and expensive.

   - Sheet metal: with a simple triangular interior support, forms made of sheet metal have proved to be successful. They are lighter and more maneuverable than steel forms but are not as strong and durable.

   - Wood: this material is commonly used because it is lightweight and strong. It must be carefully bent, waterproofed, and reinforced.

By using boards as wide as possible, form construction is easier and quicker. It also reduces the number of lines on the concrete surface that form at the junction of two boards. Plywood is excellent, especially if it has a special high density overlay surface. This allows for a smoother concrete finish, easier form removal and less wear on the forms.

If unsurfaced wood is used for forms, oil or grease the inside surface to make removal of the forms easier and to prevent the wood from drawing too much water from the concrete. Do not oil or grease the wood if the concrete surface will be painted or stuccoed.

- Earth: Any earth that can be dug into and still hold its shape can also be used as a form. Carefully dig out the desired shape and fill it with concrete. Once the concrete has set and cured it can be dug up and used where needed. A new form will have to be dug out for each piece of concrete poured.

- Other materials: Plastics and fiberglass are also occasionally used and continue to be experimented with as form materials. Fiberglass is much lighter than steel and, if handled carefully, lasts for a long time. Its cost and availability in developing nations seem to be the only factors limiting more widespread trials.

3. Concrete Reinforcement

Reinforcing concrete will allow much greater loads to be carried. Design of reinforced concrete structures that are large or must carry high loads can become too complicated for a person without special training.

Concrete alone has great compression strength but little tensile strength. Concrete is very difficult to squeeze (compression), but breaks relatively easily when stretched (put in tension). Reinforcing steel has exactly the opposite properties; it is strong in tension and weak in compression. Combining the two results in a material (reinforced concrete) which is strong in both compression and tension and therefore useful in a large number of situations.

Concrete is best reinforced with specially made steel rods which can be imbedded in the concrete. Bamboo has also been used to reinforce concrete with some success although it is liable to deteriorate with time.

- Reinforced concrete sections should be at least 7.5 cm thick although 10 cm is preferable.

- The reinforcing bar (rebar) usually comes in long sections of a given diameter.

- Exactly how much rebar is needed in a particular pour will depend on the load it will have to support. For most concrete work, including everything discussed in this manual, rebar should take up 0.5% to 1% of the cross-sectional area.

- Reinforcing bars should also have clean surfaces free of loose scale and rust. Bars in poor condition should be brushed thoroughly with a stiff wire brush.

- When placing rebar in a form before the concrete is poured it should be located:

  - at least 2.5 cm from the form everywhere.
  - in a plane approximately one-third of the way into the thickness of the pour from the bottom of the structure or slab.
  - in a grid so that there is never more than three times the final concrete thickness between adjacent bars.
  - no closer than 3 cm to a parallel bar.

- Rebar strength is approximately additive according to cross-sectional area. Four 4 mm rebars will be about as strong as one 8 mm rebar. The cross-sectional area of four 4 mm rebars equals the cross-sectional area of one 8 mm rebar.

- The rebars should be arranged in an evenly spaced grid-type pattern with more and/or thicker rebar along the longest dimension of the pour.

- All intersections where rebars cross should be tied with thin wire.

- When one rebar is tied onto another to increase the length of the rebars, the overlap should be 20 times the diameter of the rebar and be tied twice with wire.

Rebar Size	Overlap
6 mm	12 cm
8 mm	16 cm
10 mm	20 cm
12 mm	24 cm

- Larger sizes of rebar often have raised patterns on them which are designed to allow them to be held firmly in place by the concrete. Smaller sizes of rebar are generally smooth. When using smooth rebar always make a small hook at the end of each piece that will be in the concrete. Without the hook, temperature changes may eventually loosen the concrete from the rebar thereby destroying much of its reinforcing effect.

- Rebar should be carefully prepared so that the rebar is straight and square. Sloppy rebar work will result in weaker concrete and waste rebar.

- For particularly strong pieces or where small irregular shapes are being formed, the rebar can be put together in a cage-like arrangement. Use small rebar for the cross-sections and larger rebar for the length. This system is used to reinforce pieces like a cutting ring, with its irregular shape, or perhaps a well cover, which may have many people standing on it at one time.

- Where possible, it is usually best to assemble rebar inside the form so that it will fit exactly.

- The proper distance from the bottom of the pour in a slab can be achieved by setting the rebar on a few small stones before the concrete is poured or simply pulling the rebar grid a couple of centimeters up into the concrete after some concrete has been spread over the whole pour.

4. Mixing Concrete by Machine or by Hand

a. Mixing by Machine

Concrete must be thoroughly mixed to yield the strongest product. For machine mix, allow 5 or 6 minutes after all the materials are in the drum. First, put about 10% of the mixing water in the drum. Then add water uniformly with the dry materials, leaving another 10% to be added after the dry materials are in the drum.

b. Mixing by Hand

On many self-help projects, the amount of concrete needed may be small or it may be difficult to get a mechanical mixer. If a few precautions are taken, hand-mixed concrete can be as strong as concrete mixed in a machine.

The first requirement for mixing by hand is a mixing area which is both clean and watertight. This can be a wood and metal mixing trough (Fig. 8C-45) or simple round concrete floor (Fig. 8C-46).

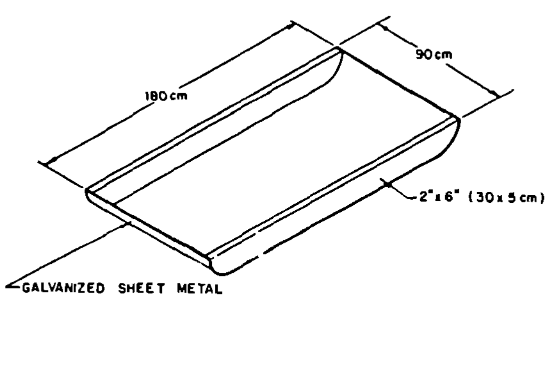


Figure 8C-47. Mixing Trough

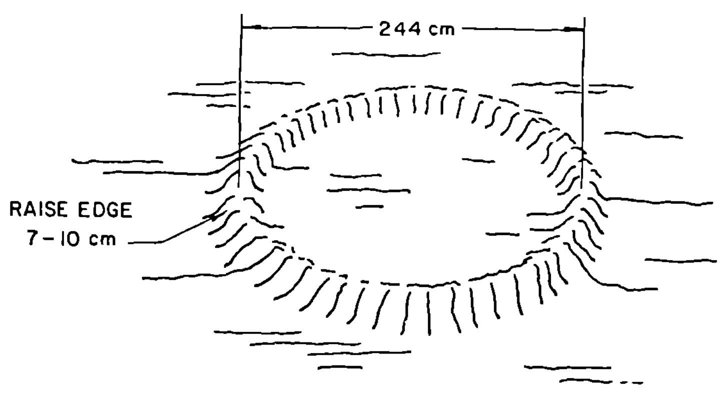


Figure 8C-48. Mixing Floor

Use the following procedure:

1. Spread the fine aggregate evenly over the mixing area.

2. Spread the cement evenly over the fine aggregate and mix these materials by turning them with a shovel until the color is uniform.

3. Spread this mixture out evenly, spread the coarse aggregate on it and mix thoroughly again. All dry materials should be thoroughly mixed before water is added.

A workable mix should be smooth and plastic -- neither so wet that it will run nor so stiff that it will crumble. If the mix is too wet, add small amounts of sand and gravel, in the proper proportion, until the mix is workable. If a concrete mix is too stiff, it will be difficult to place in the forms. If it is not stiff enough, the mix probably does not have enough aggregate, thus making it an uneconomical use of cement.

When work is finished for the day, be sure to rinse concrete from the mixing area and the tools to keep them from rusting and to prevent cement from caking on them. Smooth shiny tools and mixing boat surfaces make mixing surprisingly easier. The tools will also last much longer.

5. Pouring Concrete Into Forms

To make strong concrete structures, it is important to place fresh concrete in the forms correctly.

The wet concrete mix should not be handled roughly when it is being carried and put in the forms. It is very easy, through joggling or throwing, to separate the fine aggregate from the coarse aggregate. Do not let the concrete drop freely for a distance greater than 90 to 120 cm (3 to 4 feet). Concrete is strongest when the various sizes of aggregates and cement paste are well mixed.

Properly proportioned concrete will have to be worked into place in the form. Concrete that would on its own flow out to completely fill in a form would be too wet and therefore weak.

When pouring concrete structures that are over 120 cm high, leave holes in the forms at intervals of less than 120 cm through which concrete can be poured and which can later be covered to permit pouring above that level. Alternatively, a slide could be used through which concrete could flow down to the bottom of the form without separating. Any "U"-shaped trough wide enough to facilitate pouring concrete into it, narrow enough to fit inside the form, and long enough so that the concrete can slide down the chute without separating will work.

As the concrete is being placed it should be compacted so that no air holes, which would leave weak spots in the concrete, are left. This can be done by tamping the concrete with some long thin tools or vibrating the concrete. Tamping can be accomplished with a thin (2 cm) iron rod, a wooden pole or a shovel.

The concrete will be compacted to some extent as it is moved into its final position in the form. However, special attention must be paid to the edges of the pour to make sure that the concrete has completely filled in against the form. If the forms are strong enough they can be struck with a hammer on the outside to vibrate the concrete just enough to allow it to settle completely in against the forms. Too much vibration can force most of the large aggregate toward the bottom of the pour, thus reducing the overall strength of the concrete.

6. Finishing

Once the concrete is poured into the forms, its surface should be worked to an even finish. The smoothness of the finish will depend on what the surface will be used for. Where more concrete or mortar will later be placed on this pour, the area should be left relatively rough to facilitate bonding. Where the surface will later be walked on, as for example the cover of a well on which a pump will be mounted, it should be somewhat rough to prevent people from slipping on the concrete when its surface is wet. This somewhat rough texture can be achieved by finishing with a wooden float or by lightly brushing the surface to give it a texture. A very smooth finish can be made with a metal trowel. Over-finishing (repeated finishing) can lead to powdering and erosion of the surface.

7. Curing Concrete

After the forms are filled, the concrete must be cured until it reaches the required strength. Curing involves keeping the concrete damp so that the chemical reaction that causes the concrete to harden will continue for as long as is necessary to achieve the desired strength. Once the concrete is allowed to dry the chemical hardening action will gradually taper off and cease.

The early stage of curing is extremely critical. Special steps should be taken to keep the concrete wet. Once the concrete dries, it will stop hardening; after this happens it cannot be re-wetted in the field to re-start the hardening process.

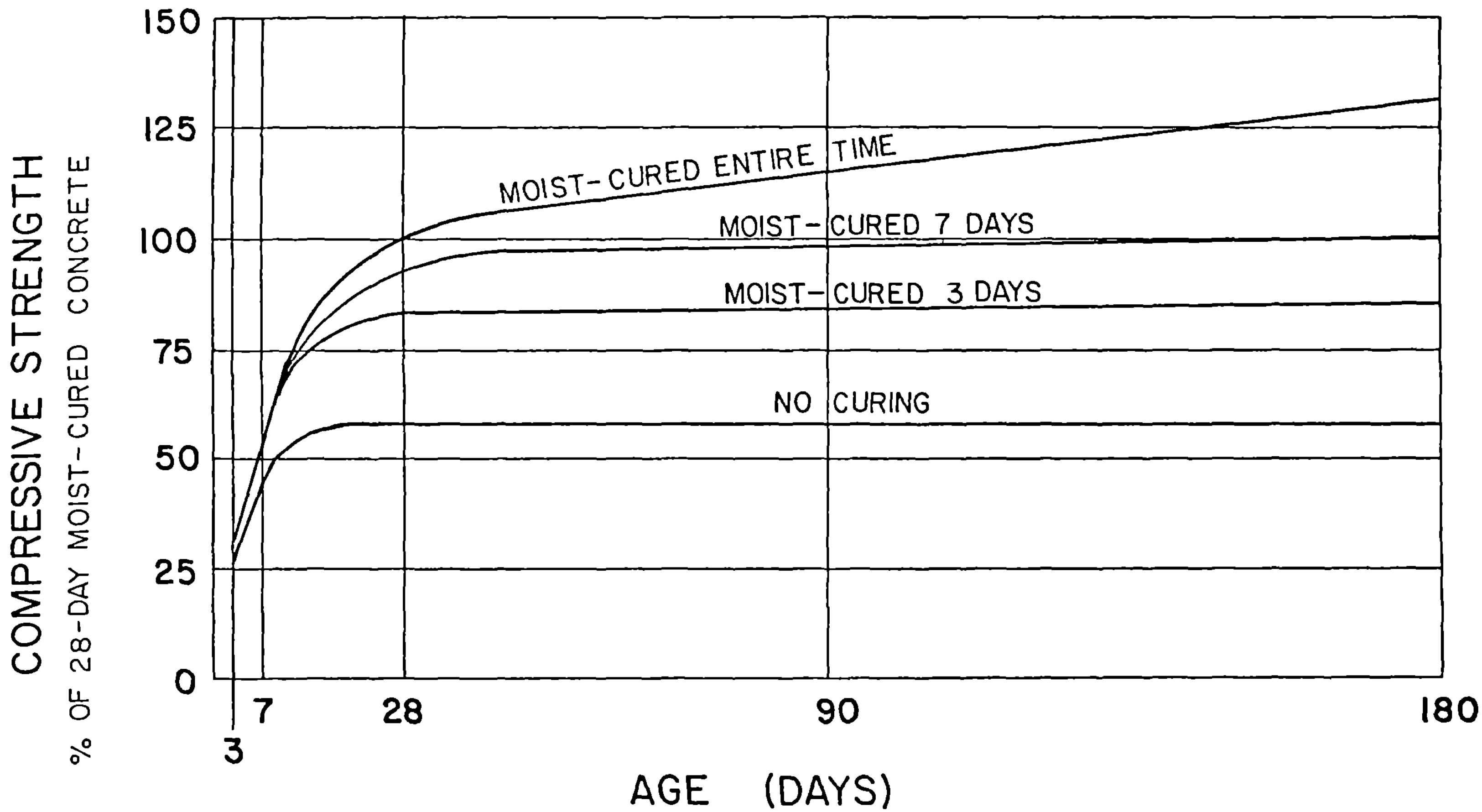
Covering the exposed concrete surfaces is usually easier than continuously sprinkling or frequently dousing the concrete with water which would otherwise be necessary to prevent the concrete surface from becoming dry. Protective covers often used include canvas, empty cement bags, burlap, plastic, palm leaves, straw and wet sand. The covering should also be kept wet so that it will not absorb water from the concrete.

Concrete is strong enough for light loads after 7 days. In most cases, forms can be removed from standing structures like bridges and walls after 4 or 5 days, but if they are left in place they will help to keep the concrete from drying out. Where concrete structures are being cast on the ground, the forms can be removed as soon as the concrete sets enough to hold its own shape (3 to 6 hours) if there is no load on the structure and measures are taken to ensure proper curing.

The concrete's final strength will result in part from how long it is moist cured. As can be seen from the Graph 8C-1, concrete will eventually reach about 60% of its design strength if not moist cured at all, 80% if moist cured for 3 days, and almost 100% if moist cured for 7 days. If concrete is kept moist, it will continue to harden indefinitely.

GRAPH 8C-1

Comprehensive Strength of Concrete



Instrument for Assessing Project Feasibility

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
Well Characteristics	• Yield of well					
	• State of disrepair of well					
	• Type of well and diameter					
Water Characteristics	• Chemical water quality					
	• Taste, odor and appearance of water					
Location of Well	• Distance from source of contamination					
	• Accessibility					
	Above known flood level					
	On small hill					

COLUMN A GENERAL AREA	COLUMN B ITEM	COLUMN C WHY IMPORTANT	COLUMN D CRITERIA	COLUMN E HOW TO GET INFORMATION	COLUMN F • IMPACT ON PROCEEDING (whether to proceed) • IMPACT ON DESIGN (how to proceed)	COLUMN G SURVEY ACTIVITIES/RESULTS (to be filled out in the field)
Community Interest and Support	Interest of village leadership and villagers in under taking project					
	Number of users					
	Potential for water committee or other responsible organization					
	Potential for village based maintenance capability.					
	Interest in supporting/promoting user education.					
Community Resources	• Available labor					
	• Available materials					
	• Ability to pay users fees, or other costs (if appropriate)					

Situations for Problem Solving

Situation #1:

Ali is an extension worker with the Ministry of Natural Resources. After attending a training workshop on handpumps, Ali surveyed the village of Potiskum and, from a technical stand point, decided it was ready to receive a handpump. There are three wells in the village, one of which meets all of the criteria for a good site. It needs a minimum of relining, it is at least 15 meters from a cattle pen, so that contaminiation from animal waste should not be a problem, and has it adequate drainage. Ali has determined that this village should be the first of the villages in his circuit to receive a handpump. Several days after his visit, Ali met the village school teacher in a nearby town. The school teacher told Ali that the villagers are talking about his visit and that the village is split between two factions-- one faction, made up mostly of women is saying that a handpump project should not be allowed to come to the village. They say that while Ali was in the village, he poisoned one of the wells; that is why he left the village so quickly after dropping something down into the wells.

Another faction is saying, "Let the handpump come. In the village of Ġadaka, a team came in and installed the pump only two weeks after the visit of the extension worker. They completed all the work in three days and then left. The villagers had to do nothing."

Situation #2:

Central government authorities have been running a media campaign to convince villagers to use clean water. In addition, mobile units have brought movies and talks about clean water into villages. The central government has publicaly announced that 500 handpumps will be installed over the next month. For Mushi, an extension worker in the Kunhan District of Si Sa Ket, this means responsibility for preparing 20 villages in four weeks to receive handpumps.

Mushi feels that handpump projects are an important way to improve the health of rural people as well as a means to encourage villagers to participate in planning and designing a village project.

Situation #3:

Villagers were not coming to work at the well site as they had been scheduled. Help was needed for the work. Finally, the extension worker, Jose, visited each person house to house the day before their appointed work day and asked them why they were not coming. He tried to find out what the problems were and stressed the importance of the handpump for creating a source of clean water for the village. Every man he visited came to work, but he had to continue visiting them and make a personal appeal to each one before they would come.

Situation #4:

The handpump in the village of Fika has been laying idle for three months. There has been disagreement in the village about how much money should be collected every month by the water committee and how this fund should be used. In the beginning ______ was being collected from every family. Now, however, there are complaints that it is too much, especially since there has been an outbreak of pests and all the villagers are forced to spend money to buy pesticides. Most families have refused to give money to the water committee treasurer for the last two months. The pump needs a foot valve in order to work again. The village caretaker has estimated this would cost ______.

Situation #5:

Women in the Bahr El Ghazil Province of Sudan spend many hours fetching and carrying water long distances. Often this water is contaminated and causes illness and death.

A water supply project was started in response to the need for clean water and to provide the women with a more accessible water source. Handpumps were installed and villagers were trained in their use and maintenance. Health education was also given to stress the importance of using the new water source.

When the women used the handpumps they found that the time spent for fetching water was lessened and there was a decrease in water-related illnesses. Nevertheless, they did not use this water source consistently. When questioned, they gave the following reasons:

1. The water tastes bad and can lessen appetite when used in food.

2. The water changes color when boiled for tea or exposed to air.

3. Too many people use the pump and there is a long wait. This often causes fights among the villagers

4. The pump is often broken.

Mid-Point Evaluation

1. Do you feel capable of accomplishing all of the session objectives covered so far? If not, which ones present the most problems (specify session and objectives)?

2. What are the things you have learned from the first half of the workshop? Place a check next to the items which are most useful to you in your work.

3. In general, what are the problems you encountered during the first half c [illegible] workshop? What do you think should be done to resolve them?

Team Work Plan Guide

Group	Task	Approximate Time
Group A	. remove planking . place hatch cover	1 hour 10 minutes
Group B	. remove forms . plaster exposed surfaces	20 minutes 45 minutes
Group C	. dig sump . fill sump with gravel and cover . grade area around sump	20 minutes 30 minutes 30 minutes
Group D	. dig drain . place drain, mortar in place	20 minutes 45 minutes

Team Work Plan Guide

Group	Task	Approximate Time
Group A	. remove form . plaster exposed surface	10 minutes 1 hour
Group B	. dig sump . fill sump with gravel and cover with clay . grade area around site	20 minutes 20 minutes 30 minutes
Group C	. dig drain . place drain, mortar in place	20 minutes 45 minutes

Finishing the Site

Concrete Drain and Area Around the Apron

Excavate a drainage trench from the drain space in the apron to a sump or an existing drainage ditch. Slope the bottom of the trench so water from around the apron will drain into it as shown in Figure 1 . Fill the trench with at least five (5) cm of small gravel. Using hollow blocks, construct a concrete drain over the gravel in the trench for a distance of at least five (5) meters. The floor of the drain should be five (5) cm thick and ten (10) cm wide. The concrete drain removes water from the apron while the sublayer of gravel allows water from around the apron to be drained away.

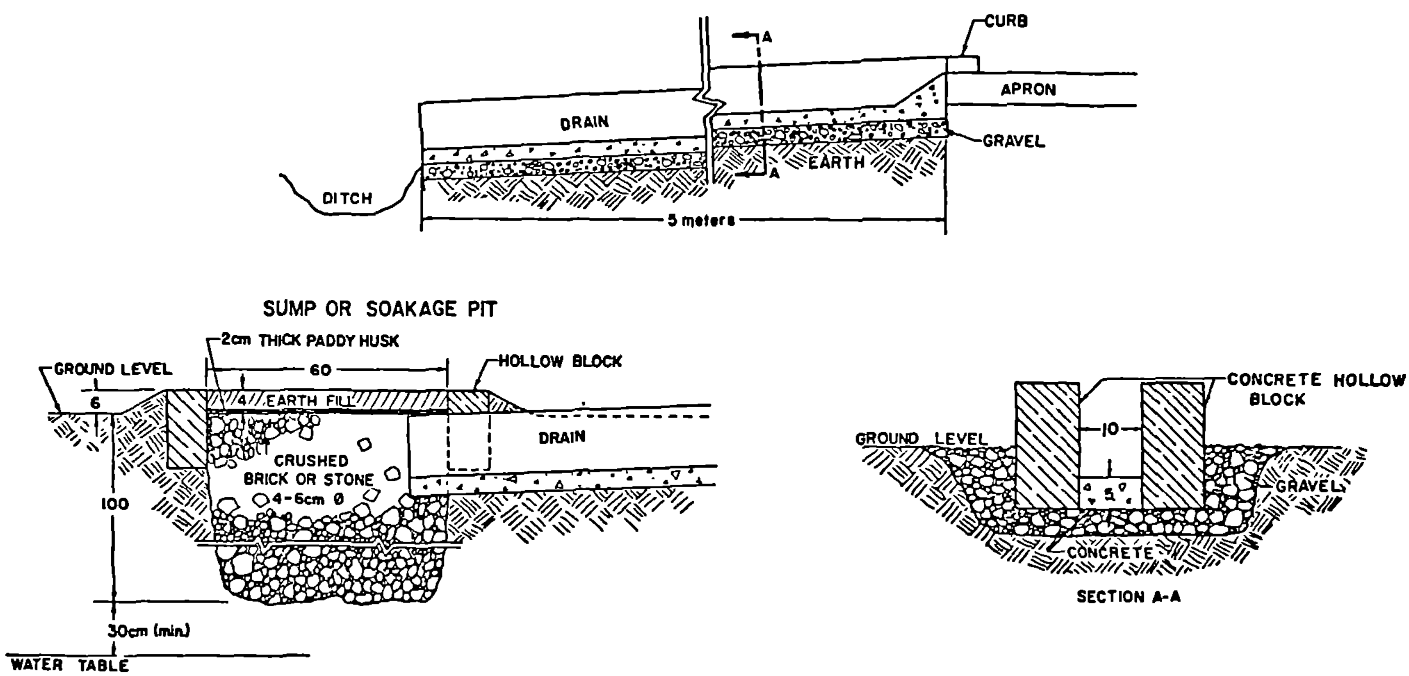


Figure 1. Apron Drain

Clear a one and one-half (1½) meter area around the apron. The area should be sloped so that waste water is drained away from the apron and toward the drain. This procedure is recommended because standing water may contaminate the well. Splash water on the cleared area to locate low spots as in Figure 2. When the low spots have been drained, cover the area with 10 to 15 centimeters of small gravel. The gravel provides a non-slip and neat surface especially during the rainy season. Sites on soft soil will require more gravel than those on hard soil.

The following figures depict completed sites and some innovative ideas for making the site more attractive or functional.

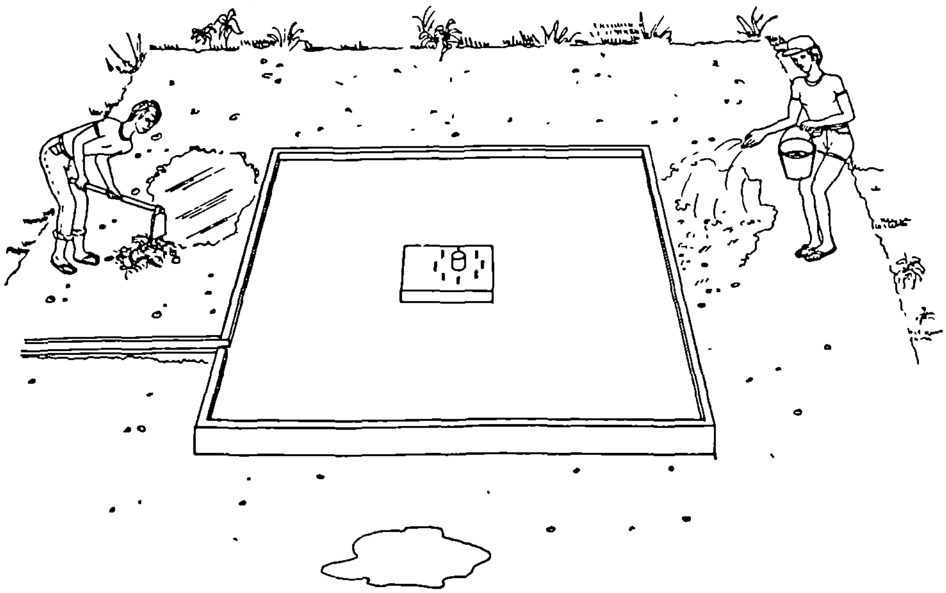


Figure 2. Drainage of Area Around Apron

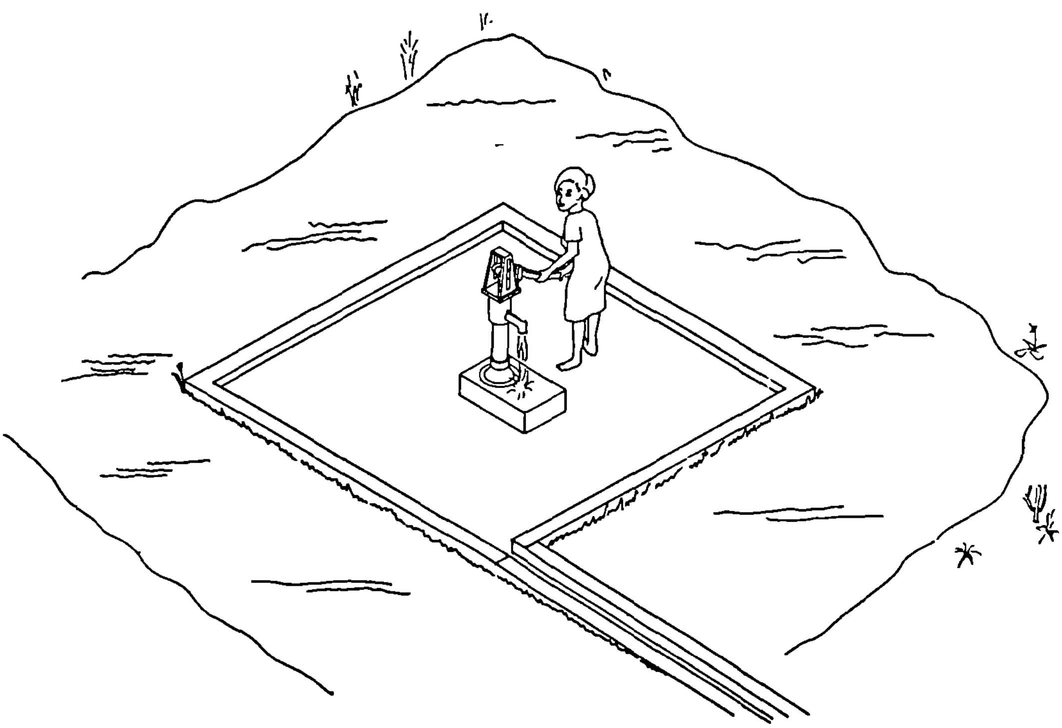
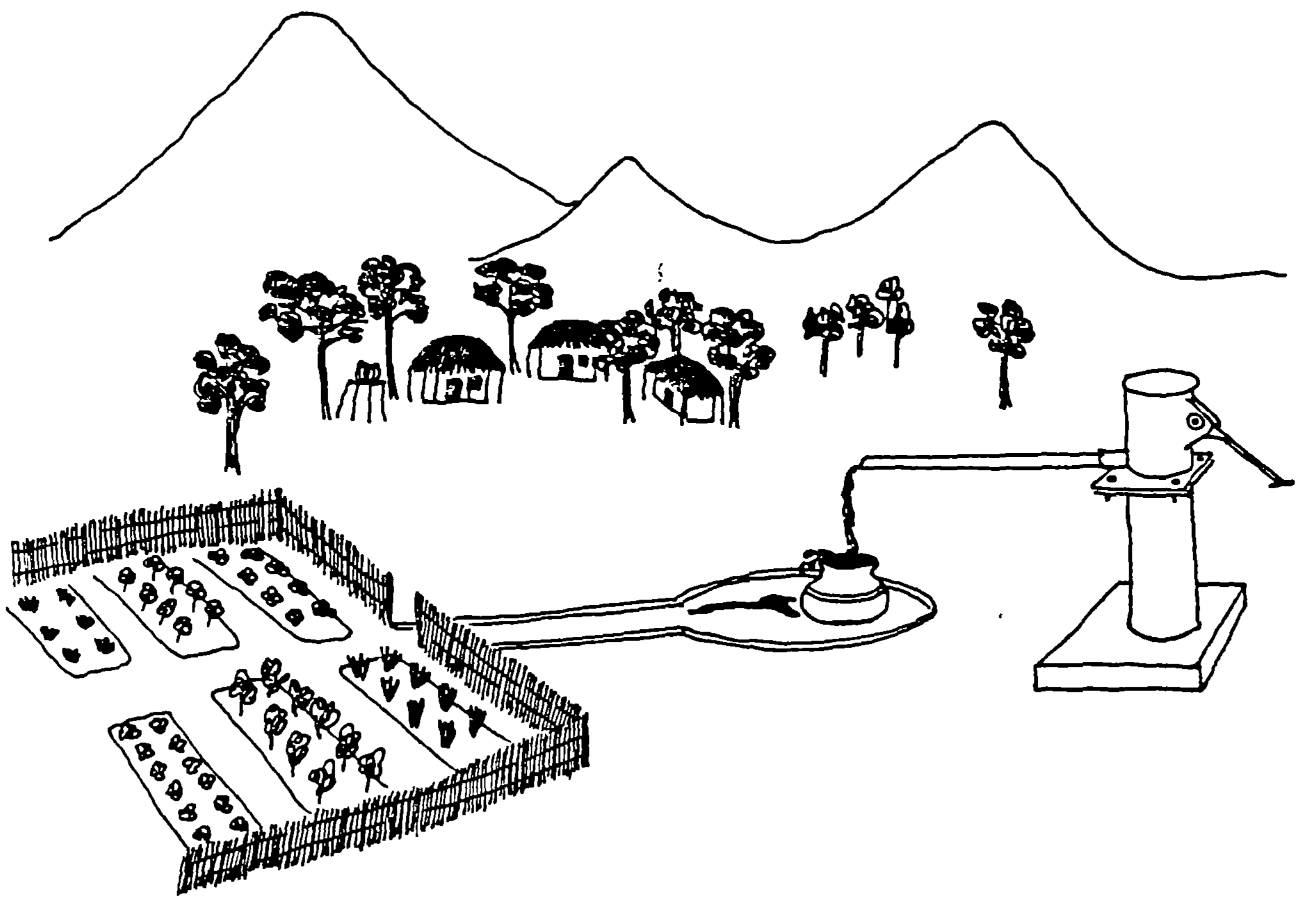


Figure 3. The Finished Site



Konzani ngalande kuti madzi wotaika pa chitsime adzeremo polowa padimbo.

Channel drain water into a garden

Estimating Rules for Pump Installation Depth

Rule I

Wherever possible the bottom of the cylinder or bottom of the suction pipe should be installed at the following depths:

Rule I A:	Shallow well pumps	- 8-9	meters below pump
Rule I B:	Deep well pumps on dug wells	- 3-5	meters below the dry season static water level
Rule I C:	Deep well pumps on drilled wells	- 10-12	meters below the dry season static water level

Rule II

When the well is so shallow that the pump cannot be installed as deep as ROT I recommends, the minimum distance that the bottom of the cylinder or suction pipe should be from the bottom of the well is:

Rule II A:	New dug well	- 30 cm
Rule II B:	Older dug well	- 10-15 cm
Rule II C:	New drilled well	- 2 meters
Rule II D:	Older drilled well	- 1 meter

Rule III

The recharge rate of the well influences the depth at which the cylinder or end of the suction pipe should be installed:

Rule III A:	Recharge rate low	- Install deeper than Rule I or 1/2 Rule II
Rule III B:	Recharge rate medium or high	- Follow Rules

Key to recharge rates:

insufficient:	recharge rate less than 8 l/min.
minimal:	recharge rate of 9-13 l/min.
adequate:	recharge rate grater than 14 l/min.

Rule IV

When the recharge rate is low a deep well pump should be used when the static water level is the following distance below the surface:

Rule IV A:	Dug well	- 7 meters
Rule IV B:	Drilled well	- 4 meters

Rule V

When in doubt, always install deeper than the Estimating Rules. When the cylinder or end of the suction pipe is not installed deep enough, or installed too deeply, do the following:

- Shorten the pipe if mud and sand are being pumped.
- Add an extra length of pipe if the bottom of the cylinder or suction pipe is out of the water. Up to 8 meters of suction pipe can be added below a deep well cylinder before additional drop pipe and plunger rod must be added.

Problems for Determining Installation Depth

Problem #1

A drilled well with a broken pump cannot be repaired and will receive a new pump. The well is 100 meters deep with the current dry season water level 38 meters. How deep should the cylinder be installed?

Problem #2

A 1.5 meter diameter dug well is 30 meters deep. It was dug down to rock many years ago by a tribal leader. The recharge rate was measured at about 10 liters/min. There is 2 meters of water in the well. How deep should the cylinder or suction pipe be?

Problem #3

A 60-meter deep well was recently drilled. The water in the well rose to within 46 meters of the surface. Its recharge rate was measured at 5 liters/min. Where should the cylinder be installed?

Problem #4

A new drilled well has a water table 14 meters below the surface. The well is 19 meters deep. During the recharge rate test, the test crew noted that the water level returned to its original level within the first minute after test-pumping stopped. How deep should the installation crew install the cylinder?

Problem #5

A 26-meter deep well was just dug by the villagers. It is the dry season and 3 meters of water are currently standing in the well. The workers couldn't dig any deeper even with others helping to bail the well. How deep should the pump cylinder be installed?

Answers to the Problems for Determining Installation Depth

Problem #1

The well is an older drilled well. According to the estimating rules the cylinder should be 10-12 meters below the static water level but not closer than 1 meter from the bottom of the well. Following rule 1, the pump cylinder should be 48-50 meters below the surface. Since the well is 100 meters deep there is not a problem with installing the cylinder too close to the bottom of the well.

Problem #2

This is an older dug well with a medium recharge rate. Because there is only 2 meters of water in the well the estimating rule recommendation of installing the cylinder 3-5 meters below the static water level doesn't apply. When the pump is installed the bottom of the cylinder should be 10-15 centimeters from the bottom of the well.

Problem #3

The well is a newly drilled deep well. The recharge rate is low. Therefore, the cylinder should be installed as deep as possible which is 2 meters from the bottom of the well according to the estimating rules.

Problem #4

The estimating rule is that the cylinder be installed 10-12 meters from the bottom of the well. Because the water level returned to its original level very quickly during the recharge rate test the well's water level won't vary much during regular use. Therefore, an installed depth of 17 meters should be acceptable even though there will be only 3 meters of water above the cylinder.

Problem #5

The well is recently dug and has a very high recharge rate as evidenced by the incoming water impeding the work. Following the estimating rules, the bottom of the cylinder should be 30 centimeters from the bottom of the wel

Steps for Installing an AID Shallow Well Pump

1. Remove cups for soaking the day before installation:

   - unbolt pump cap from body
   - disconnect plunger assembly from cap
   - put plunger assembly in bucket of water

2. Tighten pump connections:

   - tighten plunger assembly
   - tighten plunger rod lock nuts
   - tighten bolts and nuts holding cap on body
   - tighten body/base joint

3. Cut suction pipe to length: Using the estimating rules for the depth at which to locate the suction pipe, measure and cut the suction pipe to the desired length.

4. Glue adaptor to end: Solvent weld the 53 mm PVC suction pipe sections together following the directions on the can of solvent. Weld a male threaded coupling on the upper end. Attach the well strainer, if used. Allow several minutes for the solvent weld to set. Avoid getting solvent on yourself.

5. Place suction pipe in well: Lower the suction pipe assembly into the well.

6. Attach suction pipe to pump: Screw the male threaded coupling into the pump base. This task is much easier if the pump base is unscrewed from the pump body.

7. Bolt down pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the slider block tracks. Reassemble the pump.

9. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-Gallon) can in 18-22 strokes which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky footvalve or leaky joints. This situation is intolerable in shallow well pump installations since the pump may require regular priming which can introduce contaminants into the well. The pump should be removed and the cause of the leak determined and corrected before re-installation.

NOTE: The pump may require priming if the cups were not soaked overnight. Pour a bucket of clean drinking water into the plunger rod hole in the pump cap. Repeat with pumping if water cannot be raised after the first priming.

10. Disinfect the Well: Follow the steps of Handout 11-5: Steps for Disinfecting Wells to disinfect the well.

Steps for Installing an AID Deep Well Pump

1. Tighten connections: The connections in the cylinder need to be tightened before the pump is installed.

2. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. In the measurement allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe following the procedure below:

   - Wipe the loose cuttings and dirt from the end of the pipe.
   - Thread the die on the pipe until the teeth begin to bite into the metal.
   - Cut the threads by turning the die clockwise 1/2 turn and then counter-clockwise 1/4 turn to allow the cuttings to fall away.
   - Continue in this manner until approximately 1 1/2 to 2 inches of threads have been cut.
   - Carefully remove the die without damaging the threads.
   - Wipe any loose cuttings off the pipe with a rag.

3. Install cylinder, drop pipe and plunger rod to desired depth: Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the threads to make future disassembly easier, attach a length of plunger rod to the plunger rod section in the cylinder. Tighten firmly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly. If used, attached a strainer to the bottom of the cylinder.

   Lower this portion of the drop pipe assembly into the well.

   Put a section of plunger rod inside an equal length section of drop pipe. Raise these sections over the already-lowered portion of drop pipe assembly, connect the plunger rod first (being sure it is very tight), apply Teflon tape or pipe joint compound to the drop pipe threads and then connect and tighten the drop pipe. A pipe clamp and tripod will be required to perform this step and those following. Again, always wipe the threads clean before applying Teflon tape or a pipe joint compound and joining sections of pipe together.

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

4. Attach drop pipe to base: Unbolt the pump cap from the pump body. Attach the pump body and base to the drop pipe.

5. Cut rod to length and thread rod: Push the plunger rod down to the lowest position (until it cannot be pushed any more, refer to handout). Mark the rod 1 inch above the top of the pump body. Cut and thread the plunger rod. Follow the same threading procedure as for the drop pipe. This step ensures that the plunger assembly will be well centered within the cylinder.

6. Attach cap to rod and body: Holding the pump cap over the pump body, join the plunger rod sections. Rebolt the pump cap to the pump body. Check all exposed nuts and bolts for tightness.

7. Bolt down pump onto apron: Lower the pump base onto the anchor bolts and fasten it in place.

8. Lubricate the pump: Remove the cotter pins from one side of the bearing pins and slide the bearing pins out of the handle, fulcrum and pump cap. Grease the pins and the slider block tracks. Reassemble the pump.

9. Test the pump: Perform the following tests on the pump:

   - Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The AID pump should fill a 19-liter (5-gallon) can in 18-22 strokes which is about one liter per stroke. The flow rate of installation will vary when pumps other than the AID pump are used.

   - Leak Rate: Allow the pump to stand idle for 15 minutes before pumping again. Count the number of strokes. Ideally, water should flow out on the first or second stroke. If it takes more than one or two strokes, there may be a leaky footvalve or leaky joints. This situation is very inconvenient to the users since they may have to pump a long time to get water in the morning. The pump should be removed and the cause of the leak determined and corrected before re-installation.

10. Disinfect the Well: Follow the steps given in Handout 11-5: Steps for Disinfecting Wells, to disinfect the wells.

INSTALLING THE PUMP

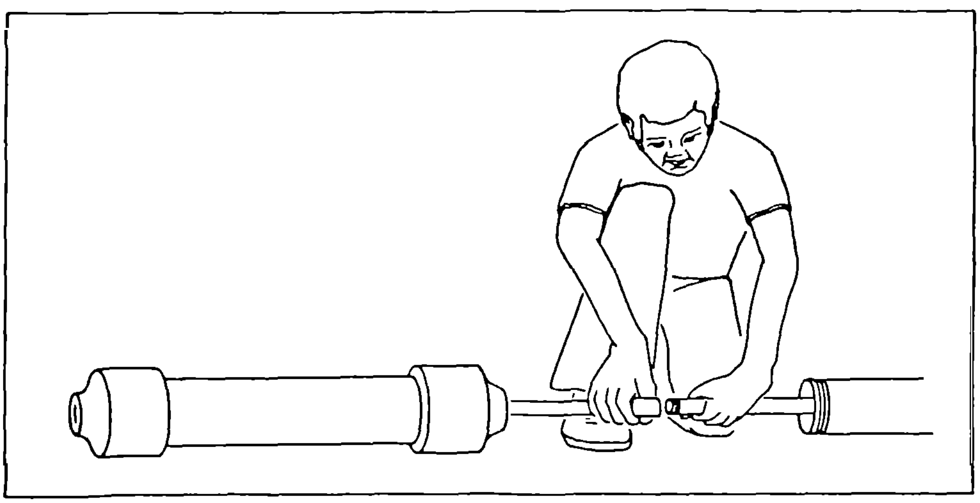
1. Determine how much drop pipe you need. Use the Rules of Thumb below Then cut and thread the drop pipe.

RULES OF THUMB FOR DETERMINING CYLINDER DEPTH FOR DEEP WELL PUMPS

IF the well is	AND IF it is	THEN the cylinder should be
Dug	New	3 - 5 meters below the static water level BUT No closer than 30 cm from the bottom of the well
	Old	3 - 5 meters below the static water level BUT No closer than 10 - 15 cm from the bottom of the well
Drilled	New	10 - 12 meters below the static water level BUT No closer than 2 meters from the bottom of the well
	Old	10 - 12 meters below the static water level BUT No closer than 1 meter from the bottom of the well

2. Put the cylinder in the well:

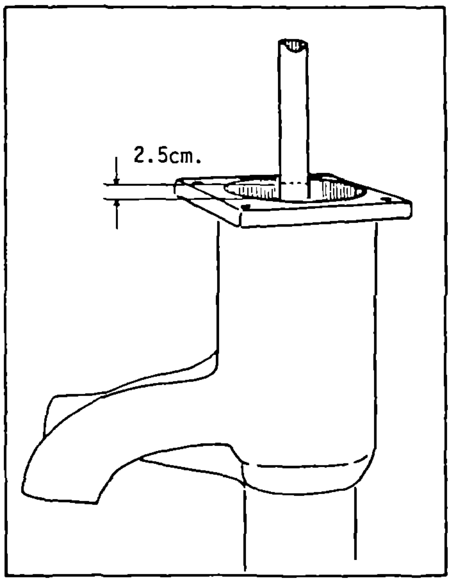
   a. Attach the plunger rod to the rod in the cylinder.



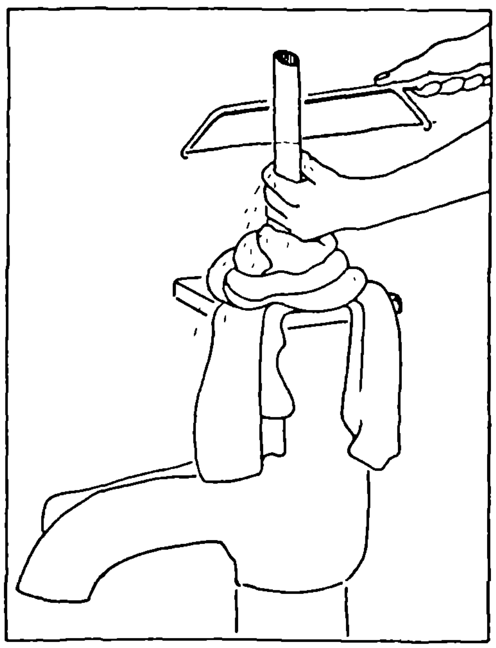
   b. Attach the drop pipe to the cylinder.
   c. Continue adding sections of rod and pipe until desired depth is reached.

INSTALLING THE PUMP (PAGE 2)

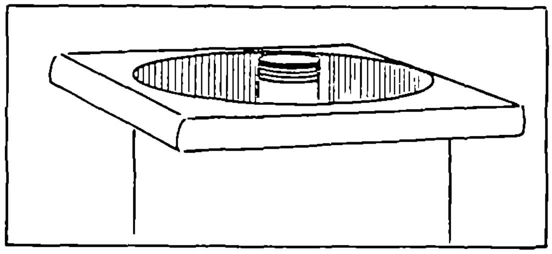
3. Cut the plunger rod to length and thread it·
   a. Push the plunger rod to full "down position."
   b. Mark the plunger rod at 2.5cm. above the body of the pump.



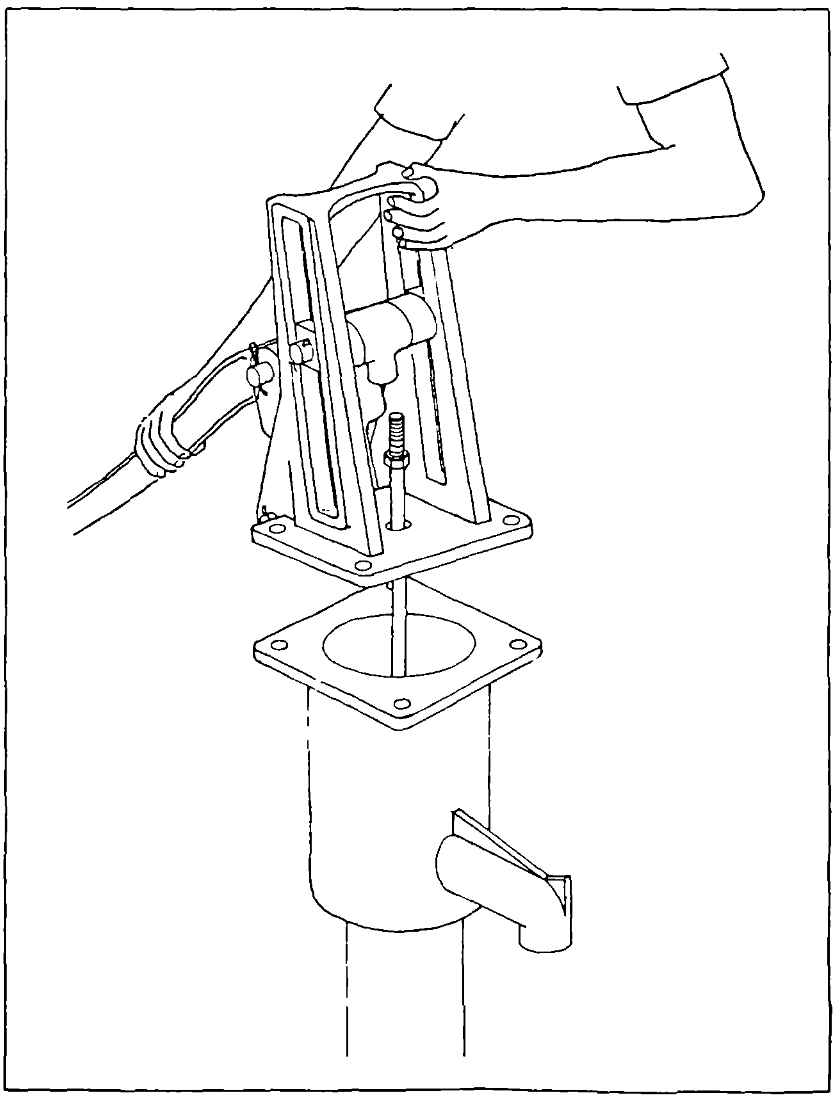
   c. Wrap a rag around the rod to cover the pump opening. Then cut the excess rod away.



d. Thread the plunger rod.



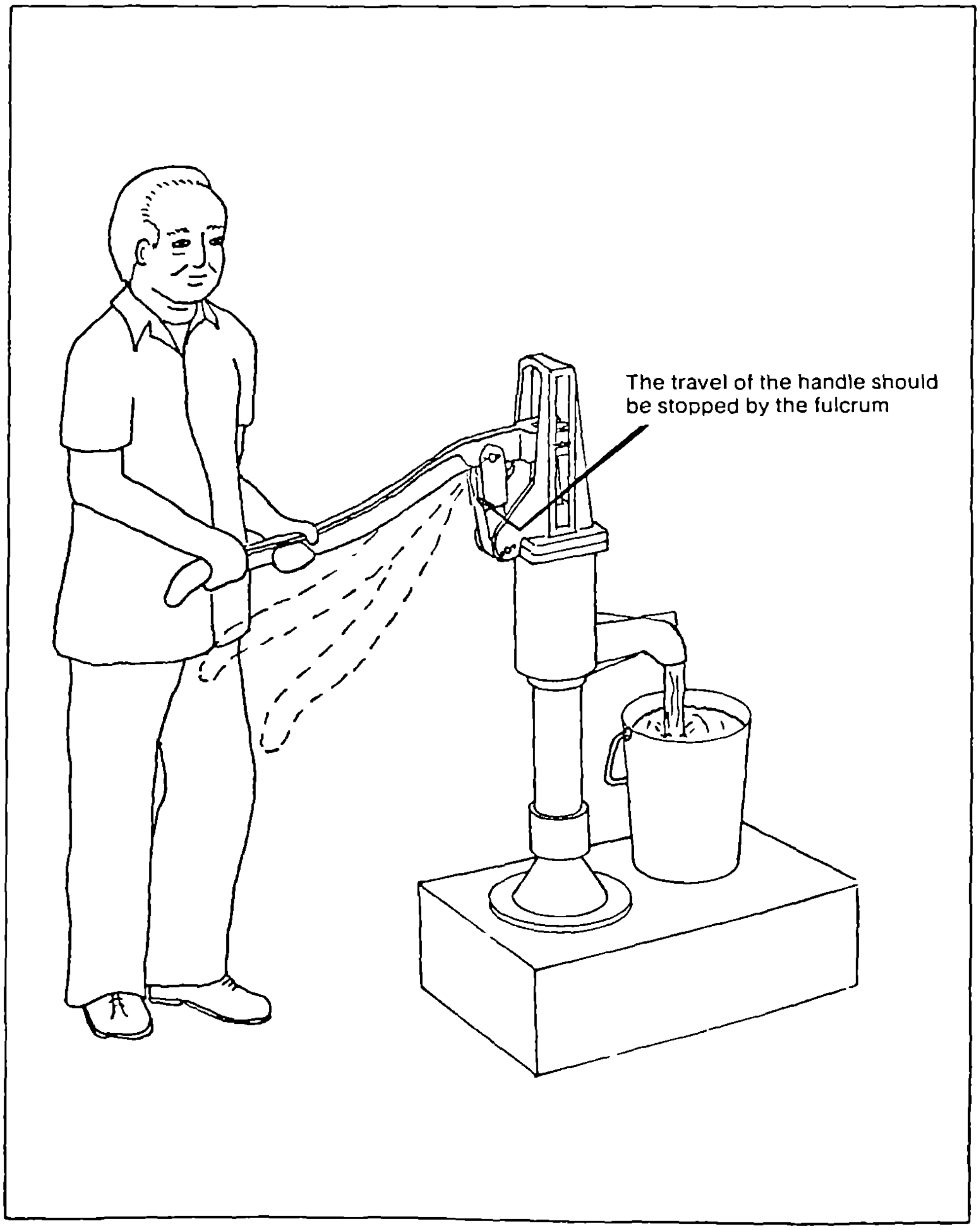
4. Put the cap on the pump, and attach the plunger rod to the handle



TESTING THE PUMP

Check these.

- The handle should move fully, as shown in this picture.
- Check the flow rate. You should be able to fill a 12 liter container in about 12 full strokes.
- Check the leak rate. Leave the pump alone for about 15 minutes, then start pumping again. You should have water after 2 or 3 strokes



Steps for Installing a Mark II Deep Well Pump

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

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

3. Cut drop pipe to length and thread: Using the estimating rules for the depth at which to locate the cylinder, measure and cut the drop pipe to length. Allow for the length of the cylinder and the distance from the point at which the well depth was measured to the base of the pump.

   Thread the drop pipe. Follow the procedure below:

   - wipe loose cuttings and dirt from the end of the pipe
   - thread the die on the pipe until the teeth begin to bite into the metal
   - apply cutting oil or animal lard liberally to the end of the pipe
   - cut the threads by turning the die clockwise 1/2 turn and then counter clockwise 1/4 turn to allow cuttings to fall away
   - continue in this manner until approximately 1 1/2 to 2 inches of threads have been cut
   - carefully remove the die without damaging the threads
   - wipe any loose cuttings off the pipe with a rag

4. Install cylinder, drop pipe and plunger rod to desired depth: Thoroughly brush the pipe and rod threads with a stiff wire brush to remove dirt and rust. Wipe the threads with a clean rag. After applying grease to the rod thread to make future disassembly easier, attach a length of plunger rod to the rod section in the cylinder. Tighten the connection and lock nut tightly. Next, attach an equal length section of drop pipe to the cylinder. Use Teflon tape or a pipe joint compound on the pipe threads and tighten firmly. If used, attach a strainer to the bottom of the cylinder.

   Lower this portion of drop pipe assembly into the well. Secure it with a pipe clamp or tripod.

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

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

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

6. Cut plunger rod to desired depth and thread: Push the plunger rod down to the lowest position (until it cannot be pushed down any further). Mark the rod lever with the top of the water tank with a hacksaw or scribing tool. Raise the rod up as far as possible. Place a rag into the water tank to keep rod cuttings from falling into the well. Clamp the rod with a rise or clamp. Cut and thread the plunger rod following the same procedure as for the drop pipe. Remove the rag. This step ensures that the piston assembly will be centered in the cylinder.

7. Attach plunger rod to head assembly: Remove the inspection cover from the head and lower the head onto the water tank. Screw the chain section onto the rod. Tighten the connection and the lock nut firmly. Using a bar, lift the head off to the tank and remove the rod clamp. Then bolt the head to the tank.

   Next, insert the handle through the head and bolt the chain firmly to the handle. Insert the axle through the handle and tighten retaining nuts on axle.

8. Test the pump: Perform the following tests on the pump:

   • Flow Rate: Using full strokes, fill a container of known size while counting the number of strokes. The standard cylinder (2 1/2" ID) of the Mark II pump should fill a 19-liter (5 gal.) container in 30-34 strokes which is about 2/3 liter per stroke.

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

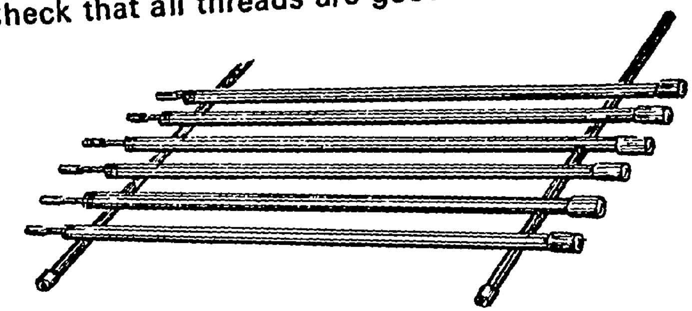
9. Lubricate the pump: Apply grease to the chain. The handle bearings are sealed and do not need lubrication.

10. Disinfect the well: See Handout 11-5: Steps for Disinfecting Wells for disinfecting the well. For drilled wells it is usually easier to disinfect the well before installing the pump.

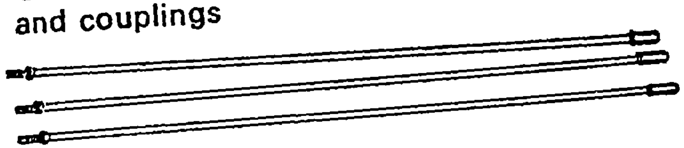
9

SEVEN DAYS LATER

(1) Lay out pipes and connecting rods.
Check that pipes and rods are threaded 40 mm.
Check that all threads are good and clean.



(2) Check rods are fitted with check nuts and couplings



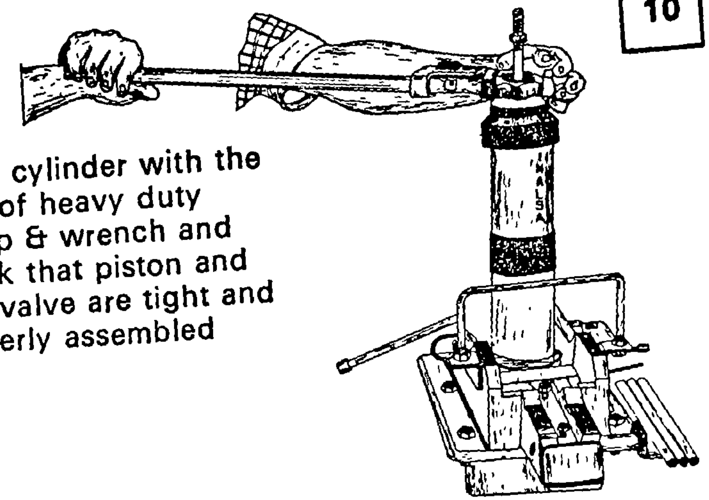
(3) If rods have couplings welded at one end, fit check nuts at the other end

(4) Make sure you have spare check nuts

From INALSA

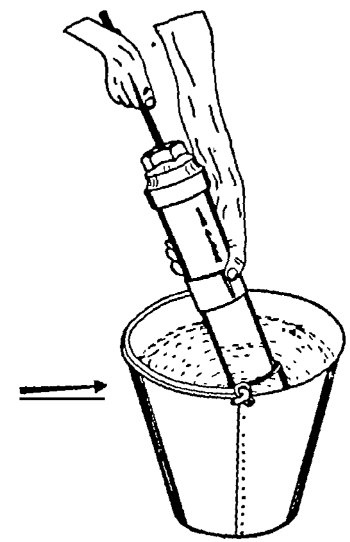
10

(1) Open cylinder with the help of heavy duty clamp & wrench and check that piston and foot-valve are tight and properly assembled



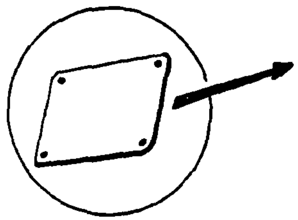
(2) Re-assemble cylinder

(3) Test cylinder in a bucket of water. If foot-valve leaks replace it.

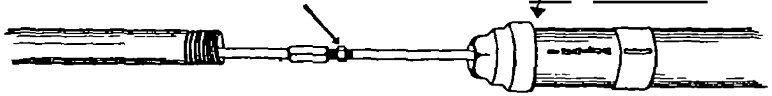


11

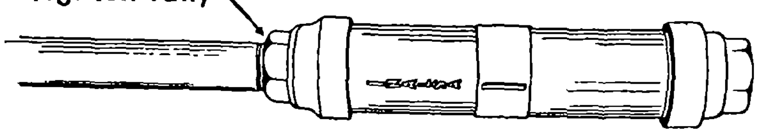
(1) Remove cover of pedestal



(2) Join first connecting rod to cylinder rod



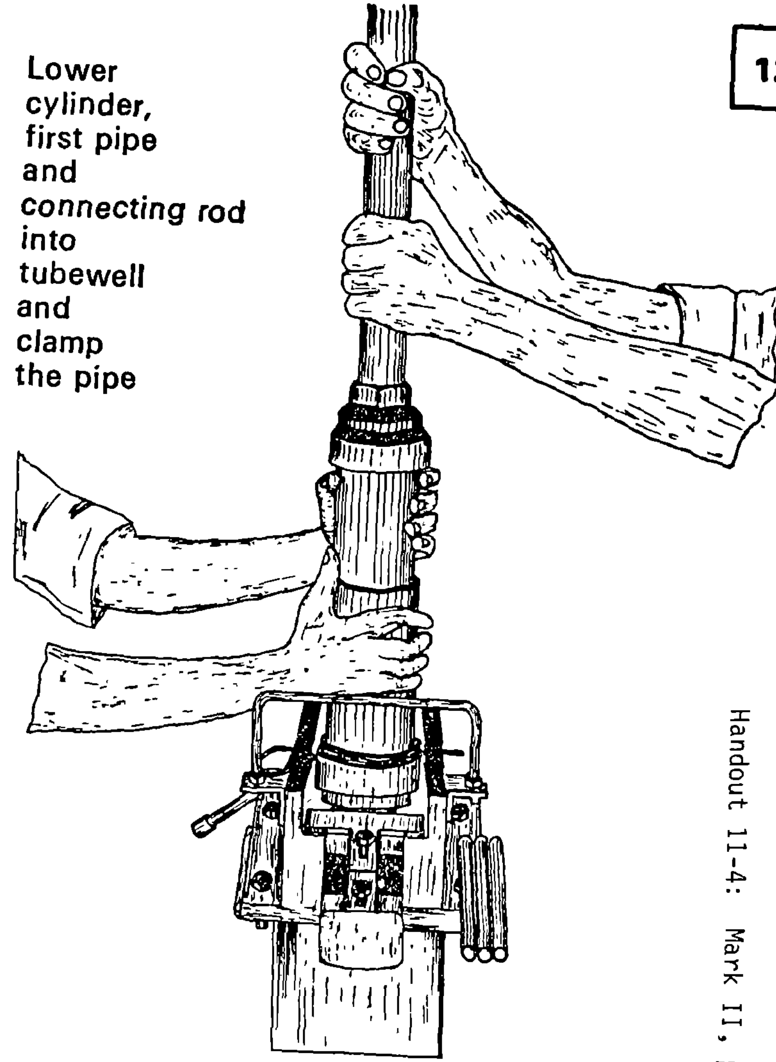
(3) Screw first pipe into cylinder.
Use jointing compound.
Tighten fully



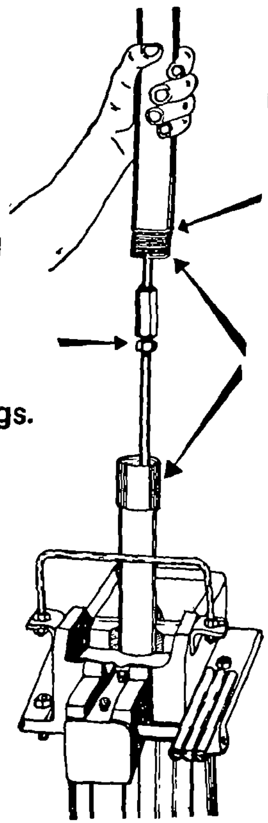
(4) Wipe off excess jointing compound

12

Lower cylinder, first pipe and connecting rod into tubewell and clamp the pipe



13



(1) Join connecting rods together. Use check nut at every joint. Tighten fully against couplings.

(2) Put jointing compound on pipe threads

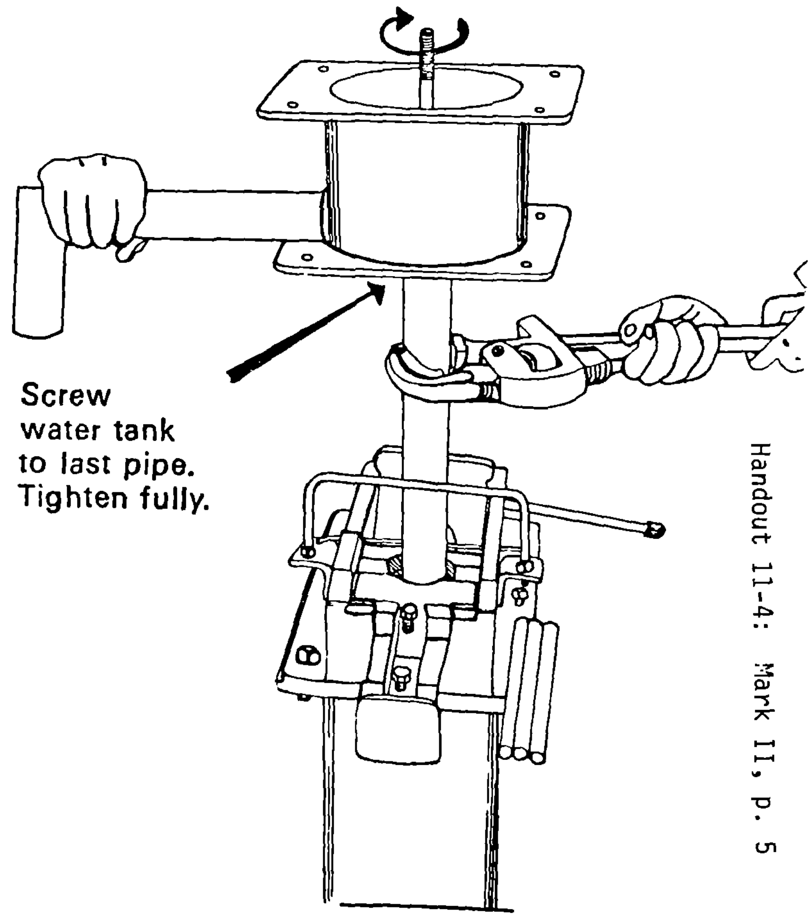
(3) Join pipes together. Tighten fully.

(4) Wipe off excess jointing compound or it will spoil the water in the tubewell

(5) Lower cylinder, pipe and connecting rod into tubewell and clamp. Continue to last pipe. For this, use heavy duty clamp as shown.

14

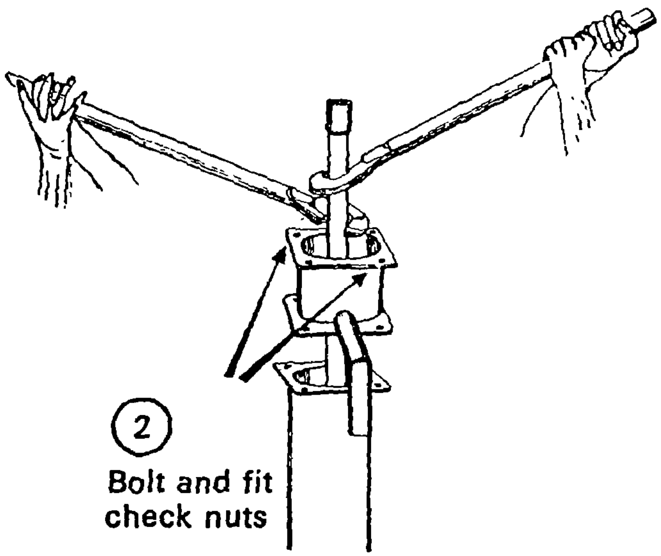
Cylinder should be installed at a minimum depth of 24 metres (80′) for maximum efficiency



Screw water tank to last pipe. Tighten fully.

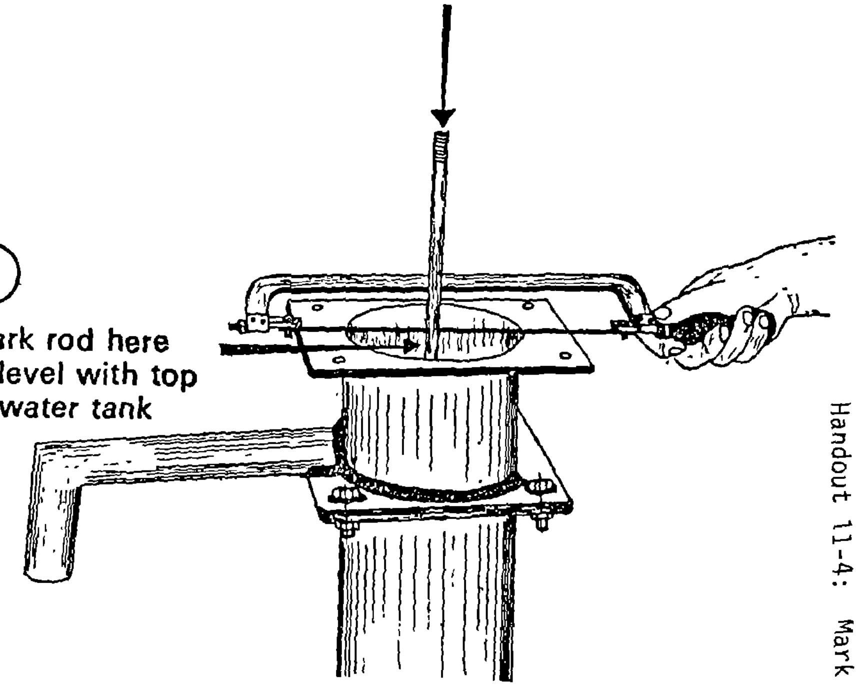
16

(1) Carefully lower water tank on to pedestal with the help of lifter pipe and lifting spanners. Spout must face drain.



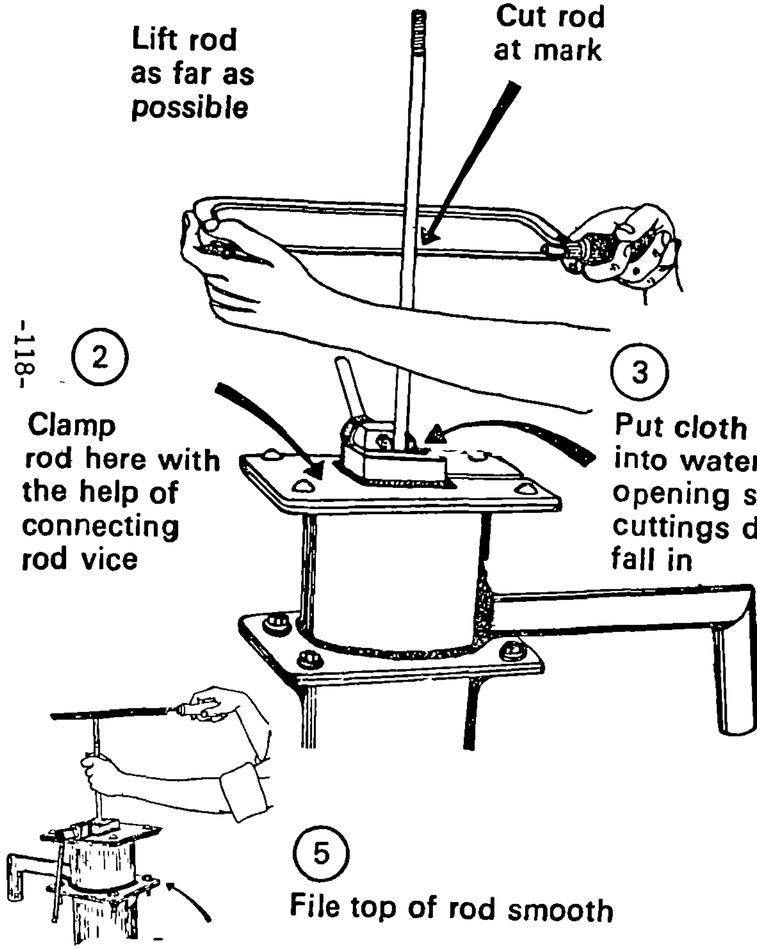
(2) Bolt and fit check nuts

(1) Push rod down as far as possible



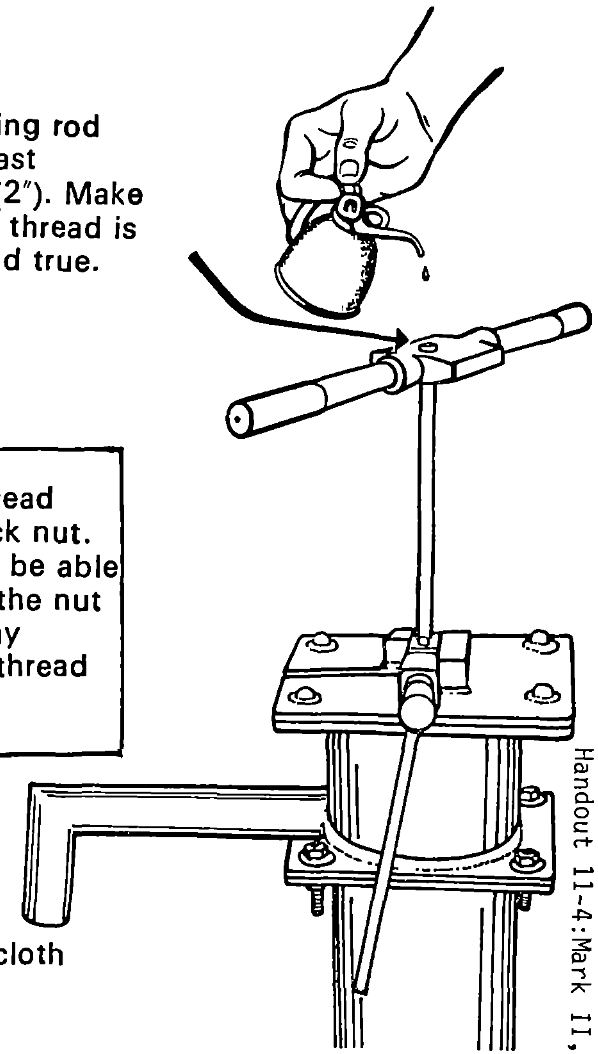
(2) Mark rod here — level with top of water tank

17



Leave cloth in water tank

18



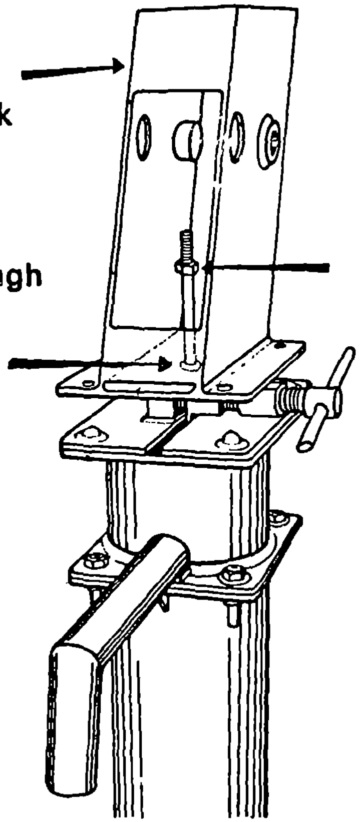
19

(1) Remove inspection cover of head

(2) Lower head onto water tank

(3) Rod goes through guide bush

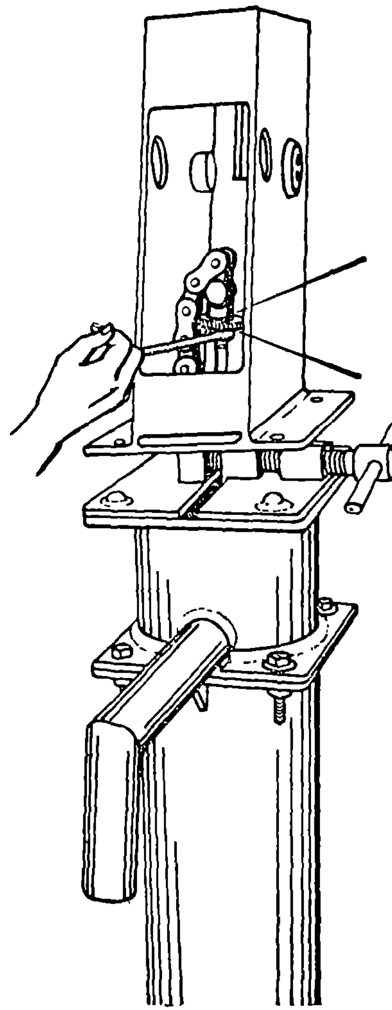
(4) Fit check nut here

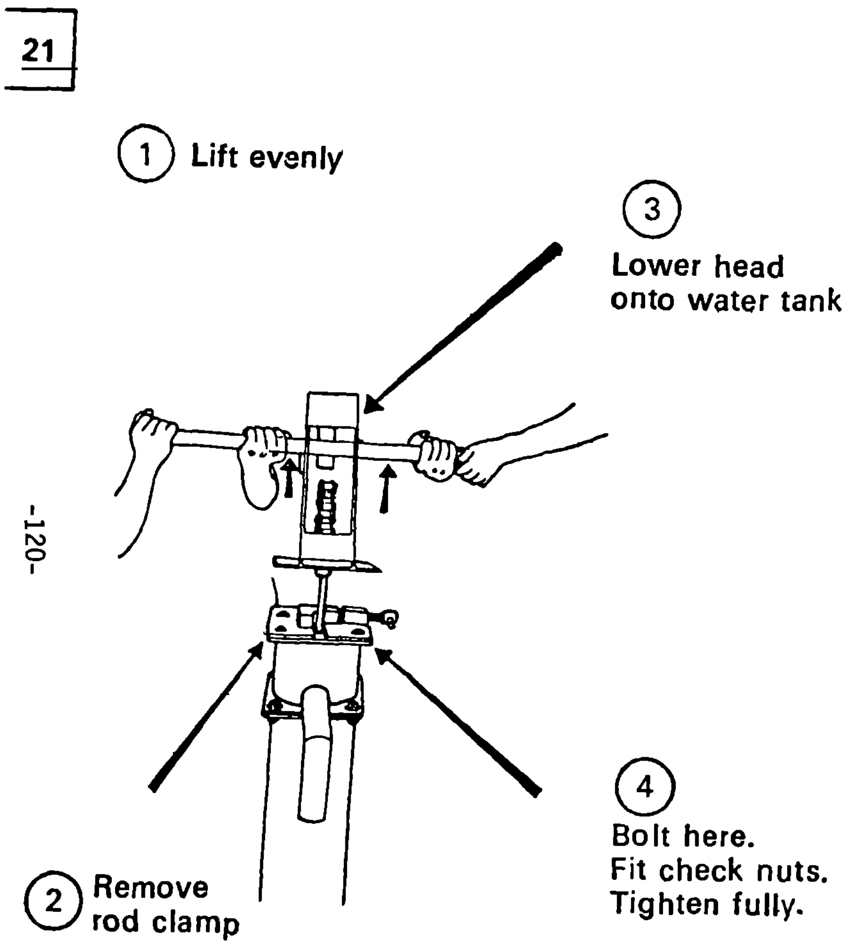


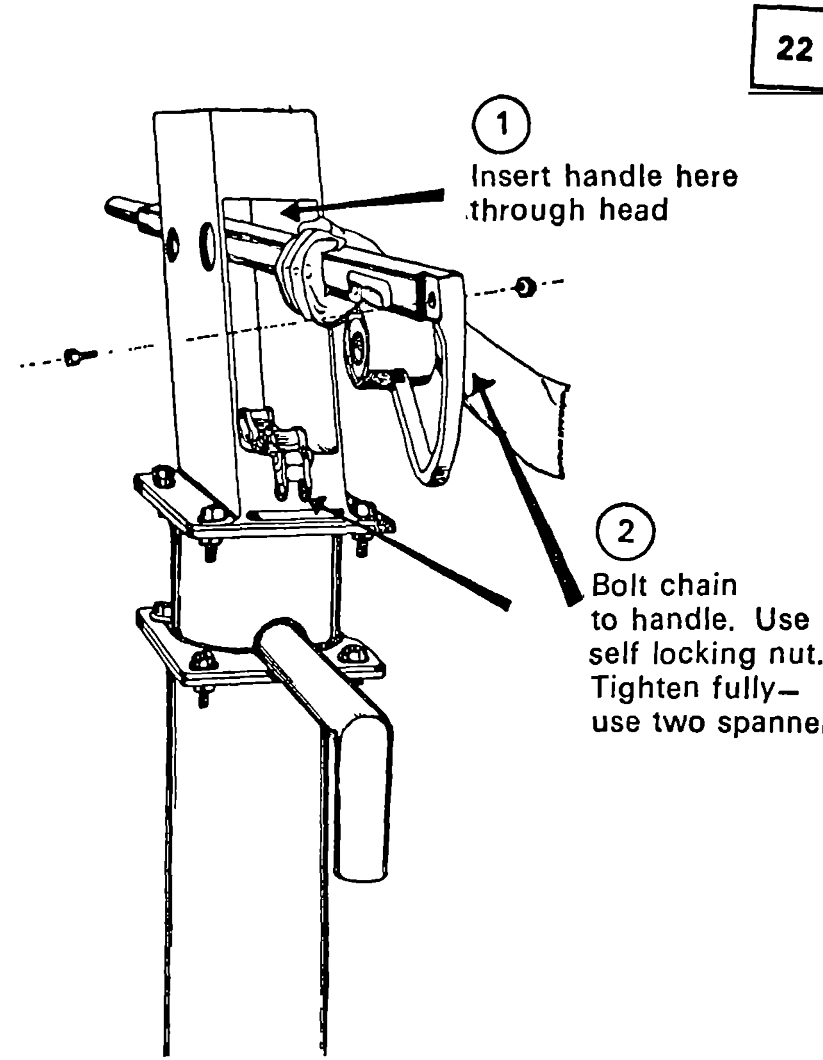
20

(1) Screw chain onto rod. Tighten rod fully into chain coupling

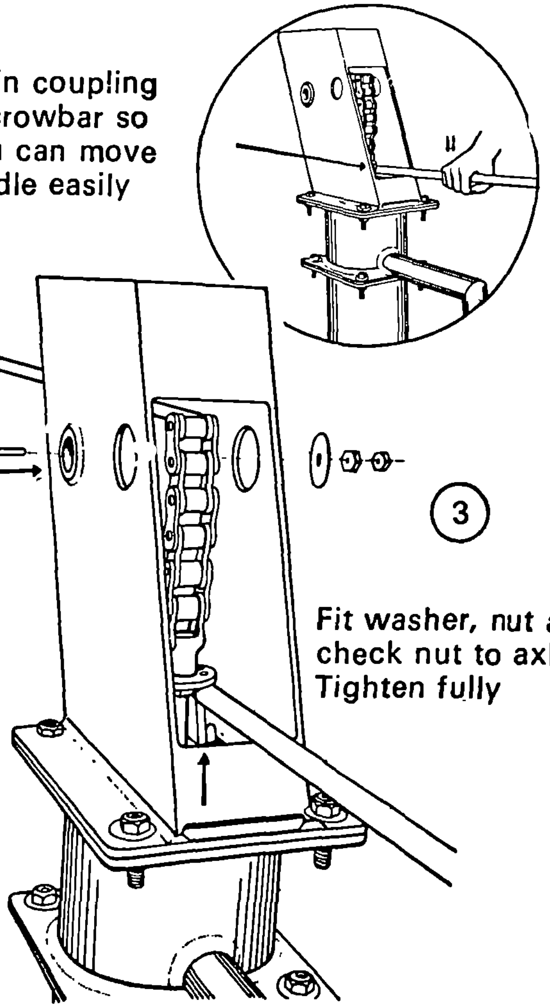
(2) Use two spanners—tighten check nut fully against chain coupling




21
1 Lift evenly
3 Lower head onto water tank
2 Remove rod clamp
4 Bolt here. Fit check nuts. Tighten fully.


22
1 Insert handle here through head
2 Bolt chain to handle. Use self locking nut. Tighten fully— use two spanners.

23



24

Now make sure that . . . . . .

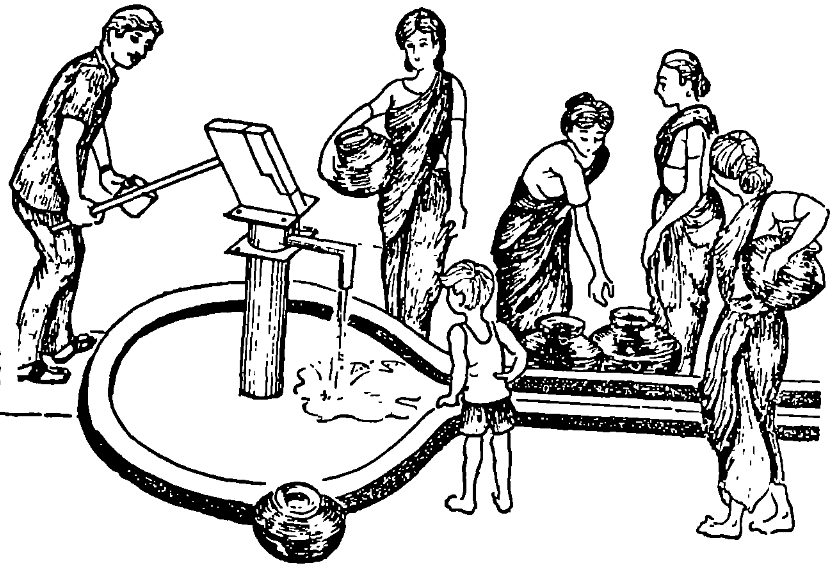
- When you pump, the handle touches the top and bottom stops. **If it does not,** then remove head and check the setting of the top connecting rod. Refer to Step 16.
- Connecting rod moves up and down freely in guide bush. **If it does not,** then the rod has been bent while threading.
- You have threaded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

Now fit inspection cover.
Tighten cover bolt fully.

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

25

Pump one hundred times
to get clean water.



Check the water. Is it clear of oil, jointing compound, dirt ?
If water is not clean, pump another 100 times.

The water may taste strange to the villagers.
Explain to them that it is good, safe water.
They will soon get used to it.

FINAL CHECK LIST

Before you leave, have you . . .

- ▫ talked to the villagers about the importance of the handpump for their health ?
- ▫ purged the tubewell ?
- ▫ checked the quality and taste of the water ?
- ▫ explained to the villagers that the water from the handpump may taste different, or strange? You must explain that they should still drink it, because this water is safe. They will get accustomed to the new taste soon.
- ▫ given the villagers the address of your office, so that they can inform you if the pump breaks down ?
- ▫ made a note of any problems with the tubewell or the handpump, so that you can report them to the District Executive Engineer ?

Steps for Disinfecting Wells

Finding the Correct Amount of Disinfectant

A) Measure the well diameter and the number of meters of water in the well.

B) Calculate the volume of water in the well in cubic meters (see Worksheets in Handout 11-6: Water for the World, Disinfecting Wells).

C) Find the volume of water on the disinfectant table and read off the required amount of disinfectant. (See Table 1 in Handout 11-6).

Disinfecting the Well

A) Pump the well: Pump the well until the water is relatively clear and as free from cloudiness (turbidity) as possible. If there are no other sources of water nearby to use in step E below, save 25 to 40 liters of water. Remove the pump after this step if the well does not have an access hatch.

B) Dissolve powdered disinfectant: Dissolve the powdered chlorine compound in a bucket before adding it to the well. It is important that the solution be prepared in a clean container and mixed with clean utensils. Dirt, grease, oil and organic matter will reduce the strength of the chlorine solution. Avoid the use of metal containers because the strong chlorine solution will cause them to rust. Instead, use plastic, ceramic, glass, or rubber-lined containers. This step can be deleted if only liquid disinfectants are used.

C) Pour disinfectant into well: Slowly pour the required amount of chlorine solution, as determined above, into the well. Allow the solution to wash down the sides of the well. Use a brush to distribute the disinfectant on the walls of dug wells.

D) Mix disinfectant into well water: Mix the chlorine solution with the water in the well. This can be done by tying a rope around a large, clean rock and moving it up and down in the water in the well. In the case of deep wells with a high water table, special steps should be taken to ensure that the chlorine is thoroughly mixed with the well water. If a concentrated solid form of the disinfectant is available (like HTH), place it in a burlap (or similar) bag with a rock. Tie a rope tightly around the top of the bag and lower it into the well. Alternately raise and lower the bag in the water to distribute the disinfectant. If only liquid forms of the disinfectant are available, a plastic bottle with perforations near the top will allow well water to mix with the disinfectant without disinfectant being spilled before it is lowered into the well. Alternately raise and lower the bottle, as with the bag.

E) Force disinfectant into aquifer: Add 25 to 40 liters (5 to 10 gallons) of clean, chlorinated water to the well to force the solution into the aquifer.

F) Disinfect exterior of pump: Wash the exterior surface of the pump cylinder and drop pipe (or suction pipe). If the well does not have an access hatch, wash the exterior surface of the pump cylinder and drop pipe as they are being reinstalled in well.

G) Operate the pump: After waiting 20 minutes operate the pump until you can smell chlorine.

H) Allow time for disinfectant to work: Stop pumping and allow the chlorine solution to remain in the well for at least 12 hours, but preferably 24 hours. It must be stressed that this strong chlorine solution is not suitable for consumption by humans or animals.

I) Pump out odor of disinfectant: After disinfection, pump the well until the odor and taste of chlorine in the water is no longer objectionable. Chlorine is used up as it disinfects. If there is no chlorine odor after the disinfection period, disinfection shoud be repeated. This assures that all the disease-causing bacteria will be destroyed and that there will still be some chlorine available to kill other contaminants which might enter the water at a later time.

The disinfectant compounds and solutions used to disinfect wells can cause irritation to skin and eyes. If you get chlorine on your skin or in your eyes, wash it off with water immediately. Do not rub your eyes until you have washed the chlorine off your hands. Work with chlorine only in areas with good ventilation. Never use chlorine when persons are working inside the well.

Water for the World

Disinfecting Wells
Technical Note No. RWS. 2.C.9

Disinfecting a well is necessary to eliminate the contamination that was introduced by equipment, materials, or surface drainage during construction or repairs. A chlorine compound is generally used for the disinfectant. Disinfecting a well involves calculating the required amount of chlorine compound, mixing a chlorine solution, and applying the solution to the well.

This technical note describes how to disinfect a well. Read the entire technical note before beginning the disinfection process.

Useful Definitions

AQUIFER - A water-saturated geologic zone that will yield water to springs and wells.

AVAILABLE CHLORINE - The amount of chlorine present in a chemical compound.

DISINFECTION - Destruction of harmful microorganisms present in water, through physical (such as boiling) or chemical (such as chlorination) means.

Materials Needed

To disinfect a well, you will need:

Chlorine compound such as calcium hypochlorite, bleaching powder, or liquid bleach,

Mixing container which should be rubber-lined or made from crockery or glass,

Stiff broom with a long handle, for hand dug wells,

Length of rope,

Length of perforated pipe, 0.5-1.0m long, 50-100mm in diameter, for deep-drilled wells with a high water table.

Caution!

Chlorine compounds or solutions may irritate skin and eyes upon contact. If possible, wear gloves, protective clothing, and glasses when handling chlorine. If you get chlorine on your skin or in your eyes, immediately wash it off with water.

General Information

The most easily obtainable and safest disinfectants are chlorine compounds. These compounds have various amounts of available chlorine, that is, chlorine that can be released to disinfect the water.

Calcium hypochlorite, also knows as high-test hypochlorite or HTH, has 70 percent available chlorine. It is produced as powder, granules, or tablets. Bleaching powders have 25-35 percent available chlorine. Common household laundry bleach, such as Clorox and Purex, has about 5 percent available chlorine.

Chlorine compounds should be stored in their original containers in a cool, dark place.

Calculating the Amount of Compound Needed

To disinfect a well properly, make a mix of available chlorine and water from the well in a ratio of 100 parts per million, ppm. To illustrate: 1 ml per 1000 liters equals 1 ppm; 100ml per 1000 liters equals 100ppm.

Table 1 shows the amounts of HTH, bleaching powder, and chlorine bleach that must be added to various volumes of well water to produce 100ppm of available chlorine. Before you can use the table, you must calculate the volume of water in the well.

The volume of water in a well equals the radius of the well squared times the depth of the water in the well times 3.1416.

$$V = r^2 \times D \times 3.1416$$

The radius, r, equals the diameter, d, of the well divided by two.

$$r = \frac{d}{2}$$

The diameter, d, can be measured directly or read from design drawings or from the driller's log described in "Maintaining Well Logs," RWS.2.C.6.

The depth, d, of the water in the well can be measured directly by lowering a rock tied to a length of twine to the bottom of the well, retrieving the twine, and measuring the wet portion. Or, it can be read from the driller's log.

For example, suppose the diameter of the well is 100mm (0.10m) and the depth of the water in the well is 12m. First, calculate the radius.

$$r = \frac{d}{2} \qquad r = \frac{0.10m}{2} \qquad r = 0.05m$$

Then calculate the volume of water.

$$V = r^2 \times D \times 3.1416$$
$$V = 0.05m \times 0.05m \times 12m \times 3.1416$$
$$V = \text{about } 0.1m^3$$

See Worksheet A Lines 1-4.

From Table 1, you can see that in order to disinfect this well you would need to use 0.2 liters of chlorine bleach, 5 percent available chlorine, or 33 grams of bleaching powder, 30 percent available chlorine, or 14 grams of high-test hypochlorite, 70 percent available chlorine.

For another example, suppose the diameter of the well is 1.2m and the depth of the water in the well is 2.6m. The radius equals the diameter divided by two = $\frac{1.2m}{2}$ = 0.6m Now calculate the volume.

$$V = r^2 \times D \times 3.1416$$
$$V = 0.6 \times 0.6 \times 2.6 \times 3.1416$$
$$V = 2.9m^3$$

See Worksheet A, Lines 5-8.

From Table 1, you can see that the nearest volume to this is $3.0m^3$, so to disinfect this well you would need to mix in 6.0 liters of chlorine bleach, or 1010 grams of bleaching powder, or 433 grams of HTH.

Table 1. Amounts of Chlorine Compounds for Well Disinfection

Water in Well (m^3)	Liquid Bleach 5% available chlorine (liters)	Bleaching Powder 30% available chlorine (grams)	Calcium Hypochlorite (HTH) 70% available chlorine (grams)
0.1	0.2	33	14
0.12	0.24	40	17
0.15	0.3	51	22
0.2	0.4	68	29
0.25	0.5	86	37
0.3	0.6	100	43
0.4	0.8	133	57
0.5	1.0	170	73
0.6	1.2	203	87
0.7	1.4	233	100
0.8	1.6	267	113
1.0	2.0	334	143
1.2	2.4	400	173
1.5	3.0	500	217
2.0	4.0	670	287
2.5	5.0	860	367
3.0	6.0	1010	433
4.0	8.0	1330	567
5	10	1700	730
6	12	2000	870
7	14	2300	1000
8	16	2600	1130
10	20	3300	1430
12	24	4000	1730
15	30	5000	2170
20	40	6700	2870

Worksheet A. Calculating the Volume of Water in a Well

Drilled Wells

1. Diameter of well = $\frac{(\ 100\ mm)}{(1000 mm/m)}$ = 0.10 m

2. Radius of well = $\frac{\text{~~Line 1~~}}{2}$ = $\frac{(\ 0.10\ m)}{2}$ = ~~0.05~~ m

3. Depth of water in well = 12 m

4. Volume of water in well = Line 2 x Line 2 x Line 3 x 3.1416 =
0.05 m x 0.05 m x 12 m x 3.14.6 = 0.09 m^3

Hand Dug Wells

5. Diameter of well = 1.2 m

6. Radius of well = $\frac{\text{Line 5}}{2}$ = $\frac{(\ 1.2\ m)}{2}$ = 0.6 m

7. Depth of water in well = 2.6 m

8. Volume of water in well = Line 6 x Line 7 x 3.1416 =
0.6 m x 0.6 m x 2.6 m x 3.1416 = 2.9 m^3

Mixing the Solution

Do not pour the chlorine compound directly into the well. It will not mix properly. First make a chlorine solution.

To make a chlorine solution from chlorine bleach, mix one part of bleach with one part of water, then pour the entire solution into the well. In the second example, this would mean mixing 6.0 liters of chlorine bleach with 6.0 liters of water and pouring 12.0 liters of chlorine solution into the well.

To make a chlorine solution with HTH or bleaching powder, first mix the compound with enough water to form a smooth paste, then mix the paste with water in the ratio of one liter of water per 15 grams of compound. To calculate the amount of water needed to make a chlorine solution, divide the amount of chlorine compound by 15. In the second example,

$\frac{\text{1010 grams of bleaching powder}}{\text{15 grams}}$ =

67 liters of water

$\frac{\text{433 grams of HTH}}{\text{15 grams}}$ = 29 liters of water

Mix the chlorine paste with the water for 10-15 minutes. Allow inert materials to settle and use only the clear chlorine solution. Discard the rest. Pour the clear chlorine solution, about 67 liters in the case of bleaching powder or about 29 liters in the case of HTH, into the well.

Do not mix chlorine solutions in metal containers. Mix them in clean containers that are rubber-lined or made from crockery or glass.

Disinfecting a Hand Dug Well

If the well has no cover, it should be disinfected every day, or as often as possible. If the well is covered it must be disinfected before the first use and every time it is opened for maintenance or repair.

For a dug well with pump and cover:

1. Prepare a chlorine solution to wash the inside of the well casing. Mix 10 liters of water with one of the following: 0.02 liters of chlorine bleach, or 3.3 grams of bleaching powder, or 1.4 grams of HTH.

2. Wash the exterior surface of the pump cylinder and drop pipe with the chlorine solution before they are lowered into the well.

3. Remove all equipment and materials that will not be a permanent part of the well.

4. Wash the inside surface of the well casing with a clean, stiff broom and the 10 liters of chlorine solution. See Figure 1.

5. Install the cover over the well.

6. Calculate the amount of chlorine solution needed to disinfect the well. Prepare the solution and poor it through the access hole in the cover, making sure that the solution covers as much of the surface of the water in the well as possible. See Figure 2.

7. Mix the chlorine solution with the water in the well by using a rope tied to a large, clean rock. Lower the rock into the well and move it up and down in the water.

8. Cover the access hole. Pump water from the well until you can smell chlorine.

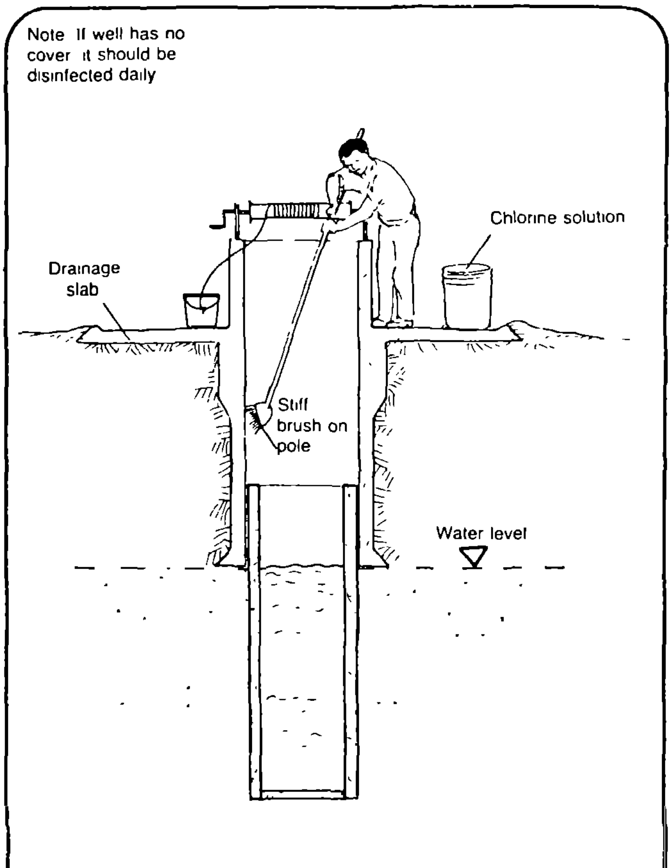


Figure 1. Washing Inside of Casing (Hand-dug well)

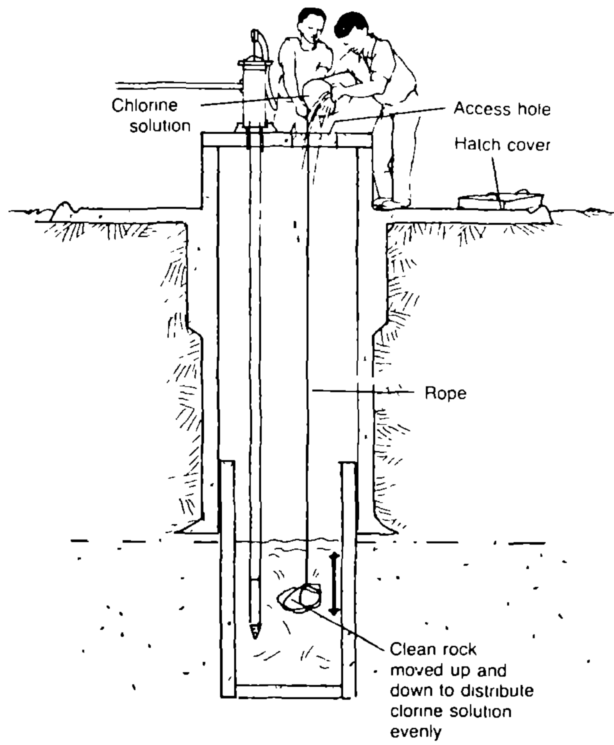


Figure 2. Pouring Chlorine Solution into Well

9. Allow the chlorine solution to remain in the well for 24 hours.

10. Pump water from the well until chlorine can no longer be smelled or tasted. Dispose of this water in a soakaway.

Disinfecting a Driven, Jetted, Bored, or Cable Tool Well

After the well has been tested for yield as described in "Testing the Yield of Wells," RWS.2.C.7, it must be disinfected before its first use and every time it is opened for maintenance or repair.

1. Remove the test pump from the well.

2. Calculate the amount of chlorine solution needed to disinfect the well. Prepare the solution and pour it into the well.

3. Mix the chlorine solution with the water in the well by using a rope tied to a clean rock. Lower the rock into the well and move it up and down in the water.

4. Add 40 liters of clean, chlorinated water to the well to force the solution into the aquifer. This solution can be made by mixing 40 liters of water with either one-half teaspoon of HTH or 20ml of chlorine bleach.

5. Prepare a chlorine solution to wash the pump cylinder and drop pipe. Mix 10 liters of water with one of the following: 0.02 liters of chlorine bleach, or 3.3 grams of bleaching powder, or 1.4 grams of HTH.

6. Wash the exterior surface of the pump cylinder and drop pipe as they are lowered into the well.

7. Pump water from the well until you can smell chlorine.

8. Allow the chlorine solution to remain in the well for 24 hours.

9. Pump water from the well until chlorine can no longer be smelled or tasted. Dispose of this water in a soakaway.

Deep Well with High Water Table

In the case of a deep well with a high water table, you need to take special steps to ensure that the chlorine and well water are properly mixed.

1. Drill a number of small holes through the sides of the pipe that is 0.5-1.0m long and 50-100mm in diameter. Cap one end of the pipe.

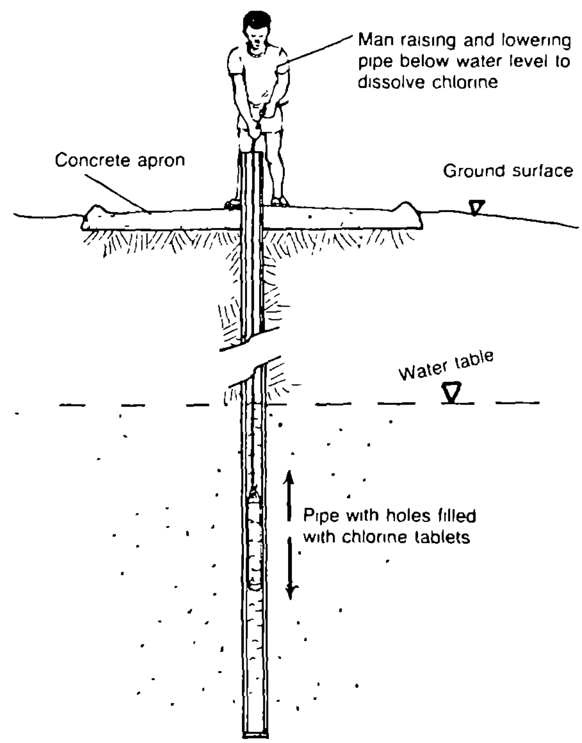


Figure 3. Disinfecting Deep Well with High Water Table

2. Pour the calculated amount of HTH granules or tablets into the pipe. Only HTH can be used in this method.

3. Fit the other end of the pipe with a threaded cap equipped with an eye loop.

4. Tie a rope to the eye loop, lower the pipe into the well, and alternately raise and lower the pipe in the water. Continue until the HTH has dissolved and the chlorine is distributed in the water. See Figure 3.

Notes

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U S Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association Artwork was done by Redwing Art Service Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled Using 'Water for the World' Technical Notes " Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D C , 20523, U S A

Troubleshooting Pump Problems

A) The pump must be pumped several times before water comes out (particularly in the morning).

Cause:
1. Footvalve is excessively worn or dirt is allowing water to leak past.
2. A leak has developed in the drop pipe (loss of water) or suction pipe (loss of vacuum).

Remedy:
1. Examine footvalve. Clean or replace as necessary.
2. Examine drop pipe or suction pipe. Correct leak.

B) The amount of water pumped per stroke is significantly less than when the pump was new.

Cause:
1. Plunger cups are worn and not sealing against the cylinder walls.
2. The footvalve is excessively worn or dirty.
3. A leak has developed in the drop pipe (loss of water) or suction pipe (loss of vacuum).
4. Dirt and debris are obstructing the flow of water.

Remedy:
1. Examine the plunger cups for excessive wear or a tear. Replace as necessary.
2. Examine the footvalve. Clean or replace as necessary.
3. Examine drop pipe or suction pipe. Correct leak.
4. Examine drop pipe, suction pipe, foot valve, and plunger valve for dirt and debris. Remove the dirt and debris.

C) No water can be pumped.

Cause:
1. Footvalve is broken or is stuck in the open position
2. Plunger cage is broken
3. Plunger assembly or a section of plunger rod has become unscrewed from the rest of the plunger rod

Remedy:
1. Examine footvalve. If broken, replace. If stuck, clean it or remove the blockage: if the valve still sticks, replace it.
2. Examine plunger assembly. A broken plunger cage is usually the result of the plunger rod being too long or too short. To prevent the plunger cage from being broken after it has been replaced, it is necessary to determine how much too short or long the plunger rod is and make the needed adjustment in length.
3. Examine the plunger assembly and plunger rod. Reconnect the joint tightly. In the case of an unscrewed plunger assembly, be sure that the lock nut on the plunger rod is tightened securely.

TROUBLESHOOTING PUMP PROBLEMS

COMMON HAND PUMP TROUBLES AND REMEDIES

TROUBLE	LIKELY CAUSE	REMEDY
1. Pump handle works easily but no water delivered.	A. No Water at the source. Well dry.	Rehabilitate well, or develop a new source or sources of water.
	or	
	B. Level of water has dropped below suction distance of pump	Can be checked with vacuum gauge or with weighted string Reduce pumping rate or lower pump cylinder.
	or	
	C Pump has lost its priming.	Prime the pump If the pump repeatedly loses its priming it may be periodically pumping the well dry, the suction line may be leaking, or the suction valve or discharge check valve may be leaking Repair line or valve. Also check 1-A and 1-B.
	or	
	D. The cylinder cup seals ("leathers") may be worn out	Renew the cylinder cup seals ("leathers").
	or	
	E The valves or valve seats may be worn or corroded.	Renew valves and repair or renew seats.
	or	
	F With a deep-well plunger pump the plunger rod may be broken.	This trouble would be indicated by the pump running freer and and probably quieter Turn the pump over by hand and note if there is resistance on the upstroke Broken rods must be renewed and this usually means pulling the drop pipe and cylinder out of the well.
	or	
	G Shutoff valve may be closed (force pump)	Open valve
	or	

Continued

TROUBLE	LIKELY CAUSE	REMEDY
1. Pump handle works easily but no water delivered (continued)	H Hole in suction pipe	Renew suction pipe. Cylinder may be lowered below water level in well.
	or	
	I The suction pipe may be plugged with scale or iron bacteria growth or sediment.	Can be checked with vacuum gauge. Remove suction pipe and clean or renew
	or	
	J. The pump cylinder may be cracked	Renew the cylinder
	or	
	K Leak at base of cylinder	Renew cylinder gasket.
	or	
	L One or more check valves held open by trash or scale	Remove valves and inspect for trouble. With deep-well plunger pumps this may mean pulling the pump cylinder or plunger and valves out of the well.
2. Pump runs but delivers only a small amount of water	A. Plunger leathers badly worn (plunger and piston pumps).	Renew leathers
	or	
	B Well not yielding enough water.	Decrease demands or establish new sources of water
	or	
	C Cracked cylinder (plunger or piston pump)	Renew cylinder.
	or	
	D Check valve(s) leaking.	Repair valve(s)
	or	

Continued

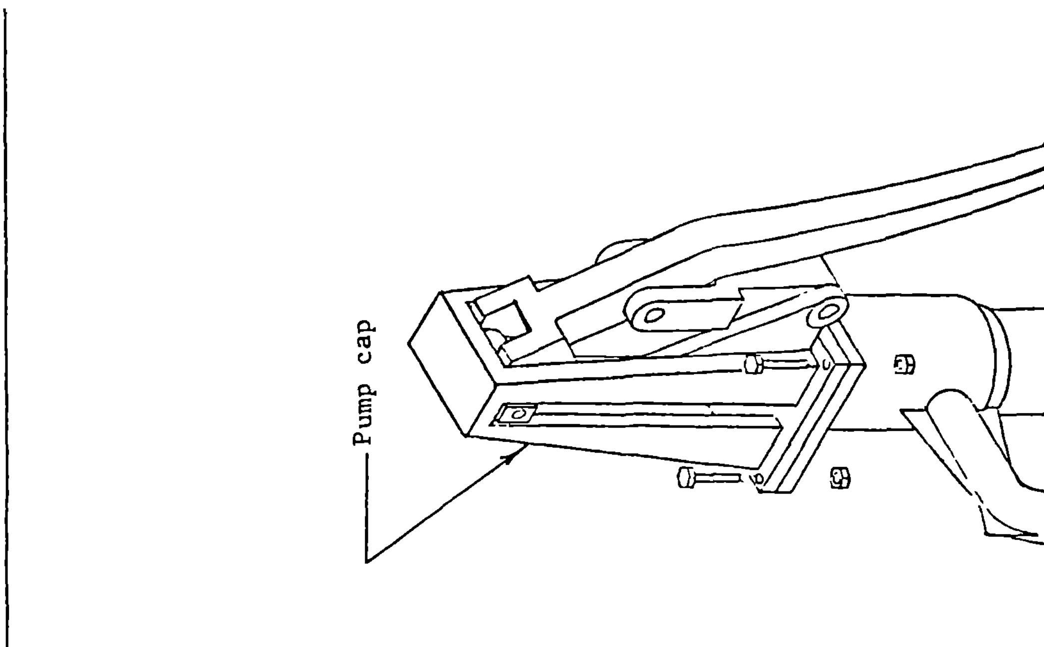
TROUBLESHOOTING PUMP PROBLEMS

TROUBLE	LIKELY CAUSE	REMEDY
2. Pump runs but delivers only a small amount of water. (continued)	E. Screen or suction valve may be obstructed.	Remove and clean
	or	
	F. Suction pipes are too small.	Can be checked with vacuum gauge. Install pipe with larger diameter, or for deep well pump, lower pump cylinder below water level in well.
	or	
	G. Suction valve(s) may be out of order.	Repair valve(s).
	or	
	H. Cracked drop pipe or coupling.	Renew drop pipe or coupling.
3. Pump needs too many strokes to start	A. Pump has lost its priming.	Prime the pump If the pump repeatedly loses its priming, it may be periodically pumping the well dry, or the suction line or the suction valve may be leaking. Repair or renew line or valve.
	or	
	B. The cylinder cup seals ("leathers") may be worn out.	Renew the cylinder cup seals.
4. Handle springs up after down stroke.	A Suction pipe plugged up below pump cylinder.	Remove pump and clean out suction pipe If well has filled with dirt up to suction pipe, the well should be cleaned out or the pipe cut off.
	or	
	B. Plunger check valve fails to open or to close.	Repair check valve
	or	
4. Handle springs up after down stroke (continued)	C. Suction pipe too small.	Replace with larger suction pipe.
	or	
	D Water too far below pump (suction pipe too long).	Place cylinder nearer water.
5. Leaks at stuffing box	A. Packing worn out or loose.	Renew or tighten packing. Leave packing nut loose enough to allow a slow drip of water The water serves as a lubricant
	or	
	B. Plunger rod badly scored.	Renew plunger rod
6 Pump is noisy	A Bearings or other working parts of the pump are loose.	Tighten or renew parts.
	or	
	B. Pump is loose on mountings	Righten mountings
	or	
	C. With deep-well plunger pumps having a steel plunger rod the rod may be slapping against the drop line	Use a wooden rod or install guides for rod or straighten drop pipe if crooked.

Continued

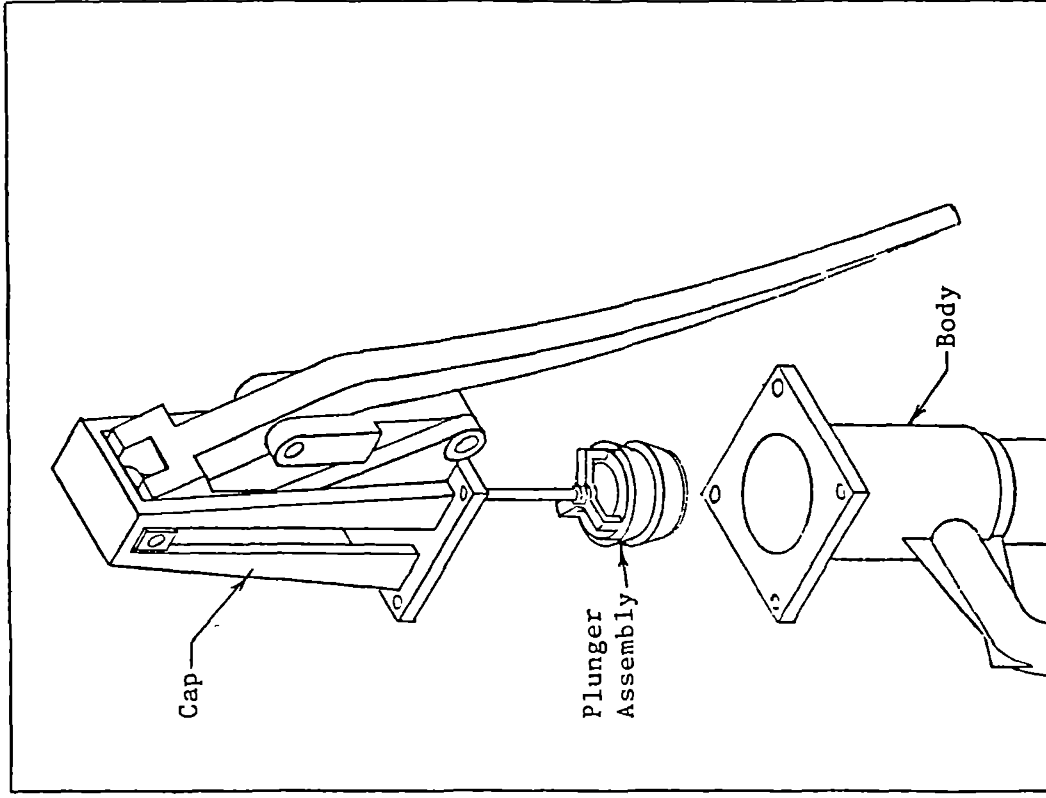
US AID HAND PUMP - MAINTENANCE MANUAL

REPAIRING THE SHALLOW WELL PUMP

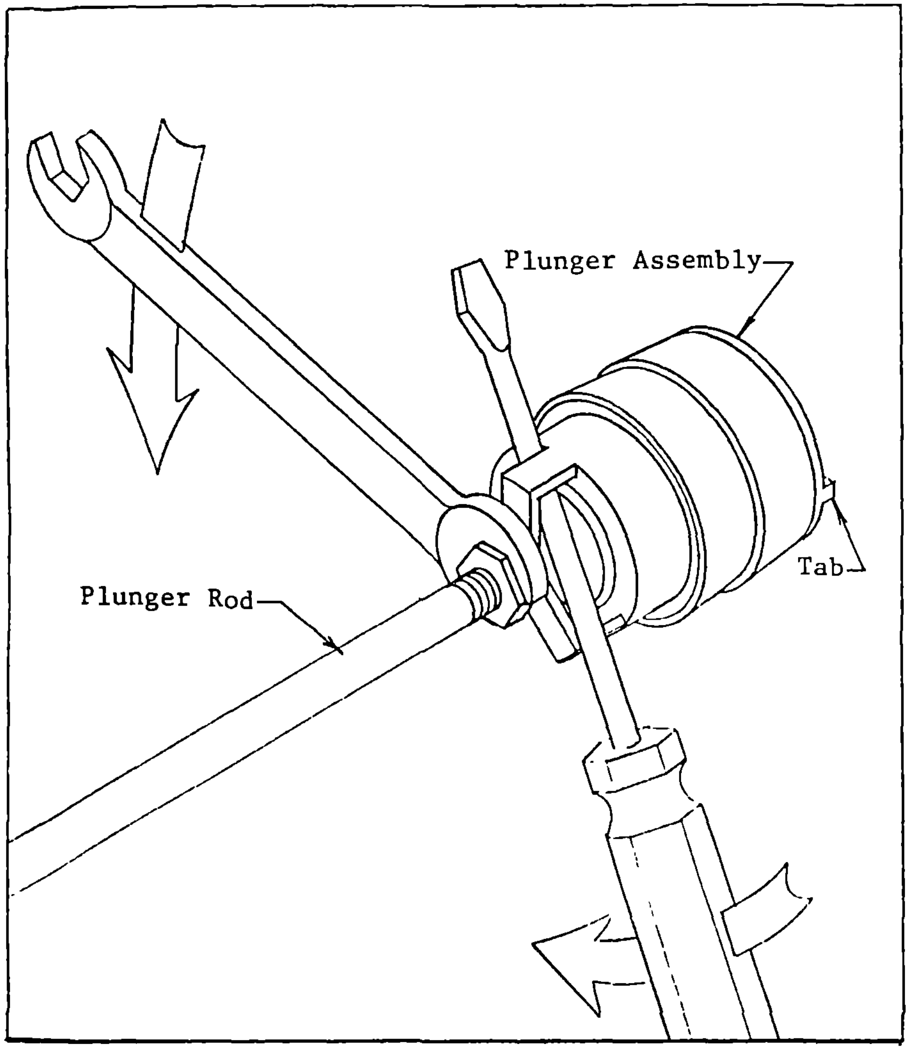


CUP REPLACEMENT

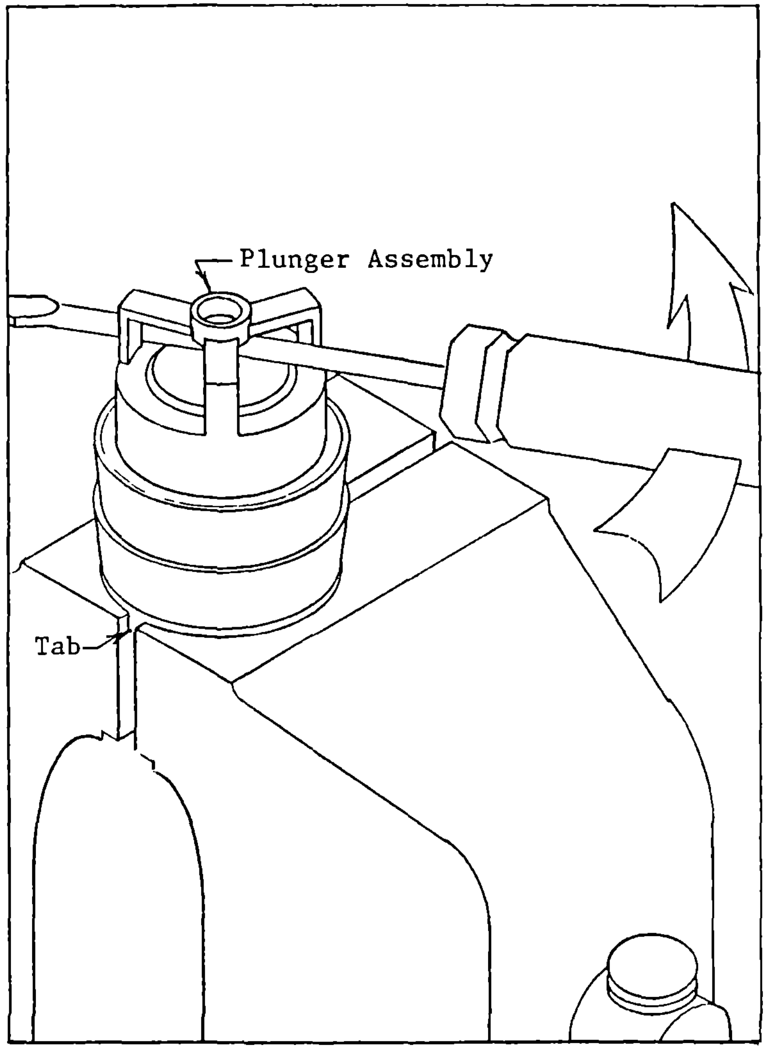
Remove the four bolts holding down the pump cap.



Lift the cap off of the pump body.

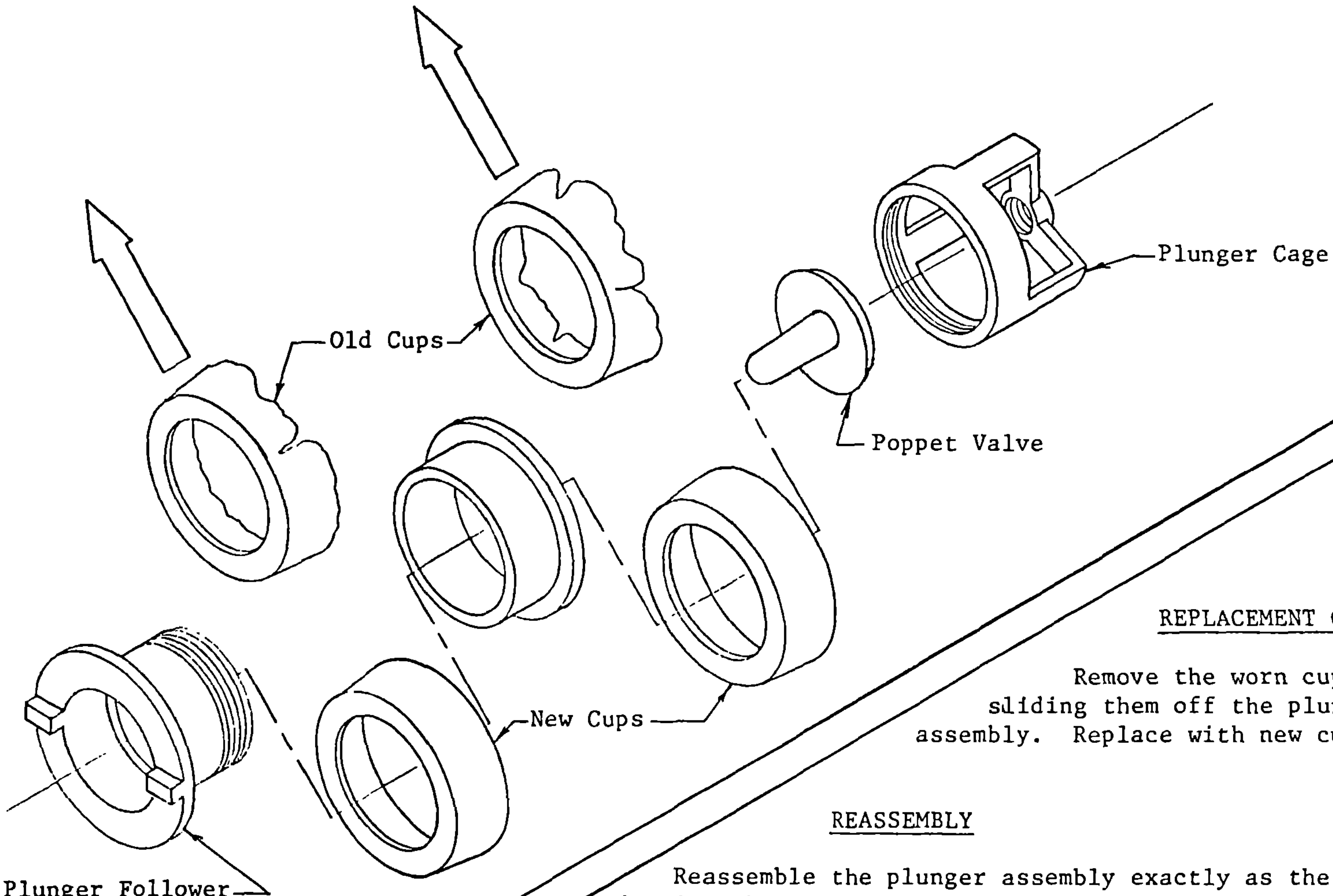


Unscrew the plunger assembly
from the plunger rod.



Unscrew the plunger assembly.
A wrench can easily be used in place
of the vice to grip the tabs.

REPAIRING THE SHALLOW WELL PUMP



REPLACEMENT OF CUPS

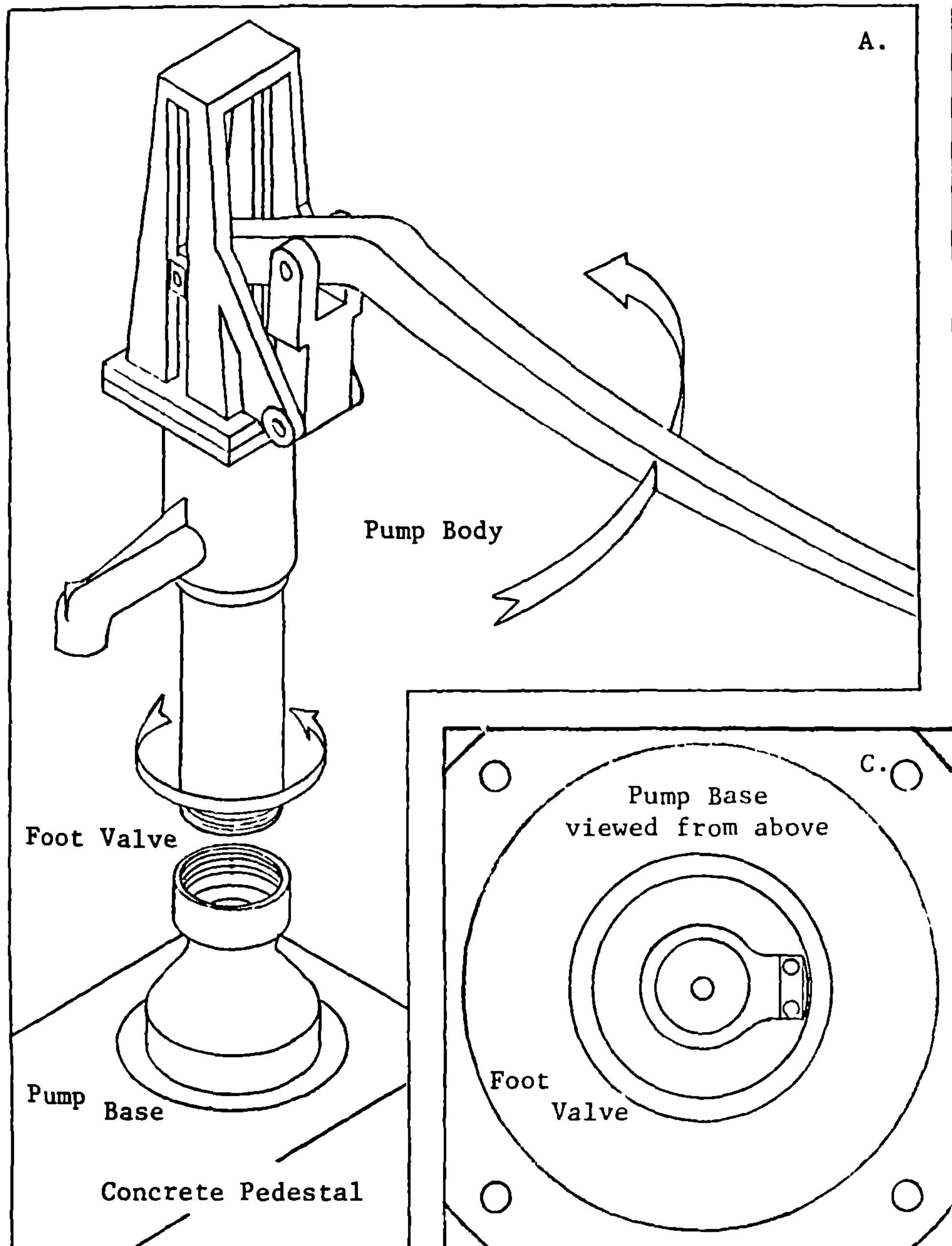
Remove the worn cups by sliding them off the plunger assembly. Replace with new cups.

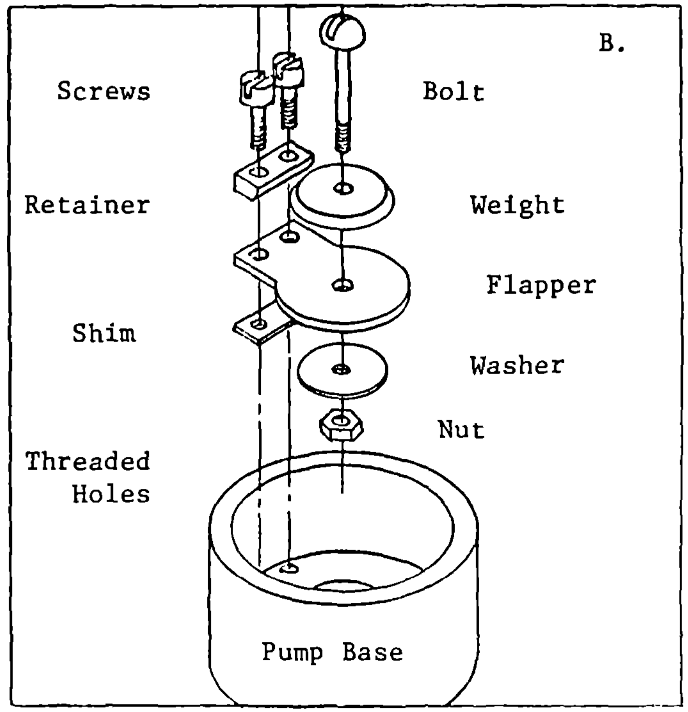
REASSEMBLY

Reassemble the plunger assembly exactly as the drawing above shows. Screw the plunger assembly back together snugly, but not too tightly. This will make disassembly next time very difficult. Be sure that the lock nut is tightened firmly on the plunger rod. Replace the pump cap and rebolt.

FOOT VALVE REPLACEMENT

REPAIRING THE SHALLOW WELL PUMP





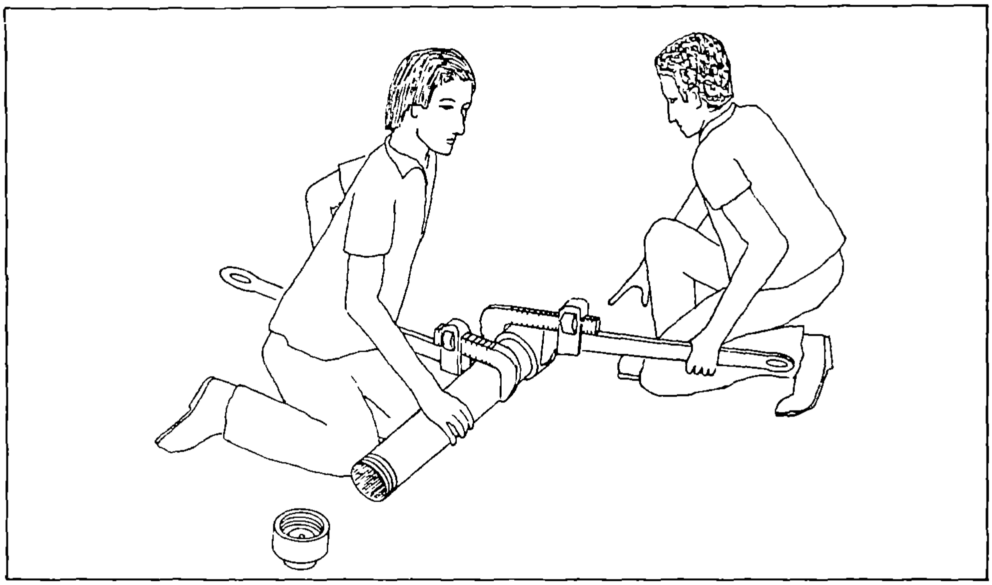
A. Unscrew the pump body from the pump base. If a large pipe wrench is unavailable, the handle may be used as a lever.

B. Replace the old footvalve flapper. Wipe any oil or dirt off the valve seat. Reassemble as shown.

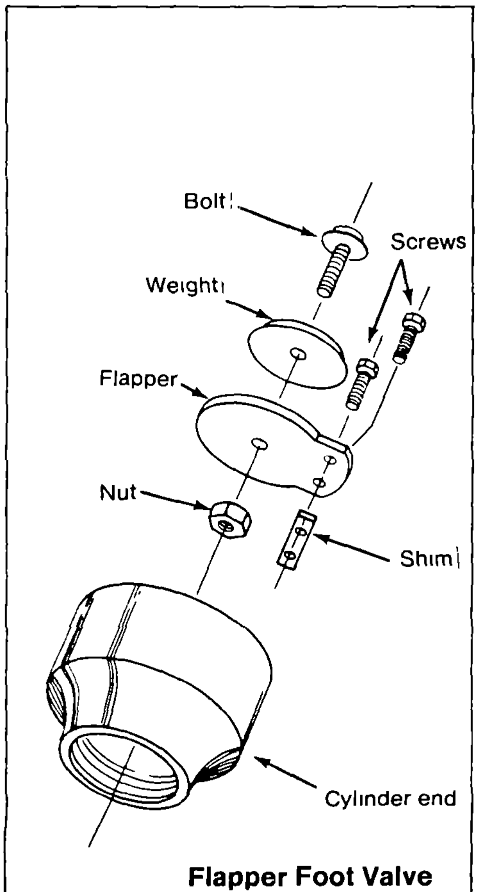
C. The reassembled valve should be centered as shown when viewed from above.

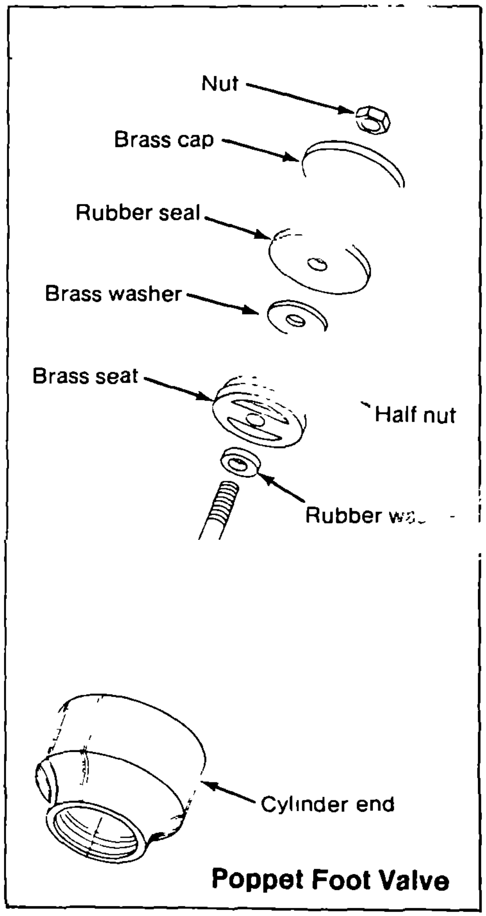
REPAIRING THE DEEP WELL PUMP

1. Take both ends off of the cylinder

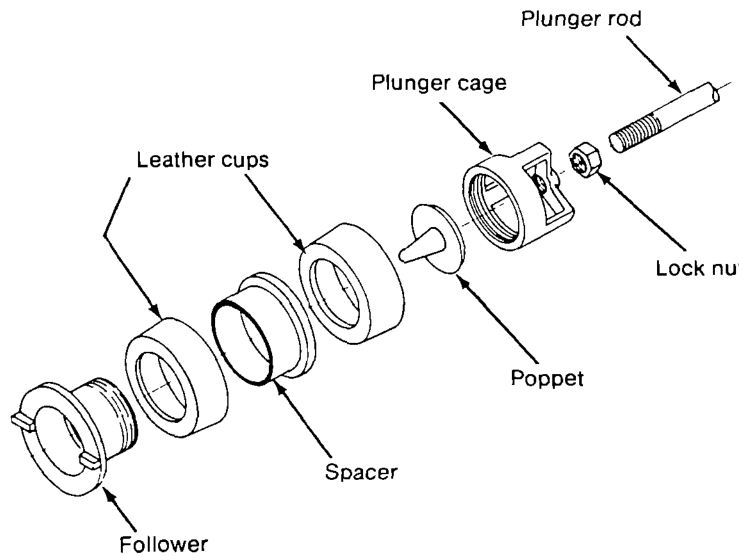


2 Look at the foot valve and repair worn or broken parts.





3. Examine the plunger assembly for worn or broken parts.



4 Double-check your repair

- Did you see any pipe joints leak when you took the cylinder out of the well? Did you repair these?
- Did you examine **all** the cylinder components?
- Are all the pipe joints resealed with pipe sealant or teflon tape?
- Does the cylinder leak after reassembly?
- Are all the lock nuts tight?
- Are all rod joints tight?
- Are all pipe joints tight?
- Did you test the pump for smooth operation, flow rate and leak rate? Are they acceptable?

Step-by-Step Procedure for Pump Overhaul

Before you move out of any handpump site, consult the India Mark II Handpump Installation Manual for checklist of tools and materials, and use this checklist to ensure you have all the tools and materials with you on the vehicle.

When starting the work, ensure that all the tools you will require are within hand's reach to facilitate your work. You can spread out a gunny bag or some other material upon which you can put the tools to protect them from dirt. You should do the same for all the handpump components you are going to remove. Ensure here also that the components are kept off the ground and protected from any dirt. Also, a pipe stand can be used to keep the G.I. pipes and rods off the ground.

DISMANTLING THE PUMP

1. Remove top-head front cover.
2. Disconnect handle from chain by removing the nyloc nut and bolt.
3. Take out handle-axle. While removing, use axle punch to protect axle threading and remove handle from top-head.
4. Remove top-head flange bolts.
5. Insert one pipe lifting spanner into the holes provided in the top-head and lift top-head (see step 21 of Manual).
6. Fit the connecting rod vice onto the water chamber top flange and tighten.
7. Remove chain and chain lock nut and remove top-head.
8. Remove bottom flange water tank bolts.
9. Lift water tank by using lifter pipe & lifting spanners.
10. Fit heavy duty clamp and tighten, and remove water tank.
11. Disassemble rising main and connecting rods. Remove, at a time, three metre lengths only.
12. While removing the pipes and rods ensure that you place these off the ground (see step 9 of Manual). Continue doing so until the entire below-ground assembly has been removed from the tube-well.
13. Disconnect cylinder from the last pipe.
14. Check all the pipe threads, clean out the threads by using wire brush. Remove any dirt and rust from the pipes by using sandpaper or wire brush. Re-thread if necessary. If any pipe is damaged, replace. Ensure that all pipe couplings are intact and fit properly.

CONNECTING RODS

15. Check all the connecting rod threads and couplings. Clean out threads with wire brush. Remove any dirt and rust from the rods by using sandpaper or wire brush. Fit lock nuts. If any connecting rod lock nut is missing, replace. Re-thread connecting rods if required. Check each rod for straightness. If rods are bent, try to straighten them. If not possible, replace.

CYLINDER OVERHAUL

16. Unscrew top and bottom reducer caps using heavy duty clamp and wrench. Remove piston assembly and foot-valve. Check piston and foot-valve assembly and replace any worn out components. Replace, if

From INALSA

necessary, leather cup-washers, leather sealing ring, rubber seating etc. Check for cracks which may have developed in the cylinder components. Replace parts if necessary. Assemble complete cylinder assembly.

IMPORTANT :

Check cylinder assembly for any leakage. Put cylinder in a bucket of water and move piston up and down. When cylinder is full of water, hold up and check whether any water is seeping through the foot-valve. If so, re-open cylinder, check piston and foot-valve assembly again for correct assembly and proper tightening. If necessary, replace foot-valve. Lock the upper valve seat and rubber seat retainer of the cylinder by punching at right angle at circumference of mating surface.

PUMP BODY OVERHAUL

17. Clean inside of water chamber and top-head Remove all dirt and rust inside and outside the handpump body Use wire brush and/or sandpaper to remove rust patches. Apply anti-rust paint.

    Assemble the handpump following the handpump installation procedures, as shown in the Manual.

PLATFORM CHECKING

As you know, the India Mark II Handpump ought to be installed with a proper concrete platform and pedestal. A handpump platform is essential since: (1) it provides the foundation for the pump pedestal; (2) it acts as a hygienic seal; (3) prevents any surface water percolation into the tube-well and hence excludes any contamination of the tube-well water. Therefore, special attention should be paid to the platform condition and (1) you should check for cracks which may have developed in the platform and (2) check whether the pump pedestal is tightly secured to its foundation.

If the platform has any cracks, or if the pedestal is loose, do the following:

18. Fill up cracks in the platform with cement. Make sure that exposed platform brickwork is covered again with cement plaster.
19. To reinforce the handpump pedestal base, dig out a circular space of minimum 5 cms. wide and 10 cms. deep around pedestal base and fill this up with a 1:2:4 concrete mixture. Whenever cement plaster for concrete mixture is re-applied to an existing platform, curing time should be allowed which is normally 7 days. Disconnect the handle from the chain so that nobody can operate the pump and ask the villagers not to use the hand pump for the duration of the prescribed time. The required setting time can be reduced if quick setting compound is mixed with the cement and concrete mixtures. When quick setting compound is used, 24 hours curing time is required.

CHLORINATION OF THE TUBEWELL

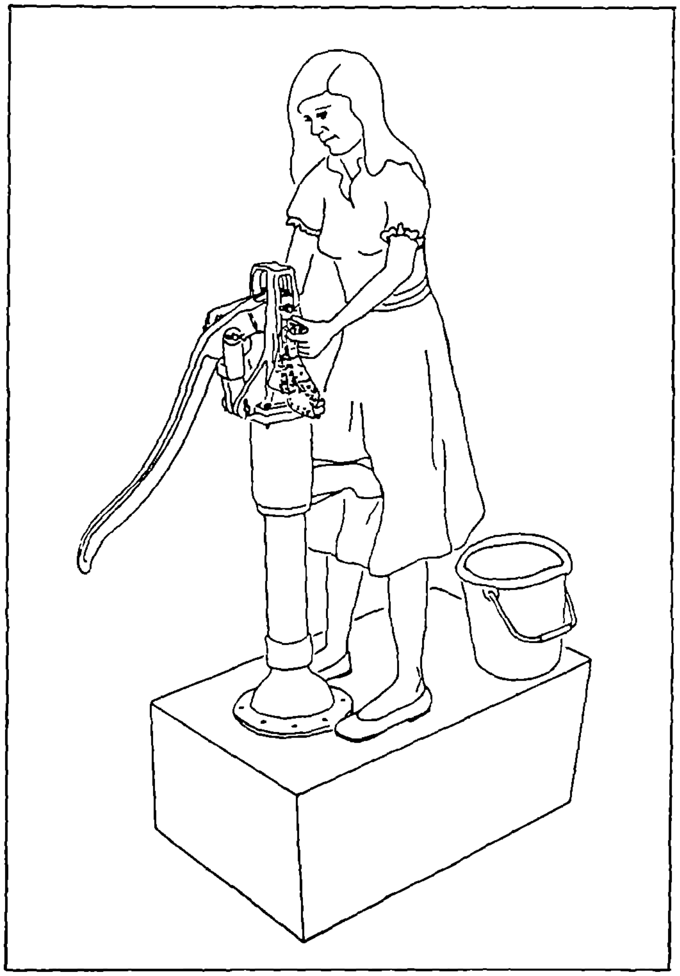
20. Upon completion of the overhaul job, the tubewell should be chlorinated. Follow the chlorination instructions as indicated on page 38 of the manual.

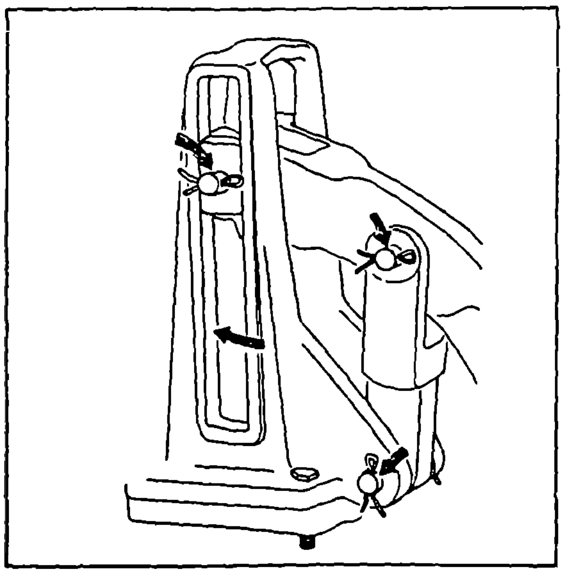
Possible Caretaker Tasks

- Lubricate wear surfaces on pump periodically
- Clean pump periodically
- Replace bushings, pins
- Replace shallow well cups
- Repair shallow well foot valve
- Repair shallow well plunger assembly
- Replace broken handle, fulcrum or other above ground part
- Repair deep well foot valve
- Replace deep well cups
- Repair deep well plunger assembly
- Fix leaks in drop pipe or suction pipe
- Order spare parts
- Request assistance from water supply agency
- Collect user fees
- Keep animals away from pump surroundings
- Discourage villagers from spilling water off the apron
- Drain water away from well site
- Teach villagers how to correctly operate pump
- Keep children from playing with pump
- Prevent vandalism of pump
- Tighten nuts, bolts and connections periodically
- Keep record of pump repairs
- Keep record of fees collected and costs of maintenance and repair
- Disinfect the well
- Teach villagers how to keep water clean while storing it
- Lock and unlock the pump at hours agreed by the village
- Clean the apron periodically
- Record any comments from users about irregularities in pump operation
- Paint all exposed parts to prevent development of rust
- Repair any cracked concrete in apron or drain
- Periodically test pump for footvalve leaks and worn leather cups
- Inspect pins and bushings wear

LUBRICATING THE PUMP

First, clean off the old lubricant with a rag.

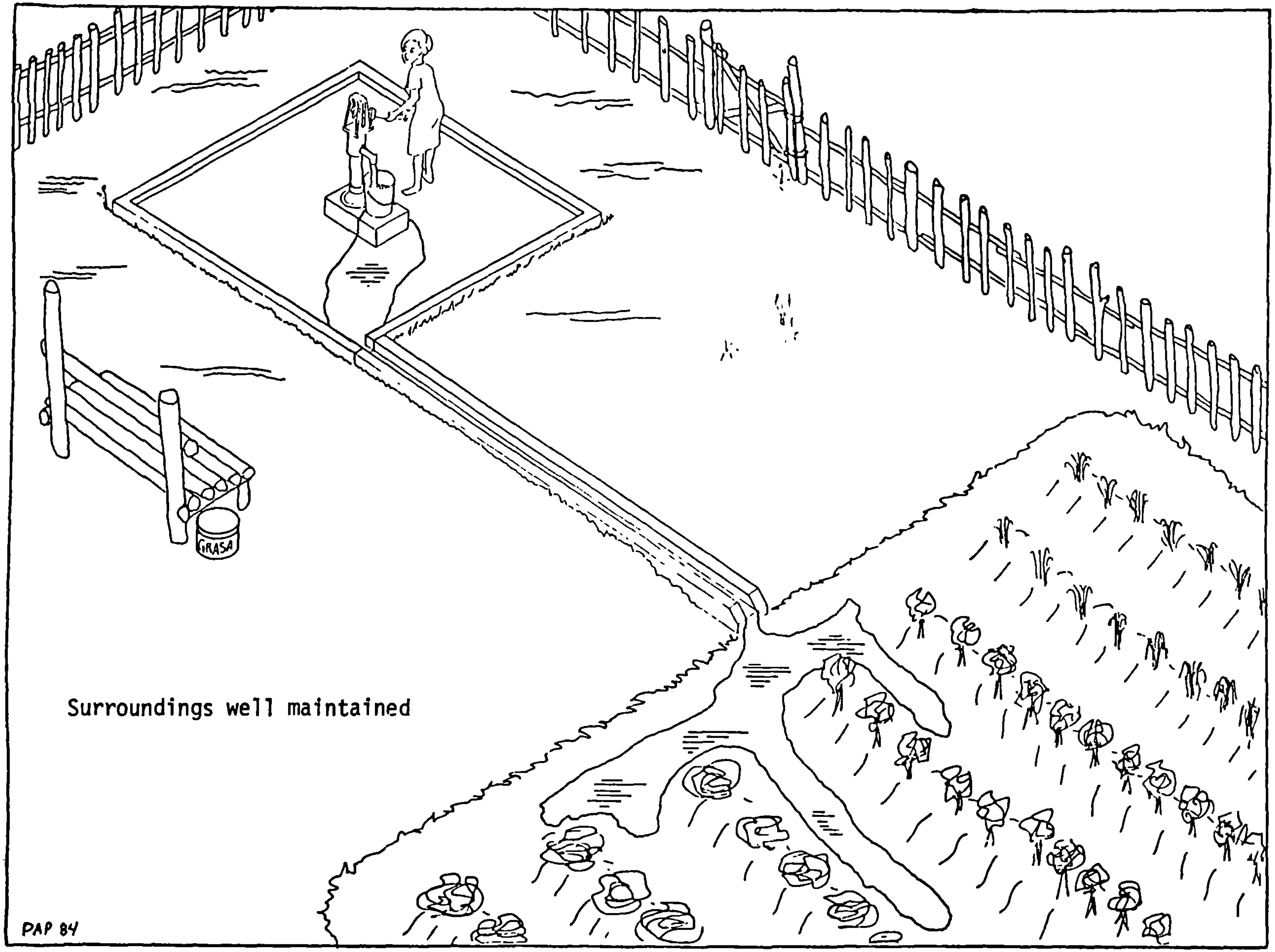




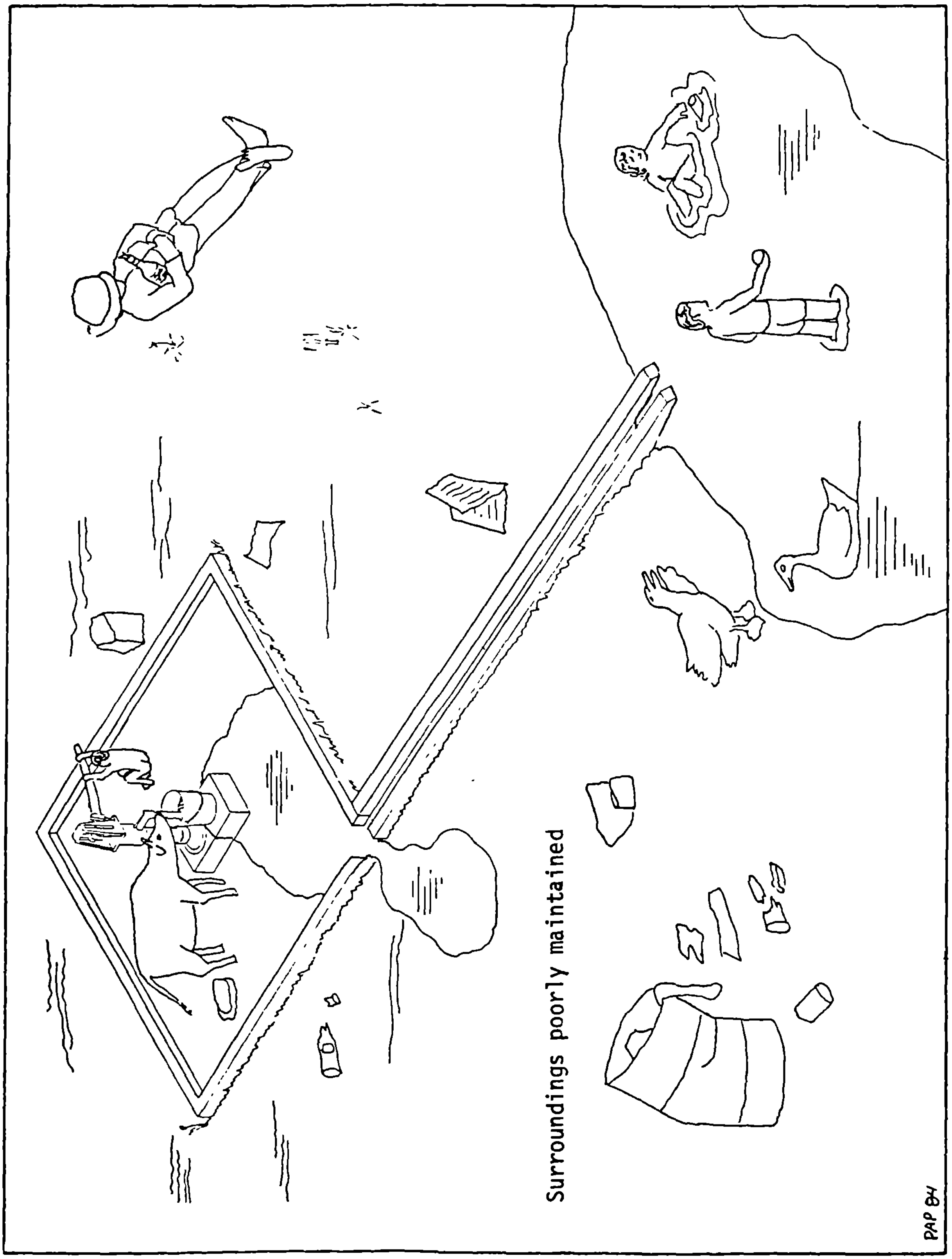
Put new lubricant on the parts indicated by the arrows.

Remove the pins to lubricate them.

MAINTENANCE OF THE PUMP AND SURROUNDINGS



MAINTENANCE OF THE PUMP AND SURROUNDINGS



SCHEDULE FOR MAINTENANCE OF SIMPLE HAND PUMPS

daily

1. lock and unlock the pump at hours agreed by the village.
2. clean the well-head.

weekly

1. thorough clean-up of pump, well-head and surroundings.
2. oil or grease all hinge pins, bearings, and sliding parts, after checking that no rust has developed on them.
3. record any comments from users about irregularities in working (tightness of parts, leaks from stuffing box, fall-off in water raised). Correct these when possible.

monthly

1. if necessary, adjust the stuffing box or gland (this does not apply to the Craelius pump). Usually this is done by tightening the packing nut. This should not be too tight - there should be a slight leak when the adjustment is correct.
2. check that all nuts and bolts are tight, and check that there is no evidence of loose connections on the pump rods.
3. check for symptoms of wear at the leathers, noting any comments from users about any falling off in the water raised. If the pump fails to raise water when worked slowly (e.g., at 10 strokes per minute), replace the leathers.
4. carry out all weekly maintenance tasks.

annually

1. paint all exposed parts to prevent development of rust.
2. repair any cracked concrete in the well-head and surrounds.
3. check wear at handle bearings and replace parts as necessary. On the Craelius pump, worn bushes can be replaced by short sections of pipe of suitable diameter.
4. check plunger valve and foot valve; replace if found leaking.
5. check the pump rod and replace any defective lengths or connectors.
6. replace packing at the stuffing box or gland (does not apply to the Craelius pump).
7. carry out all monthly maintenance tasks.

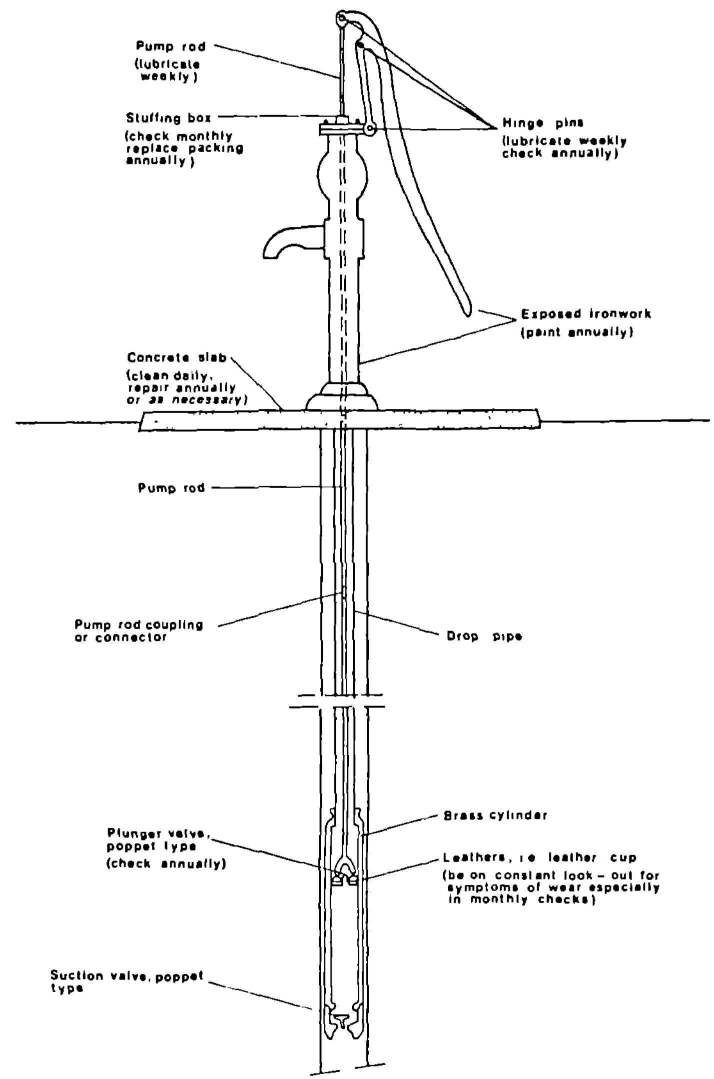


FIGURE 4-4 MAINTENANCE NEEDS OF HAND PUMP COMPONENTS

(after Pacey, 1976)

Calculating Material Quantities

A. Calculating the volume of concrete needed for the lining.

1. Determine the thickness, the length and the perimeter of the lining.

2. Use the following approximation to determine the volume of concrete needed for the lining:

   Thickness x Length x Perimeter = Volume (approx.)

B. Finding material requirements for concreting the lining.

1. Refer to the table, "Lining Concrete Material Quantities." The table assumes a 1:2.5:5 concrete mix. The numbers mean that one bucket of cement is mixed with two and one half buckets of sand and five buckets of gravel to make the concrete mixture.

2. Using the table:

   a. Find the volume of the lining calculated in step A.2 above on the left hand side of the table.

   b. Read the required number of leters of cement, sand and gravel from the table.

   c. When the total amount of cement needed to line the well, pour the apron, plaster the apron sides and construct the drain is known, convert the number of liters of cement to bags of cement using the table, "Cement Conversion: Liters to Number of Bags."

C. Determining apron size

1. Follow the standards established by the sponsoring water agency, or, if none exists,

2. Follow the widely accepted standard that the apron should extend 1-1/2 meters beyond the edge of the well and that the drain should be 5 meters in length.

D. Finding material requirement for concrete

1. Refer to the table, "Apron Concrete Material Quantities." The table assumes a 1:2:3 concrete mix and a 10 cm thick apron slab. The numbers 1:2:3 mean that one bucket of cement is mixed with two buckets of sand and three of gravel to form the concrete mixture. Both the concrete mixture and the apron thickness are recommended for a durable apron.

2. Using the table:

   a. If the shape of the apron will be round, use the upper half of the table which has a circle beside it. If the apron will be square use the lower half of the table with the square beside it.

   b. Find the diameter or width (length of the side) of the apron on the table.

   c. Read the number of liters of cement, sand and gravel required from the table.

   d. When the total amount of cement needed to line the well, pour the apron, plaster the apron sides, and construct the drain is known, convert the number of liters of cement to bags of cement using the table, "Cement conversion: Liters to Number of Bags."

E. Finding the size and quantity of rebar required for dug wells.

1. For drilled wells, the use of reinforcement is optional. Reinforcement should be used when the soil under the apron is soft or recently tamped e.g., when a substantive fill is used to raise the ground level around the well.

   Reinforcement suggested for drilled wells is a steel fabric mesh whose members are 3 to 6 mm (1/8 to 1/4 m) in diameter spaced on 7.5 to 10 cm (3 to 4 in) centers. The mesh should be placed roughly in the middle of apron slab (5 cm from top or bottom) and extend to the perimeter of the apron. For a 3-meter square apron, approximately 9 square meters of fabric mesh will be required.

2. For dug wells, reinforcement is need in the concrete that spans the well. For most hand dug wells 10 mm (3/8 in) rebar on 15 cm (6 in) centers will be sufficient for normal maximum loadings. Above 1 1/2 or 2-meter diameter wells, the reinforcing material and diameters should be calculated for each well.

   When the slab covering the well opening is raised above the apron, the rebar should be extended to within 3-5 cm (1-2 in) of the outer edge of the slab. When the slab covering the well opening is construceted as an integral part of the apron, the rebar should be extended 30-50 cm (12-18 in) beyond the edge of the well opening.

   To use the "Rebar Quantities" chart, find the longest length of rebar needed to span the well in the left column. The right column gives the total amount of rebar needed for that well.

3. The lining of a well should be reinforced with 10 mm (3/8 in.) rebar. Usually the rebar is on 30 to 50 cm (12-18 in) centers. To find the quantity of rebar, add the number of vertical and

horizontal rebars used and multiply them by their length. For vertical rebar, the length is roughly that of the lining depth. For horizontal rebar, the length is the perimeter of the well.

F. Finding form requirements

1. Measure the perimeter of the apron and of any other structures requiring forms (eg. pump pedestal, if used).

2. Add all the perimeters and select enough form material (wood, brick, metal, etc.) to make the apron. See handout on constructing the apron which was passed out in Session 5 for an example of using wooden forms to form the apron.

G. Finding plaster and mortar requirements for the apron and drain

Total quantities of sand and cement used to plaster the apron and mortar the drain is small but not negligible. A fixed quantity of 40 liters of cement and 80 liters of sand should be alloted to make sure there is enough.

H. Finding the quantity of gravel to be spread around site

Gravel is needed around the well site so it won't become muddy. Estimate the gravel requirements at 250 liters of gravel for each meter of the apron's diameter or width. Note: There may be design alternatives available to keep the apron site from becoming muddy.

I. Finding brick or concrete block requirements for the drain

Bricks or concrete blocks are usually used to make the drain. To find the number of blocks or bricks needed, divide the length of the drain by the length of the blocks. This is the number required for one side. The drain has two sides so multiply by 2.

J. Finding the number of sections of plunger rod and drop pipe (or suction pipe) for installing the pump

The drop pipe and plunger rod will be cut to length during installation. At this time, it is necessary only to determine the sufficient quantity of pipe and rod to be procured. The length depends on several factors which are discussed in Session 11. For example, if the cylinder is to be installed 15 meters deep, it is necessary to procure at least 15 meters of pipe and rod. If the pipe and rod are available in six meter sections, three sections of both drop pipe and plunger rod will be needed.

"Lining Concrete Material Quantities"

(Based on 1:2.5:5 mix)

Volume of Lining (cubic meters)	Cement (liters)	Sand (liters)	Gravel (liters)
.20	37	91	184
.40	74	184	368
.60	110	276	552
.80	147	368	736
1.0	184	460	920
1.2	221	552	1104
1.4	258	644	1288
1.6	294	736	1472
1.8	331	828	1656
2.0	368	920	1840

Apron Concrete Material Quantities

(Based on a 1:2:3 mix)

Apron Diameter (meters)	Cement (liters)	Sand (liters)	Gravel (liters)
2.0	70	140	210
2.5	110	220	330
3.0	160	320	480
3.5	215	430	650
4.0	280	560	850
4.5	360	720	1,100
5.0	440	880	1,300
5.5	550	1,100	1,600
6.0	650	1,300	1,900

Side of Apron (meters)	Cement (liters)	Sand (liters)	Gravel (liters)
2.0	90	180	270
2.5	140	280	420
3.0	200	400	610
3.5	225	550	830
4.0	360	720	1,100
4.5	455	910	1,400
5.0	550	1,100	1,700
5.5	700	1,400	2,000
6.0	800	1,600	2,400

Cement Conversion: Liters to Number of Bags

Liters	Bags of Cement
0 - 33	1
34 - 66	2
67 - 99	3
100 - 133	4
134 - 166	5
167 - 199	6
200 - 232	7
233 - 266	8
267 - 299	9
300 - 332	10
333 - 365	11
366 - 398	12
399 - 432	13
433 - 465	14
466 - 498	15
499 - 531	16
532 - 564	17
565 - 598	18
599 - 631	19
632 - 664	20
665 - 697	21
698 - 730	22
731 - 764	23
765 - 797	24
798 - 830	25
831 - 863	26
864 - 896	27

Re-bar Quantities for Dug Well Cover Slab

Length of Longest Re-bar (meters)	Total Quantity of Re-bar Rquired* (meters)
1	11
1.2	15
1.4	20
1.6	27
1.8	33
2.0	40
2.2	51

*Based on re-bar spacing of 15 cm (6 in) on center

Construction Tasks

Name of Village: ____________________ Name of Well: ____________________

Diameter of Well: ____________________ Diameter or Width of Apron: _______

Depth to Cylinder: ____________________

Place a check next to construction tasks to be undertaken and add steps as needed:

Lining the Well

______________ prepare well for lining

______________ excavate walls to desire diameter

______________ cut and place reinforcing

______________ place forms

______________ pour lining

______________ remove forms and finish rough concrete

______________ remove debris from well

Constructing the Apron

______________ clear and level apron site

______________ measure and cut form material

______________ assemble forms

______________ cut and place planking over well opening (Dug Well)

______________ locate and place pipe section and access hatch forms (Dug Well)

______________ cut hole under pipe section (Dug Well)

______________ place apron forms

______________ cut, place and tie rebar (Dug Well)

_____________ place anchor bolts

_____________ mix and place concrete

_____________ construct access hatch cover (Dug Well)

_____________ cover concrete for curing

Finishing the Site

_____________ remove forms from apron (if removable)

_____________ cut hole in planking for access hatch and place access hatch form (Dug Well)

_____________ plaster newly exposed apron surfaces

_____________ dig drainage ditch and sump

_____________ lay drain

_____________ fill sump with gravel and cover with clay

_____________ grade area around apron, drain low spots

_____________ spread gravel around apron

Installing the Pump (Shallow Well)

_____________ cut suction pipe to length

_____________ glue adapter to end

_____________ place suction pipe in well

_____________ attach suction pipe to pump

_____________ bolt pump to apron

_____________ test the pump

Installing the Pump (Deep Well)

______________ cut drop pipe to length and thread

______________ install cylinder, drop pipe and plunger rod to desired depth

______________ attach drop pipe to base

______________ cut rod to length and thread

______________ attach cap to rod and body

______________ bolt pump to apron

______________ test the pump

COST ESTIMATE SHEET FOR LINING THE WELL

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Cement				
Sand				
Gravel				
Reinforcing bars				
Tying wire				
Forms (wood or metal)				
Nails (wood forms)				
Tools				
Hammer	1			
Screed	1			
Trowel	1			
Shovel	2			
Bucket	2			
Pick/Maddox	1			
Tape measure	1			
Wire brush	1			
Wire cutter	1			
Hack saw				
Pliers				
Labor				
Skilled mason	1			
Unskilled worker	2			
Subtotal for Construction task				

COST ESTIMATE SHEET FOR CONSTRUCTING THE APRON AND FINISHING THE SITE

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Cement				
Sand				
Gravel				
Anchor bolts				
Form material				
Nails (for wooden forms)				
String				
Reinforcing bars (Dug well)				
Tying wire (Dug well)				
Planking and Joints (Dug well)				
Straw, burlap				
Pipe section (Dug well)				
Tools				
Hammer	1			
Screed	1			
Trowel	1			
Shovel	2			
Bucket	2			
Wire brush (Dug well)	1			
Wood saw	1			
Square	1			
Pick/Maddox	1			
Tape measure	1			
Clear plastic hose or level	1			
Wire cuter (Dug well)	1			
Hack saw	1			
Keyhole saw (Dug well)	1			
Rebar bender (Dug well)	1			
Marker	1			
Pliers (Dug well)	1			
Labor				
Skilled mason	1			
Unskilled worker	2			
Subtotal for construction task				

COST ESTIMATE SHEET FOR INSTALLING THE PUMP

MATERIAL, TOOLS, LABOR	QUANTITY	SOURCE	UNIT COST	TOTAL COST
Materials				
Drop Pipe (DW) 6-meter sections)				
Plunger Rod (DW) (6-meter sections)				
Pipe connectors (DW)				
Rod connectors (DW)				
Teflon tape				
Suction Pipe (SW)				
PVC solvent (SW)				
Grease				
Tools				
Strap wrench	1			
Pipe wrench (8-10 cm grip) (DW)	1			
Adjustable wrench	2			
Tape Measure	1			
Pipe clamp (DW)	1			
Hack saw	1			
Wire brush	1			
Pipe wrench (5-6 cm grip) (SW)	1			
Pipe threader for plunger rod (DW)	1			
Pipe threader for drop pipe (DW)	1			
Pliers	1			
Punch	1			
Hammer	1			
Tripod (DW)	1			
	1			
Pulley (or block and tackle) (DW)	1			
Heavy rope (DW)	1			
Labor				
Skilled pipe fitter	1			
Unskilled worker	2 (minimum)			
DW - Deep well pumps only SW - Shallow well pumps only				
Subtotal for Cosntruction Task				
Total Construction Cost Estimate				

WORK PLAN GUIDE

Materials:

What must happen so that all the materials will be ready for the day construction begins:

Examples of tasks:

- determine what materials are available locally (donated?)
- determine what materials must be procured outside of village (purchased?)
- materials procured
- materials delivered

Tools:

What must happen so that all the tools will be available for the day construction begins?

Examples of tasks:

- determine what tools available locally or can be borrowed
- determine what tools must be purchased
- tools purchased/arrangements made to borrow
- tools brought to work site

Labor:

What must happen so that the needed labor is available for the day construction begins?

Examples of tasks:

- determine what skills are available locally and at what times i.e. village labor is dependent on harvest season, etc. and on festivals and holidays
- determine what skills must be brought to the village
- arrange work date and method of payment

Villagers:

What must happen so that the villagers who use the well will have safe water during the construction period?

Examples of tasks:

- inform users of impending construction
- locate alternative sources of drinking water
- communicate which days construction will be

CONSTRUCTION PLANNING CHART

ACTIVITY	TIME TO COMPLETE ACTIVITY	RESPONSIBILITY	TARGET COMPLETION DATE

Desirable Tool and Material Qualities

The following is a summary of desirable qualities of tools and materials to be procured for the handpump project. The use of higher quality tools and materials results in longer tool life and reduced maintenance requirements for the apron and pump installation.

A) Poor quality will result in shortened life and having to buy tools more often. What to look for in tools:

- forged steel (hardness, durability)
- large cross sections (strength)
- interchangeable teeth (when they wear out, buy new teeth not a new tool)
- brand with good reputation among craftsmen

B) Poor quality can result in cracking, etc. What to look for in materials:

- Cement: It should be dry, powdery and free of lumps. Lumpy cement should not be broken up and reused like sugar or salt. Store cement in a dry place away from exterior walls, off damp floors, and stacked close together to reduce air circulation. The covered storage time is limited to between six months and one year depending on conditions.
- Water: In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Use only enough water to make the concrete workable. Too much water will result in weaker concrete.
- Aggregates: Fine aggregates (sand) and coarse aggregates (gravel) together occupy 60 to 80 percent of concrete volume.
    - Size: Sand should range in size from .25 mm to 6.3 mm. Sand from sea shores, dunes or river banks is usually too fine for normal mixes. The larger the size of the gravel, the less water and cement will be required to get the same strength concrete. The maximum gravel size should not exceed 2 cm.
    - Shape: The shape and surface texture of aggregates affect properties of freshly mixed concrete more than they affect hardened concrete. Rough textured or flat and elongated particles require more water to produce workable concrete than do rounded or cubical aggregates.

- Cleanliness: It is extremely important to have clean gravel and sand. Silt, clay, or bits of organic matter, even in low concentrations, may ruin concrete. A very simple test for cleanliness makes use of a clear widemouth jar. Fill the jar about half full of sand and small aggregate to be tested, and cover with water. Shake the mixture vigorously, and then allow it to stand for three hours. In almost every case, there will be a distinct line dividing the fine sand suitable for concrete and that which is too fine. If the very fine material amounts to more than 10 percent of the suitable material, the concrete made from it will be weak.

  Solution: Other sand should be sought, or the available material should be washed to remove the material that is too fine. This can be done by putting the sand (and gravel if necessary) in a container such as a drum. Cover the aggregate with water, stir thoroughly, let stand for a minute, and pour off the liquid. One or two treatments will remove most of the very fine material and organic matter.

- Galvanized Pipe: Use Schedule 40. Thinner pipe rusts through more rapidly resulting in a leak.
  - ends should not be crushed (have to rethread them)
  - galvanizing should not be scratched off (may rust through at this point)

- Plunger Rod: It should not be out of round (cannot be threaded) and not badly bent (will rub on pipe).

- PVC Pipe: Use PVC solvent to bond pipes (versus a glue which will allow the joint to crack in time).

User Education Topics

A. Water and Your Life

- list/discuss uses for water
- most important use of water for people in your community
- kinds of water which can make people ill
- what happens when you drink water that is not clean
- who gets sick most often
- what you can do so that children don't get diarrhea often

B. Collecting, Storing, and Using Water

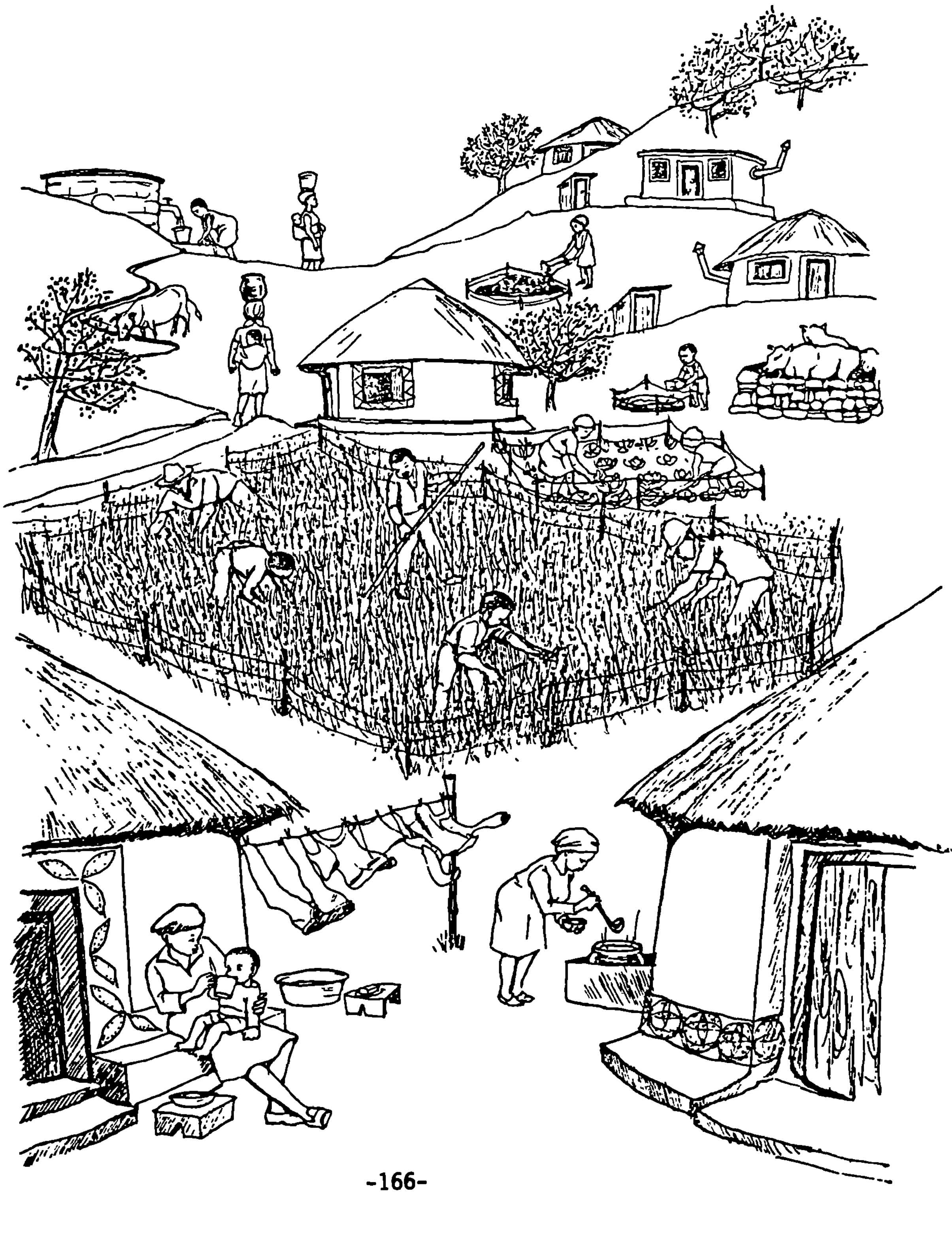
- sources of water people use in your community
- best sources for drinking water
- some communities have clean water but children still get diarrhea. Why?
- how people in your community collect water
- how people store water
- how water gets dirty
- some things a mother can do so that her child gets clean water

C. Using your New Handpump

- why a particular well is a source of clean water
- what needs to happen to keep water clean
- how the handpump can be protected from damage
- signs that could mean the handpump needs repairing
- to whom you should report repairs
- what needs to happen to maintain the handpump and site

USER EDUCATION RESOURCE MATERIAL

Many things help to keep you, your home, and the community healthy. You have already discussed some of these things. Now look at this picture of a community carefully.



Look at this picture of another community.

Is this a healthy community? What things that are good for health do you think are missing from this community?

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Look at other pictures in the booklet, "Health Problems in the Community." You can use the pictures to discuss health problems in your community.

What is happening in the picture above? Do you see this in your community? Can this cause any health problems? What kind of health problems?

SESSION 1

Water and Your Life

Water is useful for everyone in many ways. People, animals, and plants cannot live without water. How many ways do people use water in your community?

List and discuss some of the uses of water in your community.

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What is the most important use of water for people in your community?

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Everyone needs water to drink. Without water to drink everyone would die. Water keeps people healthy. But some water can make people ill. What kind of water can make people in your community ill?

Water that is not clean can make people ill.

What happens when you drink water that is not clean?

____

____

____

Unclean water can give you belly trouble. You can get pains in your belly. You may get diarrhea. Sometimes you get ill soon after you drink unclean water. Sometimes you do not get ill until two or three days after you drink unclean water.

Who do you think gets sick most often from unclean water in your community?

Old people _____
Mothers _____
Fathers _____
Young children _____

Young children get diarrhea from unclean water most often in the community.

Why is this?

____

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Young children get ill easily. Young children are not as strong as older persons. That is why young children get sick and have diarrhea more often than older persons.

Young children get diarrhea because they eat and drink from many sources. Children get diarrhea often when they eat food or drink water that is not clean. Older persons who drink the same unclean water do not get diarrhea as often. This is because older persons are stronger. Many children can die with diarrhea in the community.

What can you do in your community so children do not get diarrhea often?

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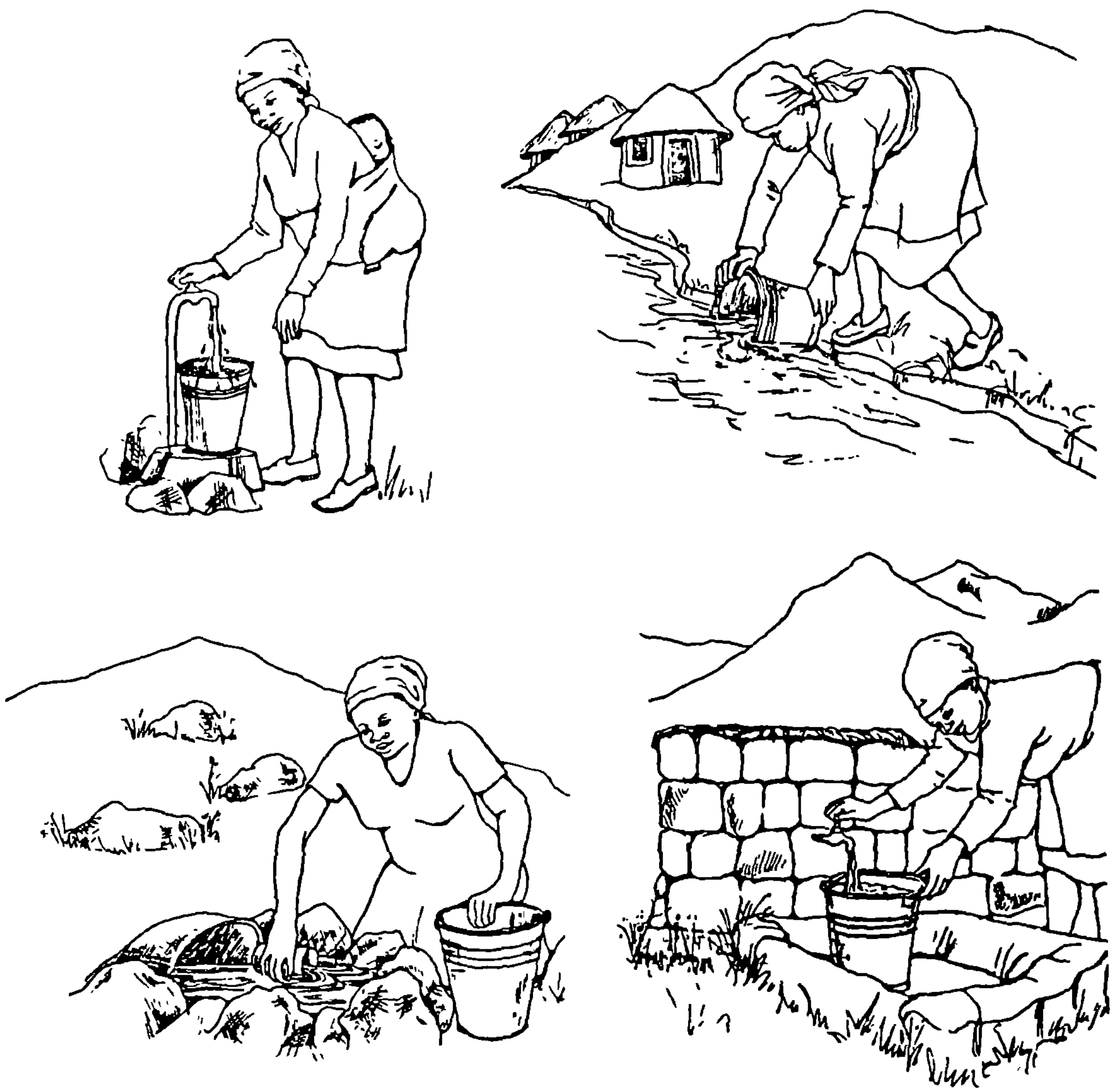
SESSION 2

Collecting, Storing, and Using Water

In this session you will learn how water gets dirty. Look at these pictures. These pictures show different places people get water. What sources of water do people use in your community?



List and discuss which sources of water have the best water for drinking.

Some sources of water are clean and some are not. Some water looks clean but may not be clean, and can make people ill. Water that is not clean can cause diarrhea. Some communities have clean water, but children in the community still get diarrhea.

Why is this?

Water can get dirty after people collect the water. How do people in your community collect water?

How do people in your community store water?

Water can get dirty in many ways. Look at these pictures. Think about where and how water can get dirty.

Write about and discuss how water gets dirty.

Think about how clean water can get dirty when mother collects, stores, and uses water.

The bucket mother uses for collecting water may not be clean.
Mother may have dirty hands when she collects water.
The storage vessel mother uses at home may not be clean.

Can you think of other ways water can get dirty?

If water gets dirty in any of these ways, a child who drinks the water can get diarrhea.

How Do Things We Eat and Drink with Get Dirty?

Children can get sick if they eat and drink with things that are dirty. The dirt goes into the belly and makes them sick. Water goes into the belly. Food goes into the belly. Mother uses her hands to cook the food and feed her child. All these things can get dirty.

How do things you eat and drink with get dirty?

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Flies sit on stool and other rubbish. Flies carry dirt on their legs. Flies carry dirt to water, and things you eat or drink with. This is one way things get dirty and make you sick.

A person's hands get dirty when he goes to the toilet. When the person's hands touch something, the thing gets dirty. What should the person do after going to the toilet?

____

____

The person should wash his hands after going to the toilet.

Can you think of other ways things get dirty?

____

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Look at the pictures on page 9 again. What should mother do so her child gets clean water to drink?

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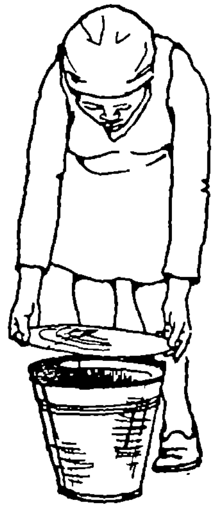
Here are some things that mother can do so her child gets clean water.

Mother should wash her hands before picking up the bucket.

Mother should wash the bucket before collecting the water. Then she will not make the water dirty.

Mother should wash her hands.

Mother should also wash the bucket before filling it with water.



Mother should cover the bucket. Then the water will not get dirty when mother is carrying the water.

Mother should wash the storage vessel after she gets home. Mother should also wash the scoop she uses to take out the water.

Mother should cover the water to make sure that the water does not get dirty. Mother should also cover the scoop.

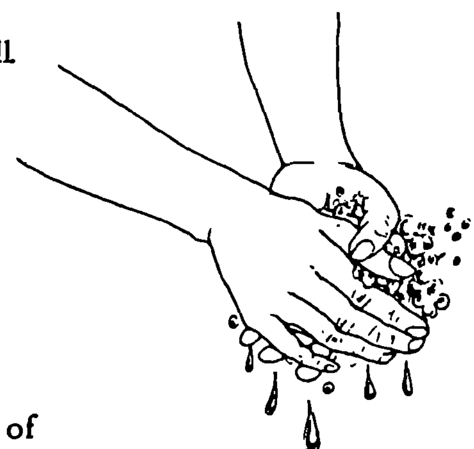
Mother should wash her hands before giving the water to her child.

Mother should also wash the cup for her child.

If mother takes such good care, then her child will stay healthy. Her child will not get diarrhea often.

Why Must You Wash Your Hands?

You must wash your hands so that your hands are clean. If you prepare food for your child with clean hands, your child will not get ill.



You can make other members of your family ill by cooking with dirty hands. You can also make yourself ill by eating with dirty hands.

When Should You Wash Your Hands?

You should wash your hands as often as possible. You must always wash your hands with soap and water:

After going to the toilet
After cleaning your child's toilet
Before preparing food
Before feeding your child
Before eating food
Before taking water from the storage vessel

When else should you wash your hands?

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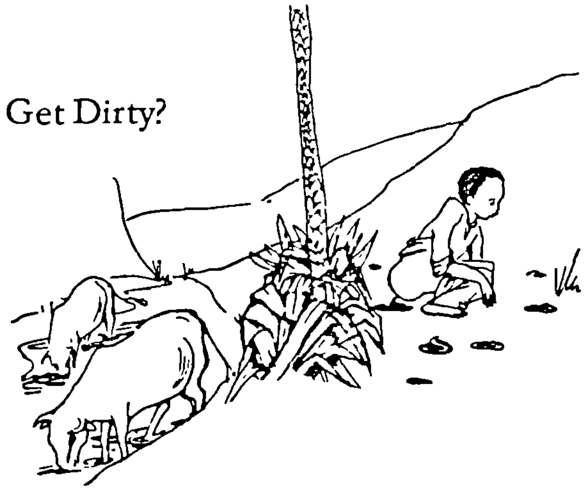
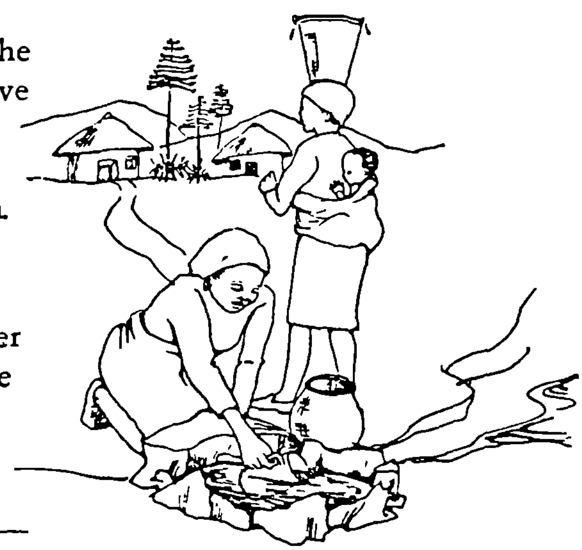
How Should You Wash Your Hands?

You should wash your hands with soap and running water. You can have running water by asking someone to pour water for you. You should wash your hands well with soap. Put soap all over your hands and wrists. Clean your nails well with soap and clean water. Also keep your nails short.

How Does Water at the Source Get Dirty?



The water gets dirty if people pass stool above or near the water. Try to get people to find another place to go to the toilet. You can show people how to build latrines. Then the water for everyone will not get dirty.



Rain water can make the spring dirty. You should ask people in the community to keep the area above the spring clean. Fence the area above the spring. Then animals and people will not dirty the area.

Rain water also flows along the ground and brings stool and other dirt with it. How can you stop the rain water from flowing into the source?

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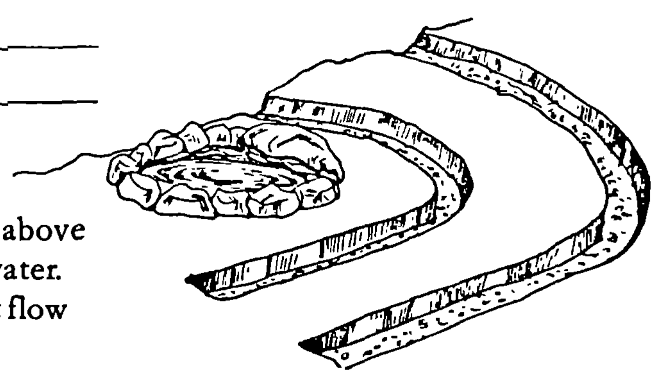

You can build two trenches above the spring to stop the rain water. Then the rain water will not flow into the spring.

What can you do if animals make the water at the source dirty?

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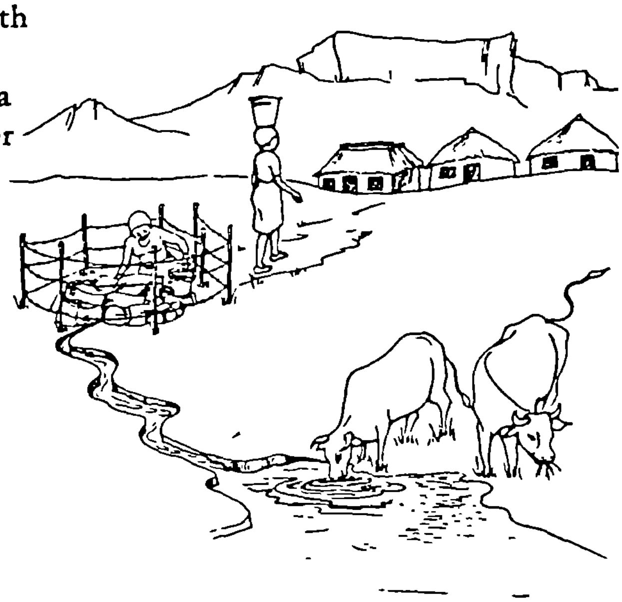
____

Make sure that animals do not drink from the same places that people get water. Make a separate place for animals to drink. Do not let animals come near the water that people drink. Animals can dirty the water with stool and with their dirty feet. Protect the water source with a fence or a wall. Cover the water source so that animals cannot reach the water source.



What can you do if rubbish in the community makes the water dirty?

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You can show people how to dig rubbish pits or how to make compost pits. You can also show people how to burn rubbish.

Basic Messages

1. Always drink clean water.
2. Protect your source of water.
3. Clean water can get dirty when you collect, store, and use water.
4. Always collect water in a clean container.
5. Always wash your hands before pouring, drinking, or using water.
6. Always store water in a clean container.
7. Boil water for young children if the water is not clean.
8. Make a separate place for animals to drink.
9. Build latrines or bury all stool to keep your community clean.
10. Cover all food and water to keep away flies.

PROJECT EVALUATION CHECKLIST

Name ____________________

Date ____________________

Village ____________________

1. How adequate is the water for the users?

2. How adequate is the site design? How does it take into account the needs and desires of the users?

3. How solid and sound is the structure?

4. Comment on the adequacy of the materials.

5. Comment on the labor force in terms of numbers, who was involved, and how effectively it worked.

6. How much did the project cost? Who paid for it?

7. How would you rate the finished area in terms of aesthetics and usefulness?

8. How adequate is the site drainage?

9. How has the well been protected from contamination and surface waters?

10. Evaluate the water quality (taste, clarity, etc.)

11. Comment on plans for a water committee or other village group responsible for the on-going project.

12. What arrangements have been made for pump and site maintenance, including training for caretakers?

13. How convenient is the handpump to use? How satisfied are the users?

14. What plans have been made for a user education strategy?

15. Other comments.

ACTION PLAN

	MONTH 1				MONTH 2				MONTH 3				MONTH 4				WHO IS RESPONSIBLE	WHO NEEDS TO BE INVOLVED
GOAL: TASKS:																		
GOAL: TASKS:																		
GOAL: TASKS:																		

Handpump Workshop Evaluation Form

(Please do not sign your name)

A. Goal Attainment: Please circle the appropriate number to indicate the degree to which the workshop goals have been achieved.

1. Identify resources necessary for a village handpump project.

1	2	3	4	5
Low				High

2. Conduct a project feasibility assessment and determine next steps.

1	2	3	4	5
Low				High

3. Identify and apply strategies for involving the community in all phases of the handpump project.

1	2	3	4	5
Low				High

4. Survey, evaluate, and select sites for handpumps including an assessment of the quantity and quality of water needed to warrant installation.

1	2	3	4	5
Low				High

5. Facilitate the formation and functioning of a water committee or other appropriate village organization.

1	2	3	4	5
Low				High

6. Develop a project cost estimate.

1	2	3	4	5
Low				High

7. Develop and implement work plans and logistics necessary for project start-up with appropriate village organization.

1 2 3 4 5
Low High

8. Coordinate and monitor construction activities and the procurement and delivery of materials.

1 2 3 4 5
Low High

9. Prepare selected sites for receiving handpumps.

1 2 3 4 5
Low High

10. Install locally available shallow or deep well pump.

1 2 3 4 5
Low High

11. Operate, maintain, troubleshoot and repair handpump.

1 2 3 4 5
Low High

12. Design a user education strategy.

1 2 3 4 5
Low High

13. Train village caretakers in appropriate maintenance and repair tasks.

1 2 3 4 5
Low High

14. Identify alternative strategies for solving most common non-technical problems which develop before, during and after handpump installation.

1 2 3 4 5
Low High

15. Monitor and evaluate the effectiveness of the handpump project.

1	2	3	4	5
Low				High

16. Develop an awareness of national and regional handpump program resources.

1	2	3	4	5
Low				High

B. Workshop Feedback and Learning: Please answer the following questions as fully as possible so that the trainers can learn the effectiveness of the workshop.

1. What was the most positive thing about this workshop? Comments:

2. What was the most negative? Comments:

3. What stands out as most important? Comments:

4. What have you learned that you did not know before? Comments:

C. Workshop Organization and Training

1. What do you have to say about the way the workshop was planned and carried out?

2. What can be done to improve similar workshops?

3. What specificly do you need to learn more about in order to successfully promote and develop a handpump project in the future?

4. What comments do you have about the trainers?