PROJECT DESIGN AND DATA COLLECTION GUIDELINES

FOR THE

RURAL ASSISTANCE PROGRAM

International Rescue Committee

September, 1991

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PART 1 - THE RURAL ASSISTANCE PROGRAM (RAP) AND THE ROLE OF PVOs

I. INTRODUCTION

A. Background

In 1985, USAID began supporting emergency relief activities implemented by Private Voluntary Agencies (PVOs) working in Afghanistan. By 1988 increasing stability in many parts of Afghanistan made it possible to provide other types of assistance to people who remained in Afghanistan.

To respond to this opportunity, the office of the USAID Representative for Afghanistan (O/AID/REP) initiated a PVO Rural Assistance Program (RAP) through the International Rescue Committee (IRC). RAP continued to provide emergency and survival assistance but also began supporting rehabilitation projects designed to increase food production and cash incomes in rural Afghanistan.

During the first year of the program the funds were split almost evenly between rehabilitation and emergency/survival assistance. Since then, most of RAP's grants have gone to rehabilitation programs in Afghanistan. Since July 1990, RAP has had a priority to support more sustainable types of projects.

The evolution of these programs from relief toward rehabilitation and sustainability has required PVOs to do increasingly complex tasks. PVOs had to provide more information to show that they too had evolved to meet the challenges of implementing these increasingly complex programs.

Since July 1990, RAP has asked PVOs to provide more technical details to justify their requests for money. RAP monitoring missions still found that technical details contained in the proposals often were not accurate. The fact that data provided in proposals were inaccurate demonstrated that some organizations were either unwilling or unable to collect accurate technical information.

The "Project Design and Data Collection Guidelines" are intended to be used along with the "Rural Assistance Program Manual." RAP believes the Guidelines will help people collect more accurate data with which to design projects. The Manual is then intended to help PVOs seeking RAP funds to present this data in a proposal form acceptable to RAP.

The data collection methods described have been gathered from PVOs working out of Peshawar and Quetta, and are intended for use by a broad range of people. Please note that these guidelines are subject to change. RAP welcomes comments from PVOs on how they think these guidelines can be revised and/or expanded. RAP will consider issuing a revised version of the guidelines if a sufficient number of useful comments are received.

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B. Purpose

The purpose of these guidelines is to present a series of data collection methods that PVOs can use to gather data to design projects, justify proposals, monitor and evaluate their projects. The guidelines also suggest a level of effort appropriate to gathering information for RAP projects.

C. Scope

The scope of this document is to:

* Describe the role of the PVO in the framework of RAP.
* Describe qualitative and quantitative project management techniques.
* Describe low-technology, low cost and low-effort data collection methods for the following kinds of projects:

  - Karez Repair
  - Canal Repair
  - Cereal Crop Production
  - Minor Road Repair

II. THE ROLE OF RAP PVOs WORKING IN RURAL AFGHANISTAN

A. The Unique Role of PVOs Working in Rural Afghanistan

Traditionally, large donor organizations such as USAID and the UN work through governments. Because most of rural Afghanistan is not under the control of the Kabul Government, donor organizations are channeling large amounts of aid through PVOs (also known as Non-Governmental Organizations - NGOs). This allows PVOs a chance to play a major role in developing strategies and policies often developed by government bodies.

PVOs are non-profit, non-political, voluntary organizations accountable to members, donors and beneficiaries. Generally, they have a board of directors that oversees the activities of the organization. PVOs may have charters or articles of incorporation that describe their mission (adapted from, Thomas, 1991).

B. Three Generations of PVO Strategies

Experts on PVO activities have noted that PVOs have tended to pass through three generations of strategies (e.g., Broadhead, 1987; Elliot, 1987; Korten, 1987). These are as follows:

1. Relief and Welfare: PVOs working with Relief and Welfare concentrate on logistical problems. They identify areas of need, not a particularly difficult task, and deliver the needed supplies.

Early projects funded by RAP supported efforts to provide food, cash or other kinds of short-term welfare and relief. Many PVOs working in Afghanistan began with this relief and welfare approach (e.g. Afghanaid, AFRANE, Solidarites Afghanistan).

2. Local Self-Reliance: These second-generation PVO strategies rely on standard project management approaches. Most rehabilitation projects are local self-reliance projects, because people should not need welfare and relief help after the projects are complete. These projects differ from relief and welfare approaches in that the benefits will be sustained beyond the period of PVO assistance.

Many current RAP-funded rehabilitation projects are local self-reliance projects. For example, by helping a community repair its irrigation system, the PVO has helped make the community self-reliant. Theoretically, the community will no longer require infusions of food or cash to meet their needs.

3. Sustainable Systems Development: PVOs working with sustainable systems development may, for example, help the community to develop income-generating projects using local materials and labor skills. These kinds of projects require a minimum of outside money. As RAP ultimately wants sustainable projects, RAP would consider proposals for sustainable systems development projects in areas where an organization has an established development program that could generate project funds.

C. Local Self-Reliance Projects in Rural Afghanistan

1. Difficulties Implementing Local Self-Reliance Projects

This manual will dwell on methods used in second generation projects (i.e. local self-reliance projects). While these Local Self-Reliance projects are not the most highly evolved types of projects, in the present context they remain difficult for the following reasons:

a.) **Many Afghans continue to view PVOs as welfare and relief organizations.** In the early years of the Soviet occupation the PVOs played a necessary welfare and relief role to refugees fleeing Afghanistan. However, as funds for distribution of commodities decrease, rural Afghans with means of producing their own food must take on the responsibility for their own sustenance. PVOs with experience implementing relief and welfare projects are well-suited to this new role of organizing rehabilitation projects.

b.) **Afghanistan remains dangerous.** Moving staff and materials to and from the project is difficult and, at times, impossible. The difficult lifestyle of rural Afghanistan often also does not appeal to university-trained people.

c.) **Some local authorities use aid for political purposes.** Sometimes authorities providing security for the PVO expect some aid to compensate them for their protection services (Malley, 1986).

2. RAP's Response to Difficulties in Implementing Local Self-Reliance Projects

RAP approached these problems by increasing accountability requirements. RAP prepared the Rural Assistance Program Manual to help PVOs develop these second generation projects. Among RAP's actions were the following:

a.) Requiring detailed information on project management strategies to show that the PVO has considered appropriate constraints in designing their project.

b.) Requiring organizations to set objectives and success criteria.

c.) Requiring technical information that would justify costs and serve as a basis for monitoring the project.

d.) Requiring detailed descriptions of the political and ethnic/tribal constraints operating in the project area.

PART 2 - PROJECT DESIGN

I. INTRODUCTION

Project design is the procedure by which an organization decides what problem they need to remedy and how to deal with that problem. Project design is essentially the logic behind the project. PVOs can use qualitative and quantitative techniques in preparing the project design.

II. THE PROBLEM PYRAMID

Often people know what kinds of work need to be done in their project area. Also, political necessity may require that the PVOs do certain projects. Still, several tools are available to help PVOs perform qualitative needs assessments. Among the most useful is the problem pyramid.

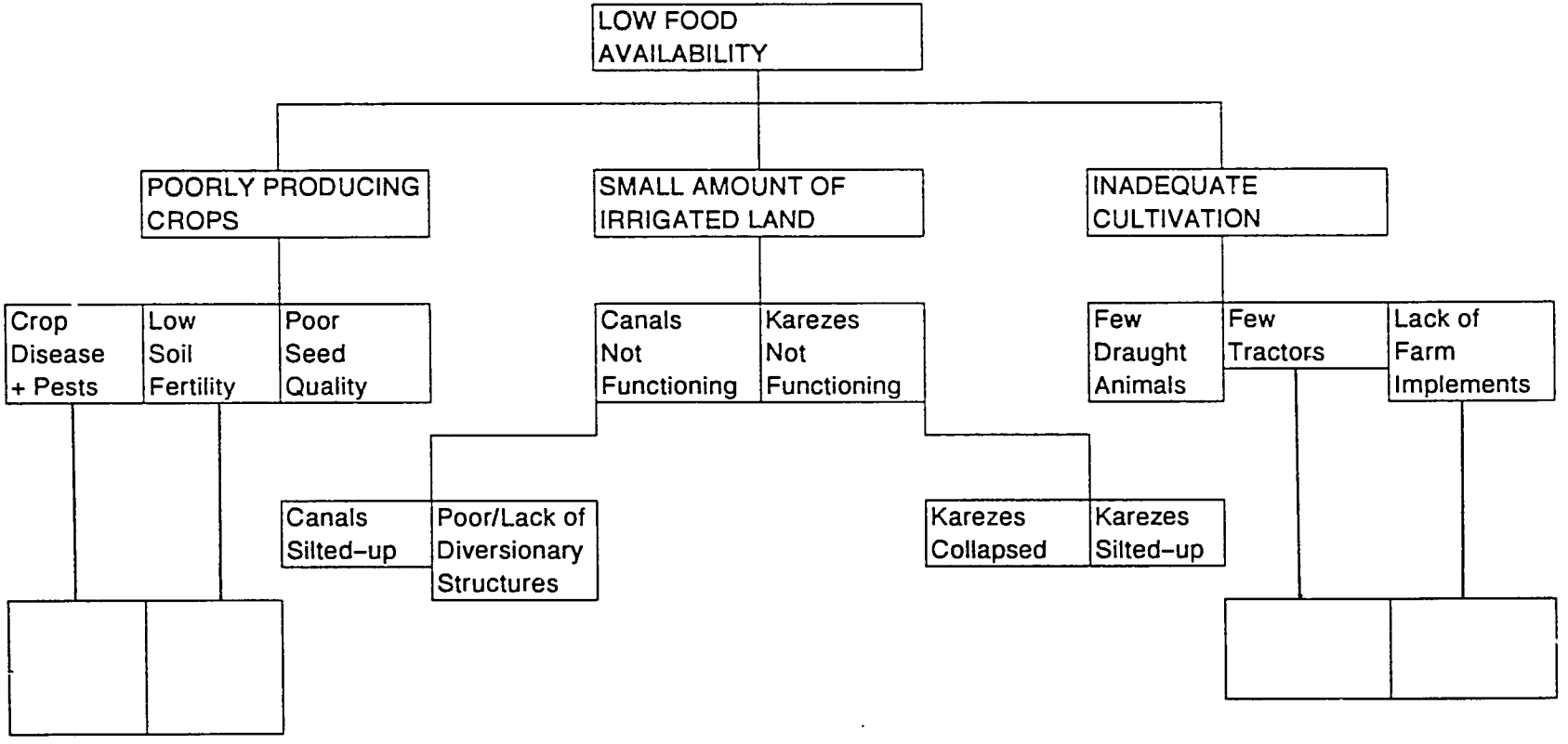
The problem pyramid places the largest overall problem on top of the pyramid and contributing problems beneath the largest problem. For example, in a general sense, a problem in many parts of the world is a low standard of living. Contributing problems to this low standard of living might be poor health, poor education, low income, lack of security, poor nutrition, etc.

A problem pyramid could be developed for any project area. For example, the problem pyramid in Figure 1 describes the agricultural problems of an individual area. Note that some of these problems might be identified by the people of the area themselves, while others such as low-productivity crops might be identified by technical staff.

By addressing the problems at the base of the problem pyramid, the PVO should help solve the problems further up the problem pyramid. In RAP's conceptual framework, PVOs should do activities (e.g. seed and fertilizer distribution, karez repair) that address problems (e.g. low agricultural productivity). Performing these activities will help solve problems higher up in the problem pyramid, and will result in PVOs achieving their objectives. Performing these activities provides the means for achieving objectives. These concepts are illustrated in Figure 2.

RAP asks PVOs to establish success criteria based on addressing these problems further up in the Problem Pyramid. PVOs should be asking themselves "Did we complete our activity (e.g. karez repair?" As well as "Did we achieve our objective (e.g. increasing the amount of irrigated land)?." Then, they should ask themselves if they are accomplishing their goal (e.g. increasing agricultural productivity).

FIGURE 1 – SAMPLE PROBLEM PYRAMID



Note: This is only an example. The purpose is to show that bigger problems have smaller contributing problems that can be structured to address the bigger problems

Figure 2: Objective Pyramid

Examples

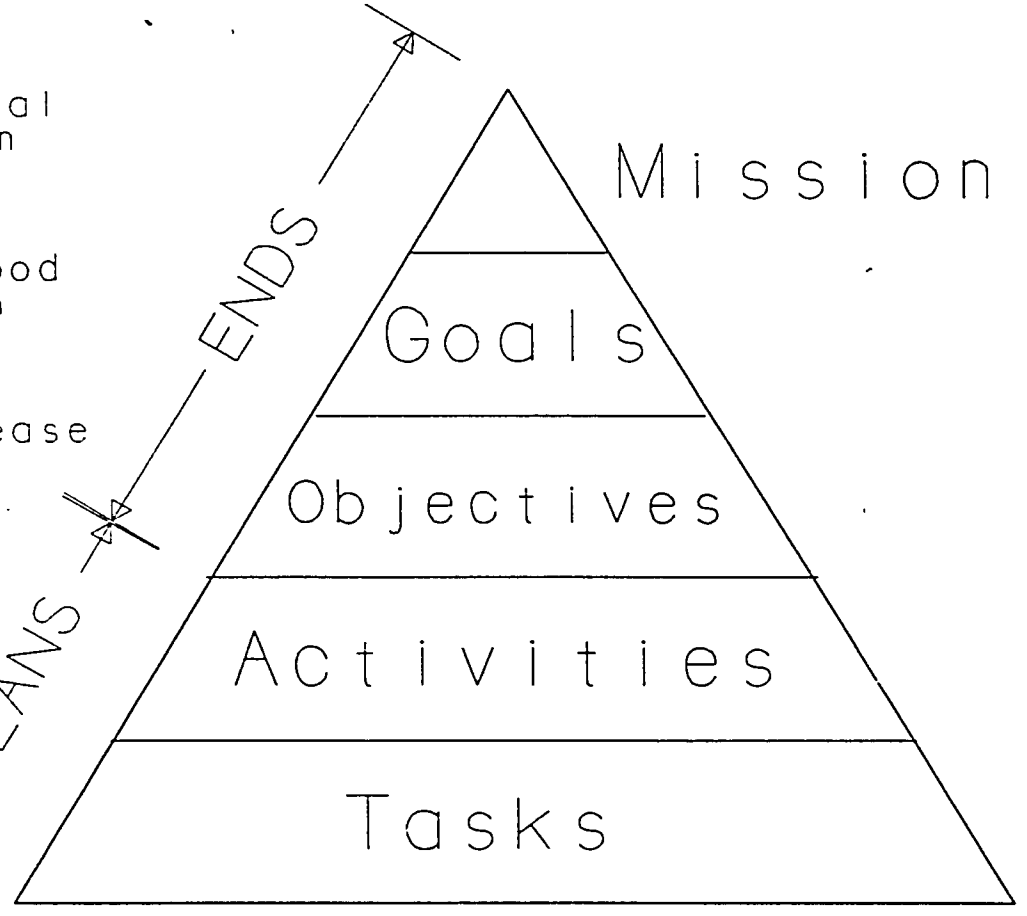
Mission: To Aid Rural People of Afghanistan

Goal: To improve food Production in North Malestan

Objective: To increase irrigated land by 9.700 jeribs by Dec.

Activity: To clean 7 Canals

Tasks:
- Tp Purchase tools
- To Pay Labor
- To Check Work



Adapted From: Grigg. 1985

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III. THE PROJECT MANAGEMENT CYCLE

A. Introduction

While a particular project may have a beginning and an end, the project management of the on-going program is often cyclical. A simplified program management cycle follows:

1. **Assessment of the Situation**
   - Gathering Initial Information
   - Making some initial Assessments

2. **Develop Policies**
   - Set Priorities

3. **Develop Strategies**
   - List Strategies
   - Analyze Alternative
   - Select Appropriate Strategies

4. **Plans of Action (i.e. Proposed Project)**
   - Allocating Resources
   - Developing Work Plan
   - Budgeting

5. **Implementation**
   - Directing
   - Supervising
   - Monitoring

6. **Evaluation**
   - Measurement of Achievement
   - Comparison with Objectives
   - Judge as to Extent Satisfied

(Adapted from UNDP, 1990)

B. Case Study/Step by Step Description of the Project Management Cycle

1. Assessment of Situation (Data Collection May be Required)

a. Summary: When the PVO first decides to work in a project area, it must do a preliminary assessment of the situation. It might do some of the following tasks:

i.) Talk with knowledgeable people from the proposed project area.
ii.) Consult the ACBAR/SWABAC database to find out if other PVOs are working in the project area.
iii.) Meet with the other PVOs working in the project area to discuss the political, technical problems etc. in the project area, and coordinate efforts.
iv.) Develop a problem pyramid based on this assessment.
v.) Send a survey team to gather technical and other necessary data on the project area.

b. Case Study: How does a PVO begin a project? People from the north part of Malestan, Ghazni approach a PVO, the Rural Irrigation Program (RIP), about beginning a project in their area. The people claim to represent an area of Malestan where no organization is currently working. RIP consults the ACBAR/SWABAC database to figure out which other PVOs are working in Malestan and what kind of projects they are implementing. RIP meets with the PVOs operating in Malestan to discuss coordination. The other groups agree that there is a need for a project in the north of Malestan, and suggest some possible projects and people to talk to.

RIP meets with some of these influential people from Malestan. Together RIP and these people develop a problem pyramid that shows shortage of irrigation water, low yields, inability to earn cash income and other needs. RIP and the people from Malestan identify some canal repair projects.

RIP sends some surveyors to look at the proposed projects and assess the local environment. The surveyors explain RIP's proposed activities to the people from the area. They make an effort to discuss the project with village elders, commanders, religious leaders and any other influential people. The surveyors say RIP would like to help people from Malestan, but that RIP's surveying is not a promise that the canals will be repaired. They emphasize that RIP and the community will be partners in implementing the project.

2. Develop Policies

a. Summary: Based on the problems identified in the initial assessment, the PVO in consultation with the people from the area might do the following:

i.) Develop an initial working policy. For example, the group might decide that the best way to work is at the village level, with a shura of commanders and tribal authorities helping the PVO to select needy villages.
ii.) Decide to work toward a certain long-term goal (e.g. rehabilitating the irrigation systems in an area).
iii.) Determine how long a commitment the PVO can make to an area (i.e. is the PVO finished when half the irrigation systems are repaired? Does it stay on longer and try to develop the agricultural productivity further?).
iv.) Decide to only hire people from the area to work on the project.

b. Case Study: How will RIP organize its projects in the area? Now that RIP and the local people have identified some needs and have some data, how will they begin to organize the projects? First they must develop a series of policies.

The group that initially approached RIP appears to represent all but one of the tribes in the area and is affiliated with three major parties operating in the proposed project area. RIP suggests to the group that this tribe be included in their group to avoid future tribal tension in the area that might endanger the success of projects. The group decides to call itself "the Shura of North Malestan" (SNM).

This shura has little technical or organizational skills, so RIP envisions that the primary roles of the shura will be to provide security. It may also help RIP select projects and identify beneficiaries.

RIP decides to commit to employing a small field staff composed of competent people available in the area. RIP will also have one educated agricultural specialist sent from the RIP office in Peshawar.

RIP decides that its long-term goals in the area will be to restore irrigation and cereal crop production to pre-war levels. It makes known to the SNM that RIP will expect to work in the area only about 1-3 years, and that RIP will expect increasingly more community contribution as the area begins to be rehabilitated.

3. Develop Strategies

a. Summary: Once PVOs, in consultation with local authorities, have determined their policies and long-term goals, they can develop strategies for achieving their goals. The PVO might do some of the following:

i.) Develop priorities for an irrigation system repair project. They might do the following:
- Select the largest irrigation systems as first priority. The PVO might decide that repair of these systems will bring enough food to the area to support a returning population.
- Select the irrigation systems with the best, most justifiable data.
- Select the irrigation systems that will irrigate the most amount of additional land with the least amount of money.
- Select the most damaged irrigation systems to be repaired because local people will be less able to repair these systems.

ii.) Develop strategies for diversifying agriculture. The PVO might do the following:
- Encourage kitchen gardens and introduce new kinds of vegetables.
- Begin a poultry raising project emphasizing both egg production and meat production to increase protein consumption.
- Introduce an animal health program.
- Introduce improved varieties of fruit trees.
- Provide bees to small farmers at a subsidized rate.

iii.) Develop strategies for getting improved seed and fertilizer to farmers. The PVO might do the following:
- Begin with demonstration plots to show the farmers how to cultivate new varieties of seed. Associated with the demonstration plots agriculturalists might multiply small amounts of promising seed varieties for use in coming years.
- Distribute seed/fertilizer to farmers with larger holdings for multiplication. These farmers may be in a position to produce good-quality seed for the area.
- Sell improved seed and fertilizer at drastically subsidized prices the first year, and increasingly reduce subsidies as the area becomes rehabilitated, and farmers are able to pay full price.

iv.) Develop strategies for implementing irrigation system repair/construction projects that might include the following:
- Paying fixed amount reimbursement (FAR), an agreed-upon price for a fixed piece of work. Lump sums will be paid in installments as each phase of work is complete. This policy may work for karez and canal repair where the local people need no technical guidance.
- Paying fixed rates for certain kinds of work. For example, a karez project may require cleaning and digging in several kinds of soil. The PVO may not be able to predict accurately the work required, but it may be able to establish rates for certain kinds of work with the karez kans. The PVO's representative may then examine the work later and pay for what the karez kans have actually done.
- Paying daily labor wages. Paying daily labor wages may be most appropriate when building structures that require some oversight by field staff. Many people feel that paying daily labor wages for work not requiring supervision encourages low productivity.

b. Case Study: How will RIP work in the project area? RIP, in consultation with the SNM, decides that it will commit to irrigation system repair in the short-term, working toward diversified agriculture in the long-term. To get the best yields using existing crops the area of irrigated land needs to be increased, so RIP decides to begin with irrigation system repair.

RIP and the SNM select the irrigation systems that will increase the greatest amount of irrigated land with the least amount of money. As the amount of irrigated land increases, RIP will begin working on less cost-effective irrigation systems.

RIP works with village elders and Mir Abs (people in charge of water rights share system) to organize the irrigation repair projects at the village level. Since a traditional system of maintenance is present in the community, the work will require a minimum of supervision by RIP staff.

RIP expects that supervisory staff should only need to visit each project once a week. RIP and the SNM decide that the supervisory staff will pay based on completed work, rather than daily labor wages, because supervisors will not visit the project site daily.

RIP and the Mir Abs agree that RIP will pay for completed work (i.e. payment per linear meter of irrigation system cleaned). The Mir Ab will then be responsible for organizing and paying labor.

4. Develop a Plan of Action (usually described in a proposal)

a. Summary: Usually for RAP, the plan of action is the proposal. The PVO will consider its initial assessment, policies and strategies in designing a project (i.e. steps 1-3) and describe the project in a proposal sent to a donor. The plan of action at minimum will include the following:

i.) A quantifiable objective stating exactly what the PVO hopes to accomplish.
ii.) Description of the activities needed to accomplish the objective. It may need to consider details such as developing appropriate administrative forms, etc.
iii.) A list of the inputs necessary to support the activities (e.g. personnel, supplies, tools, labor wages, etc.).
iv.) A budget showing the cost of the inputs.
v.) A work plan showing the scheduling of activities.
vi.) Technical details.

b. Case Study: How will the PVO begin the work? RIP decides to approach RAP about an irrigation system repair project in Malestan. RAP says that it will consider a proposal for up to $50,000 for irrigation repair in north Malestan.

RIP prepares a proposal to clean and repair 7 canals in Malestan. The proposal describes the policies and strategies that RIP has developed in the project area, and presents a methodology for repairing these canals. RIP prepares a time line showing the activities and the time required to complete the activities. Throughout proposal development RIP discusses technical and design aspects of the proposal with RAP.

When RIP submits the proposal, RAP comments and describes some potential problems. For example, RIP has estimated that all work will be completed in three months. RIP bases its estimate on engineering calculations of what a man can do in a day. RAP's experience has shown that canal projects such as the one proposed are rarely completed in the time allocated. RAP thinks that this may be because laborers also must attend to other tasks such as harvesting their crops and preparing provisions for the winter. Thus, though the job could be completed in three months, usually it will take six months.

Based on RAP's comments, RIP revises the proposal and resubmits it to RAP.

5. Implementation (Data Collection Required)

a. Summary: After the PVO's project has been approved, it will begin implementing the project according to the description in the proposal. During implementation the PVO may be collecting data at the following times:

i.) **Before Beginning Work.** The PVO may want to check that its data gathered with low-cost, low-effort data are correct before beginning to pay for work. The PVO may then choose to perform a more detailed survey.
ii.) **During Supervision.** The PVO's representative may supervise a project and collect measurements indicating progress.
iii.) **During Monitoring.** Independent monitoring of the project may also collect data on the progress of projects. Analysis of this data might be useful for suggesting changes in implementation procedures, or identify failures of the supervisory staff.
iv.) **During Agriculture Extension Work.** The PVO's agriculturalist may be collecting on-going information on demonstration plots, etc., that will be useful for providing advice to farmers.

b. Case Study: How will the PVO implement the project? After RIP receives notice that RAP has approved its project, they begin briefing field staff on their responsibilities, and preparing administrative forms to be used to document the progress of the canal cleaning. RIP field staff leave for Malestan to begin the first task - distributing tools.

Before beginning the work, RIP engineers re-survey the canals to make sure they have allocated money fairly. They find that some canals will need more work than previously expected, and others will require less.

The Field Officer tries to keep abreast of problems and implement the project as described in the work-plan. Throughout the implementation RIP compares what they said was going to happen with what actually happens. As problems develop field staff and the local people deal with and/or try to solve them.

6. Evaluation (Data Collection Required)

a. Summary: During evaluation PVOs will be expected to determine their achievement. This will mean comparing planned performance as described in the project objective with actual performance. This includes the following:

i.) **Selecting Performance Indicators/Measures of Success.** PVOs will need to determine what measures will show the physical achievement of the project. For example, indicators for additional irrigated land might be the amount of water as well as measured land. An indicator for amount of land planted with improved seed and fertilizer might be seeding rate and total amount of seed and fertilizer made available to the community.

ii.) **Selecting Methods to Measure these Indicators.** The PVO will need to select measurement techniques for their indicators. For example, if an amount of water is an indicator of additional land irrigated, the V-Notch weir may be a method for measuring this indicator.

iii.) **Comparing Achievement With Quantitative Objective.** Using data gathered on the achievement of the project, compare actual achievement with planned achievement as stated in the project objective. For example, perhaps the project objective was to have 2,000 jeribs of land planted with improved seed by December, 1991. An indicator of this would be seeding rate. The project planners expected farmers to plant at a rate of 30 kg/jerib. However, data gathered showed that farmers planted at their traditional seeding rate of 50 kg/jerib. These indicators suggest that only 1,200 jeribs were planted with improved seed and the objective of the project was not achieved.

iv.) **Making Qualitative Assessments of the Situation.** For example, perhaps the quantitative objective for wheat production was achieved, but people do not like the bread from the new wheat variety. This dislike might deter people from growing the wheat in the future.

v.) **Making an Assessment of Project Impact.** For example, one goal of RAP is to increase food availability. The person evaluating the project may want to make a quantitative determination as to how much extra food is available because of their project. This assessment will also require data collection (e.g. crop cuts).

vi.) **Making Recommendations of Ways to Make Future Projects More Effective.** For example, the PVO may determine that its initial survey techniques and costing methods were inaccurate. It might recommend ways of improving on these techniques that will be useful in future projects.

vii.) **Judging the Overall Success of the Project.** PVOs might feel that the project has been successful even if they have not achieved their objective.

b. Case Study: How will the PVO know how well they have done? At completion of the project, RIP compares what they said they would do with what they actually did. Based on this comparison they will draw conclusions about ways to improve future projects.

RIP's objective in the project had been to irrigate 9,700 more jeribs of land by April, 1992. RIP's engineers feel that they will be unable to physically measure all this area, so they select 20 indicator farms along the length of the canal.

The engineers have measured the amount of land irrigated on these farms before the project began by pacing the areas. They also measure the amount of water each farmer receives using a V-Notch Weir. Using this measure, RIP's engineer's determine how much water will irrigate how much land. They find that these 20 farms get 5% of the total water in the canal, so they assume that these farms include 5% of the total land irrigated by that canal.

At the conclusion of the project, RIP's field staff collect data on areas irrigated and flow rates on these 20 farms using these same methods. They use this data to determine the total amount of land irrigated.

RIP's field staff's data show that 6,375 more jeribs of land are irrigated in June, 1992 when the work is finished. RIP determines that it has not achieved its objective for the following reasons:

i.) **Flaws in project design.** In some cases, RIP has paid the Mir Abs and village elders when they claim work is finished, with RIP verifying after payment. On inspection RIP found that the work often was not satisfactory. RIP and the Mir Abs agree that this was a problem and that in the future all work must be verified before payment.

ii.) **Selection of the wrong person as Mir Ab in one village.** The local people considered one Mir Ab untrustworthy, so the people did not work effectively. RIP and the SNM decide that in the future they must be more careful in selecting someone to be the Mir Ab.

iii.) **Data were inaccurate.** RIP relied heavily on verbal data on areas irrigated when gathering baseline data for the proposal. The baseline data collected at the beginning of the project using simple measurement techniques shows that the proposal data were inaccurate. In the future RIP will rely on simple measurement techniques to collect baseline data. With an established field office, this should be no problem.

iv.) **RIP underestimated the time required to do certain tasks.** RIP found that it usually took longer for people to do the work than they expected. For this reason, future canal repair projects will include extra time for implementation.

C. Concluding Statement

The above-described project management cycle is generalized. In reality the situation is more complicated. For example, RAP will expect PVOs to do some survey for future projects (step 1) while they are implementing a current project (step 5). The above description is only meant to show general processes.

IV. PROPOSAL STAGE DATA COLLECTION DILEMMA

PVOs are caught in a dilemma when collecting data for a proposal. Donors such as RAP request that PVOs submit data that will justify the PVO's request for money. Obviously, RAP wants this data to be as accurate as possible. However, surveys to collect data for proposals often raise the expectations of the people being surveyed. This problem has been particularly apparent in Paktika (Paktika Task Force Report, 1989). The more detailed the survey, the more people will expect that the work will actually take place.
In areas where PVOs have established programs, RAP will expect them to gather accurate data to support their proposal. Since RAP generously supports operational costs, RAP expects groups with an on-going project to be able to gather data for a forthcoming project while implementing a current project.

RAP suggests that PVOs follow these guidelines when gathering data for a proposal in a new project area:

A.) Before considering a project area, determine if other PVOs are currently addressing the needs of the area. They might consult the **ACBAR/SWABAC Database** before deciding to work in an area. RAP rarely funds projects in areas where other PVOs have established projects.

B.) Before beginning a survey, submit a one-page description of the proposed project to RAP. The description should include the following:

1.) Project Location

2.) A brief description of the problem to be addressed.

3.) Qualitative objectives and activities.

4.) Expected implementing partners.

Based on this preliminary information, RAP will tell the PVO if it will consider a proposal for the proposed project.

C.) Rely on quick, low technology methods to collect data at the proposal stage.

PART 3 - GENERAL DATA COLLECTION GUIDELINES

I. DATA COLLECTED VERBALLY

Sometimes, PVOs must collect data by questioning local authorities. Unfortunately, often these authorities may exaggerate or underestimate numbers if they see some potential benefit in doing so. People relying on verbally-acquired data had the following recommendations about collecting data:

A.) Do not try to collect quantitative data from people who do not have a quantitative answer. For example, most farmers know how much land they own, but they may not know exactly how long their canal is.

B.) Use group discussions to prevent people from exaggerating. If people in a village are competing for the same help (e.g. a village with two karezes, or many farmers wanting improved seed), people will prevent their neighbors from exaggerating so that they get their fair share.

C.) The person asking the questions should have some credibility for the people being questioned. Usually this means that the surveyor/monitor should:

1.) Be known through political/tribal affiliations.

2.) Be old enough to be respected (usually at least 30 years old).

3.) Be qualified enough in the eyes of the community to conduct the survey.

D.) The surveyor/monitor should identify people in the community likely to give the correct answer to questions. For example, the Mir Ab will know the water rights share system and the amount of irrigated land. The village Malik will know the population of a village. Sometimes a combination of important people is necessary to obtain the correct answer to a question.

E.) The questioning should be done in a way that is respectful to the person being questioned. Mr. Abdul Naik of the Agricultural Survey of Afghanistan (ASA) suggests that the surveyor/monitor meet farmers in the evening when they have more time to spend with the surveyor/monitor.

F.) The surveyor/monitor should ask the questions in terms that the farmer understands. For example, in western Afghanistan some farmers use the land measurement of juft-gow (ERCON, 1974). These farmers may not know the unit "jerib," though they may provide an answer just to appear helpful.

G.) The surveyor/monitor should ask several questions to check that the farmer is not exaggerating or underestimating. For example, to determine the amount of land a farmer owns, the surveyor/monitor may ask the following questions:

1.) How much wheat seed do you sow in a year?

2.) How much irrigation time do you have on this karez/canal?

3.) How long does it take to plow your land?

4.) What yield do you usually get in a year?

5.) Do you sow all your land every year? (Lets surveyor know what portion of total land-holdings is used.)

6.) Do you usually buy or sell wheat? (Suggests to the surveyor if the farmer is wealthy or poor.)

7.) How many draught animals do you have? (A farmer must have enough draught animals to work all the land he claims to own.)

These questions can be used to determine the approximate area irrigated. Surveyors/monitors will have to compare these numbers with reasonable local values. For example, if a farmer in Ghazni says that he sows 200 kg of wheat seed in a year, the surveyor/monitor may guess that the farmer has 4 jeribs of land assuming a seeding rate for local seed of 50 kg/jerib.

The surveyor can cross-check this answer by determining how much time the farmer has on this karez/canal. The local Mir Ab has told the surveyor/monitor that in this area that one hour of water from this karez irrigates about one jerib of land. The farmer may claim to have five hours of irrigation time.

The surveyor/monitor can then determine that the farmer has between 4 and 5 jeribs of land. The surveyor/monitor then asks "how much land do you own?"

H.) The surveyor/monitor should not accept unreasonable answers from the people. If the surveyor/monitor is familiar with the area, he will know what a reasonable value will be for land holdings, area irrigated, etc.. Surveyor/monitors should not write down values that don't seem reasonable just because the local people are claiming that this value is correct.

II. MEASUREMENT

While PVOs may rely on verbally-acquired data at times, most data submitted to RAP should be based on measurement. As mentioned previously, PVOs may use relatively accurate, low-technology measurement techniques at the proposal stage. During monitoring and evaluation, the PVOs will be expected to collect more accurate information. They may use the following guidelines:

A.) **Determine how much time it is willing to spend collecting any one piece of information.** The PVO should then select the most accurate technique available to get this information in this amount of time.

B.) **Develop a Quality Assurance program.** Quality Assurance may be done in the following manner:

1.) Use more accurate measurement techniques on a few of the locations being measured. This will allow PVOs with limited number of staff able to use more high-tech methods to use those staff more efficiently.

2.) Appoint a Quality Assurance team that will spot check work done by less capable staff.

C.) **Train surveyors/monitors to use several techniques of varying technical complexity.** If all else fails, a surveyor/monitor should be able to use pacing to measure distance and counting to determine time.

D.) **Rely on locally-available measurement techniques.** For example, Afghanistan has a long tradition of measurement by pacing. In parts of Afghanistan traditional land surveys were done by pacing. In addition, rural people in many parts of Afghanistan use Tanab Gir, a measurement technique using a rope, to survey lands. Organizations can employ people who use these techniques.

In collecting data, surveyors/monitors should consider the difference between accuracy and precision. Accuracy is simply whether a measurement is correct. Precision is the degree of correctness. For example, by pacing, a surveyor/monitor can determine that a certain field is about 100 meters long. Using a measuring tape the surveyor/monitor may find that the field is actually 93.6 meters long. Both pacing and measuring tape are accurate. However, the measuring tape is more precise.

Surveyor/monitors should not sacrifice accuracy because they cannot be precise. It is better for the surveyor/monitor to obtain a measurement using pacing than not to measure because he does not have a measuring tape.

Surveyor/monitors should not ascribe a degree of precision to a technique that is less precise. For example, if the surveyor takes 98 paces, and he knows his pace is about 1 meter, he should not say that the field is 98 meters long as this suggests a degree of precision inappropriate to pacing. He should say that the field is 100 meters long.

III. WEIGHTS AND MEASURES

The weights and measures systems used in Afghanistan are extremely variable. Sometimes, the same word can be interpreted to mean a different measure in a different part of the country. For example, in Kandahar the word "seer" sometimes means a plate-sized amount. In Kabul, the word "seer" means a measure equal to about seven Kg.

In other cases, people will not be familiar with terms used. For example, RAP requires that PVOs submit area data in "jeribs." A jerib is an area of land 44 m x 44 m (1,936 m^2). RAP has approximated 1 jerib as 2,000 sq.m. of land. Though "jerib" is an Afghan term, some rural Afghans will not use this measure. Other measures of land include the following:

A.) **"Juft Gow"** - A "juft gow" is the amount of land that a team of oxen can plow in a day.
B.) **"Tukham-Rez"** - The amount of land that a certain quantity of wheat seed can plant. For example, "Mon," a term used in Oruzgon, is the amount of land that can be planted with a "mon" of wheat (i.e., 49 kg. of wheat). Farmers might also measure the area of their land in "seer" or "kilo."
C.) **"Shabana-Ruz"** - The amount of land irrigated in one day/night cycle of an irrigation system.
D.) **"Paikal"** - A measure of land used in northern Afghanistan.

PVOs must figure out how the weights and measures system in their project area corresponds to a western weight and measure system (i.e., kilograms, meters and liters). Even the term "jerib," though understood by many people, may not correspond to 2,000 sq.m. of land.

PART 4 - MEASUREMENT TECHNIQUES

I. LINEAR MEASUREMENT

A. Introduction

Length is a primary consideration in karez and canal repair. Longer karezes and canals tend to require a greater total volume of cleaning, so they cost more. Surveyors should keep in mind that the actual length between two shafts in a karez is longer than the surface length, because the tunnel will curve to avoid large stones and other obstacles. One study has indicated that the actual distance between any two wells is 1.1 to 1.6 times the surface distance (World Vision, 1989).

Surface length can be determined in several ways in increasing level of difficulty as follows:

B. Determining Length by Pacing.

Afghanistan has a long tradition of measuring by pacing. In some areas, initial land surveys were done by pacing.

Approximate Time: One hour (3 km karez)

Precision: +/- 11% (compared to measuring wheel)

Requirements: Pacing (measured step), hand counter. The surveyor/monitor should have tested his pacing over a known length to determine his stride length.

Methodology:

a.) Walk between the wells counting the number of paces.

b.) Mark down the number of paces between each two wells.

c.) Add up the total number of steps and multiply by the surveyor/monitor's stride length.

Difficulties:

a.) Surveyor/monitors may lose count. In such cases a hand-held counter is useful. Otherwise, surveyor/monitors can use prayer beads, a knotted string or some other device to keep count.

b.) The land might not be flat enough for accurate pacing. Surveyor/monitors should calibrate their pace on a variety of terrains.

C. Determining Length Using a Wheel

Approximate time: One hour (3 km. karez)

Requirements: A measuring wheel, bicycle tire or tractor tire. A measuring wheel is the easiest to use. The tractor tire is fastest.

Methodology:

a.) Make a mark on the bicycle or tractor tire.

b.) Drive or walk the distance of the karez, counting the number of times the wheel goes around (obviously the measuring wheel counts by itself).

c.) Measure the radius of the bicycle or tractor tire.

d.) Multiply the radius by 2Pi (i.e. 6.28) to get the length of one rotation. For some common wheels these are as follows:

28 inch bicycle tire - 2.23 meters (or about 2.25 meters) per rotation

Massey Ferguson 240 rear tire - 4.7 meters per rotation

e.) Multiply the number of times the tractor tire or bicycle tire turned by the length of one rotation to get total length.

Difficulties:

a.) Tractor tires may be a little deflated which will throw off measurements. The surveyor/monitor might consider marking the tire and driving it several rotations and then measuring to make sure the length of one rotation is correct.

b.) Tractors may not be able to drive the length of the karez because of changes in topography or the presence of obstructions.

D. Tanab Gir/Jerib Kash to Determine Length

Tanab Gir is a traditional method of surveying using a rope. People in the community have been trained in this technique. Rural Afghans often use this method to divide land inheritance.

Approximate Time: 1 day for 20 km canal

Precision: Precise as tape

Requirements: A trained Tanab Gir and a rope.

Methodology:

a.) Employ two Tanab Girs

b.) Instruct them to Survey the length of the Canal.

Difficulties:

a.) People may view the Tanab Gir with the same suspicion as a person with a transit. To avoid this, the organization might hire Tanab Gir from the area.

E. Stadia

Stadia is an engineering survey method used to measure lengths based on the difference between marks on the survey (stadia) rod as viewed through the level or transit. It is a quick, easy method accurate to +/- 10% to be used by trained surveyors.

F. Determining Average Spacing of Wells on a Karez and Multiplying by the Number of Wells

Approximate time: 10-15 minutes (for 3 km. karez)

Requirements: Measuring Tape/Pacing, (binoculars optional).

Methodology:

a.) Measure the Distances between three sets of wells.

b.) Calculate the average spacing by adding the three distances together and dividing by three.

c.) Count the total number of wells visible.

d.) Multiply the total number of wells by the average spacing to find the total length.

Difficulties:

a.) If a shaft is dug in a wash, the stream may wash away the pile of soil so that the well location is no longer be visible. In this case, the actual length will change.

b.) Distant wells may not be visible from the location where the surveyor is standing. Obviously, if the surveyor is unable to see all the wells, he will be unable to accurately calculate the length of the karez.

RAP considers this average spacing method to be the absolute minimum survey that a PVO can do to justify a proposal. They should use this method only in areas where they do not currently have projects. Because this is an inaccurate method, adequate justification must be provided for using this method. This method is illustrated in Figure 3.

G. Determining distance on topographic maps and sketching in the location.

Approximate Time: 10 minutes +

Precision: variable.

Requirements: 1:100,000 topographic map, map literate surveyor, people with detailed knowledge of the item being measured, a map-literate surveyor, a ruler.

Methodology:

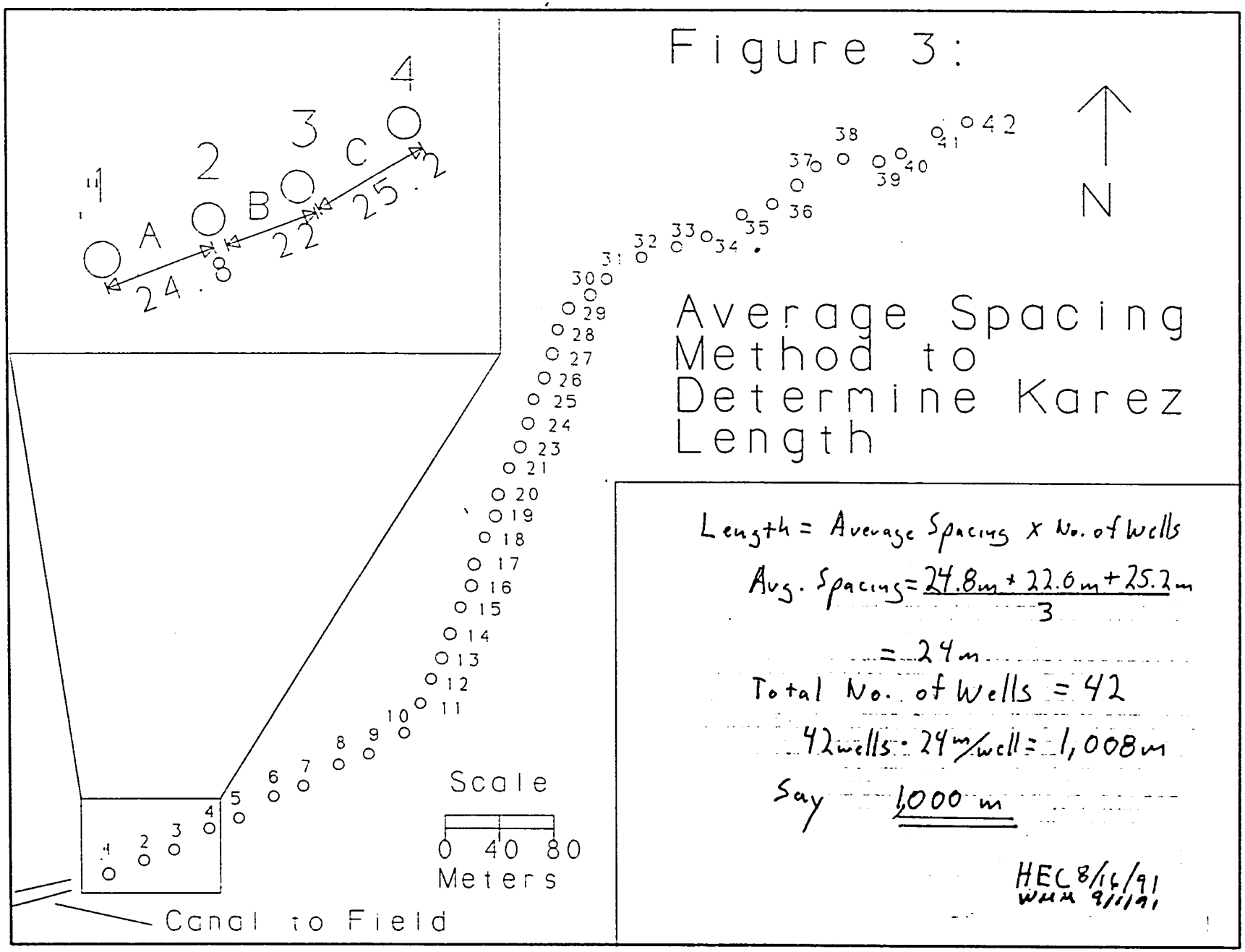
a.) The surveyor/monitor locates himself on the topographic map with some help from a member of the local community (Surveyor/monitors might also try using triangulation [i.e. taking a bearing on 3 well-known geographic points with a compass, and note the location where the 3 lines intersect. This is where the surveyor is standing]).

b.) The surveyor/monitor locates the beginning and end of the distance to be measured based on the topographic features.

c.) The surveyor monitor marks the distance on the topographic map.

d.) The surveyor/monitor measures the distance between the two points with a ruler. With the 1:100,000 scale map, 1cm corresponds to 1 km of actual length. For canals, the surveyor/monitor might want to use a string to follow the path of the canal on the map. The surveyor can then use a ruler to measure the length of the string.

Figure 3:



Average Spacing Method to Determine Karez Length

Length = Average Spacing x No. of Wells

$$\text{Avg. Spacing} = \frac{24.8\,m + 22.0\,m + 25.2\,m}{3}$$

$$= 24\,m$$

Total No. of Wells = 42

42 wells · 24 m/well = 1,008 m

Say 1,000 m

HEC 8/16/91
WMM 9/1/91

Difficulties:

a.) Topographic maps of Afghanistan are often incorrect. Villages and other political features may be located incorrectly. Contours are usually accurate, though a few people have claimed that contours, too, are inaccurate. RAP suggests that surveyors locate themselves relative to these geographic features. Surveyors may think, "I'm in the village and the mountain isn't in the correct place." When actually, the mountain is in the correct place on the map, but the village is not.

b.) Villagers may consciously or unconsciously mislead surveyors/monitors.

II. DETERMINING AREAS

A. Introduction

Area is perhaps the single, most important, measurable, indicator of the impact of a RAP project. As stated in the **Rural Assistance Program Manual**, "....achievement of these objectives (RAP's objective to increase food production) will be measured in such terms as the <u>increased area under irrigation</u>, the <u>increased area under cultivation</u>, the <u>increased area planted with improved seeds and utilizing fertilizer</u>..." Clearly PVOs should develop ways to accurately determine area.

For the most part, surveyor/monitors will need to collect baseline data on areas irrigated/planted with seed and fertilizer etc. in order to determine impact. For comparative data to be useful, baseline data should be collected using the same method as will be used in evaluation.

Determining areas in Afghanistan is a particularly difficult process for the following reasons:

1.) People are suspicious of outsiders wanting to know how much land they own because forcible land reform was one reason for beginning Jihad (Sharani, 1984).

2.) Farmers may exaggerate land irrigated to convince a PVO that the irrigation repair is particularly cost-effective.

Simple questioning as to area irrigated often results in inaccurate information (see Table 1).

TABLE 1 COMPARISON OF AREAS
Determined by Verbal and Measurment Methods

Karez #	Verbal Estimate of Area (jeribs)	Area Determined Using Transit (jeribs)
1	120	215
2	500	170
3	250	140
4	50	220
5	60	100
6	250	110
7	200	40
8	250	55
9	50	10
Total	1,730	1,060

Data From Jaji, Paktia, collected by IRC
Rehabilitation Program for Afghanistan (RPA)
Engineer Ahmed Shah Nazir, Chief Engineer

B. Verbally Acquired Data on Areas

RAP suggests that people minimize reliance on verbally-acquired data for determining areas. Surveyor/monitors should use several related questions that will yield answers that can be cross-checked to determine if they are accurate. The following methodology is similar to that used by the Agricultural Survey of Afghanistan (ASA) for determining area irrigated:

Precision: Unknown

Requirements: None

Methodology:

a.) Ask the following questions:

i) How much wheat seed do you sow in a year?

ii) How much irrigation time do you have on this karez/canal?

iii) How long does it take to plow your land?

iv) What yield do you usually get in a year?

v) Do you sow all your land every year? (Lets surveyor know what portion of total land-holdings is used.)

vi) Do you usually buy or sell wheat? (Suggests to the surveyor if the farmer is wealthy or poor enough to have the land holding claimed.)

vii) How many draught animals do you have? (A farmer must have enough draught animals to work all the land he claims to own.)

viii) How much land do you irrigate?

ix) How many jeribs of land do you have (irrigated and rain-fed)?

b.) Ask the same questions to several people along the irrigation system, and average to compensate for the fact that farmers closer to the source of water get more water per hour than those further away.

Difficulties:

a.) Surveyor/monitors must ask several people the same questions to figure out the approximate correct answer.

b.) Sometimes the surveyor/monitor may get answers that do not agree. In such cases, they must trust their instincts and estimate area irrigated.

C. Using a Linear Measurement Technique.

1. Introduction

Surveyor/monitors may choose to use a measurement technique to check the verbally-acquired areas to see if there is a discrepancy (e.g. as illustrated in Table 1). Unfortunately, areas irrigated may be irregularly shaped. So, PVOs may have to approximate the shape of the area and use geometry. This method is useful in areas that are clearly defined and of medium size (e.g. area irrigated by a karez). RAP suggests the following technique:

Requirements: Any of the materials needed for one of the methods described under Linear Measurement (Section I).

Methodology:

a.) Approximate the area as a polygon. Make a sketch.

b.) Divide the polygon into right triangles and rectangles.

c.) Decide which lengths will be needed to calculate areas of these rectangles and triangles (i.e., the following):

Rectangle: Length x Width

Right Triangle: 1/2 Length x Width

d.) Measure the length of each necessary part of the polygon: Use one of the methods described under karez length (i.e. pacing, taping, measuring wheel, Stadia).

e.) Calculate areas by calculating the area of each triangle or rectangle and summing these to get the total area. An example of this method is illustrated in Figure 4.

2. Using a Compass to Determine Angles Accurately

Because error in angle measurement may be a problem, a surveyor/monitor may want to use a compass to measure angles more accurately.

Requirements: Compass

Methodology:

a.) Use the compass to get a bearing on an object in the direct line of measuring. (On the azimuth system this will be a number between 0 and 360).

b.) Record the bearing.

c.) Measure the length to the next corner of the polygon using a linear measurement technique.

d.) At the next corner take a back bearing on the line just measured. (This number should be about 180 degrees different from the original bearing).

e.) Take a bearing on an object in a second line of measuring (i.e. another side of the polygon).

f.) Record the bearing.

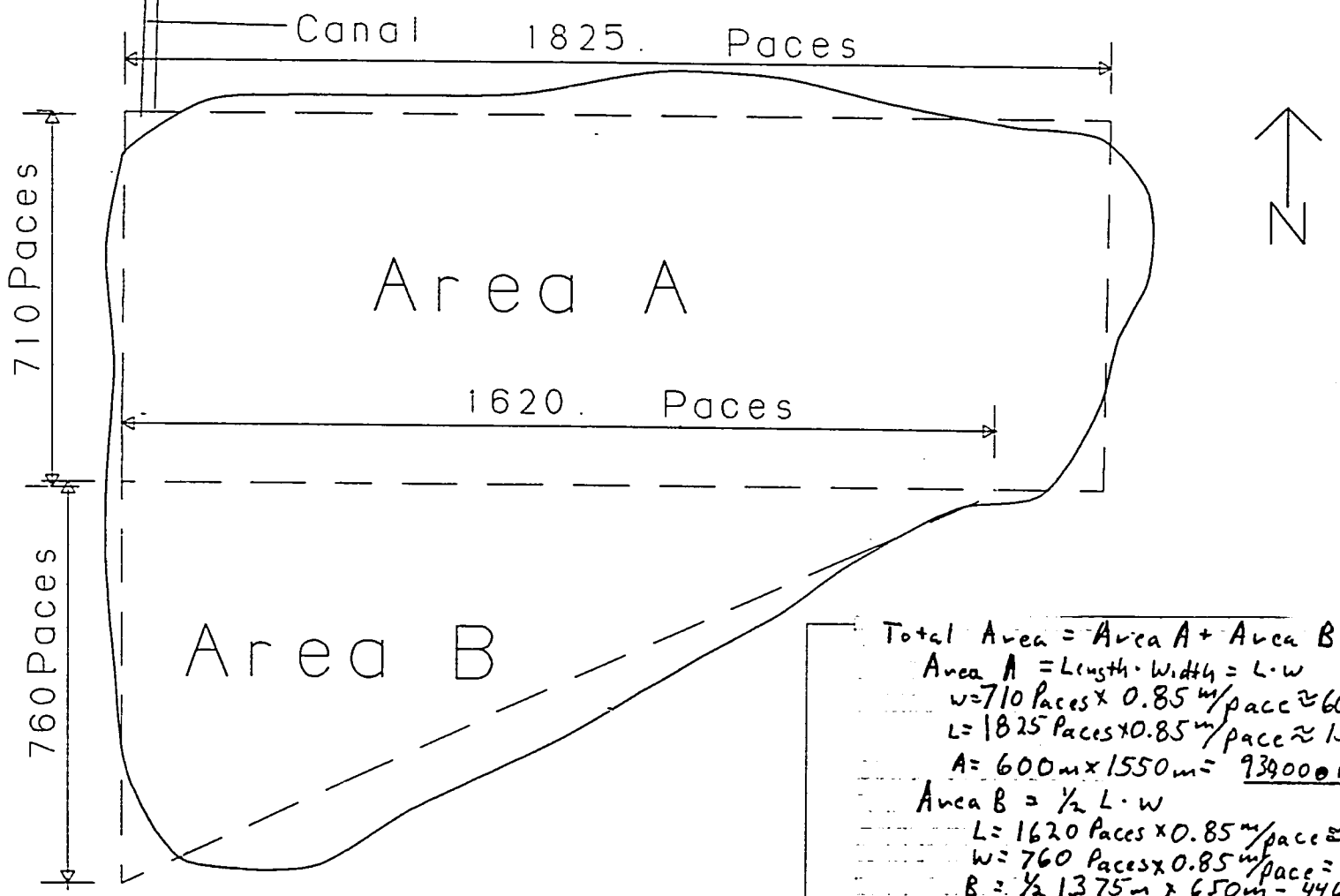
g.) Measure the length to the next corner of the polygon using a linear measurement technique.

h.) The difference between the bearing of the first line of measurement and the second is the angle at that corner of the polygon (i.e. the angle between the two sides of the polygon).

i.) In the office calculate areas by drawing a scale diagram of the field. Measure out an angle, draw a length. If surveyors measured angles and lengths correctly, the polygon will close. The degree to which it does not close reflects, to some degree, the error in the measurement.

j.) Calculate the area using geometry or a planimeter.

Figure 4: Approximating Areas



Total Area = Area A + Area B HEC 8/17/91

Area A = Length · Width = L · W

W = 710 Paces × 0.85 m/pace ≈ 600 m WHM 9/1/91

L = 1825 Paces × 0.85 m/pace ≈ 1550 m

A = 600 m × 1550 m = 930,000 m²

Area B = ½ L · W

L = 1620 Paces × 0.85 m/pace ≈ 1,375 m

W = 760 Paces × 0.85 m/pace = 650 m

B = ½ 1,375 m × 650 m = 446,875 m²

Total Area = 930,000 m² + 446,875 = 1,376,875 m²

Devide by 2,000 m²/Sesib = 688 sesib ≈ 700 J.

3. Using Geometry to Calculate Areas of Triangles in Which Angles are Not Known

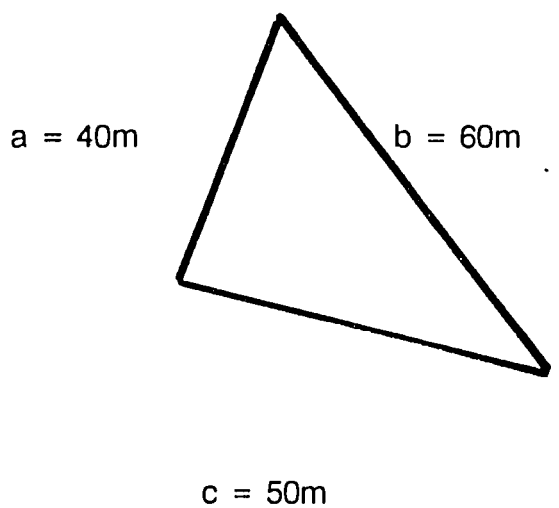
Often, fields will be irregularly shaped, and surveyor/monitors will find that they cannot approximate the area with right triangles and rectangles. In such cases, the surveyor/monitor may approximate the area as a non-right triangle. The area of this triangle can be calculated using the following equation if lengths of all sides are known.

$$\text{Area} = \sqrt{S \times (S-a) \times (S-b) \times (S-c)}$$

where: a, b and c are the lengths of the sides of the triangle.

$$S = \frac{a + b + c}{2}$$

The following is an example:



$$S = \frac{40m + 60m + 50m}{2} = 75m$$

$$\text{Area} = \sqrt{75m \times (75m-40m) \times (75m-60m) \times (75m-50m)}$$

$$= 992\ m^2$$

D. Using Topographic Maps to Find Area

As discussed in the linear measurement section, topographic maps can be useful in measurement. This is particularly true of measurement of larger areas such as the total command area under a canal. Surveyor/monitors may find it useful to enlarge maps to a larger scale. The following is a suggested methodology:

Requirements: 1:1,000,000 scale topographic map, map literate surveyor, compass, measuring wheel etc. optional.

Methodology:

a.) Surveyor/monitor locates himself on the map using geographic features. (Because locations of villages etc. may not be located correctly on the map, it is not advisable for the surveyor/monitor to locate themselves in relation to villages etc.)

b.) Surveyor/monitor locates the boundaries of the area to be measured by finding topographic features shown on the map and locating the boundary relative to those geographic features. The surveyor may choose to use a compass or linear measurement tool (such as a measuring wheel) to locate these boundaries more precisely.

c.) Find the area by using a planimeter; or by dividing the area sketched into polygons, calculating the are of the polygons and summing up the total.

E. Using a Transit/Plane Table to Determine Area

Using a transit or plane table the surveyor can get an accurate estimate of the area irrigated. Plane table survey is more appropriate for smaller areas (e.g. areas irrigated by karezes) while transit survey might be more appropriate for larger areas (e.g. areas irrigated by canals). PVOs should realize, however, that technical survey equipment may remind people of the land reform efforts during the time of Taraki. The local community might be hostile to people carrying a transit. Surveyors can follow methods described in Surveying (DCAE, 1989).

F. Estimating Area Irrigated Based on Water Flow

In some areas, geographic boundaries are not apparent. For example, some fields may have multiple irrigation sources, so it may be difficult to measure area irrigated by any one source. In this case, it may be advisable to estimate area irrigated based on flow of water.

PVOs can establish an approximate relationship between area irrigated and amount of irrigated land. A general rule is that wheat in Afghanistan needs about 1 liter/second per hectare of land (0.2 l/s per jerib). However, Anderson (1990) has estimated that given the present conditions of canals in Kunar Province, Afghanistan, 3.1 l/s per hectare of land may be required. This value assumes some losses and that farmers do not irrigate in the evening.

The amount of land irrigated per l/s of water will be dependent on soil types, crop types, climate, agricultural practices and other considerations. While this value of 3.1 l/s per hectare is only meant to apply to Kunar, people should be able to find a value somewhere between 1 l/s per hectare and 3.1 l/s per hectare that is applicable to their field area.

This method is very simple and will provide a comparative check on areas determined using other methods. RAP highly encourages PVOs to compare amount of flow with area irrigated.

People should understand that flow varies seasonally. But, by establishing actual water use at a given time at several locations (i.e. water used and total irrigated land planted), this effect can be minimized. This total irrigated land will not vary seasonally, thereby providing a constant for comparing water flow at a given time with total irrigated land.

III. DETERMINING SOIL TYPES

A. Introduction

Surveyors/monitors should be able to assess whether the soils will be more difficult to work. Rocky or hard clay soil is difficult to excavate. In general, surveyor/monitors should consider the following:

1.) Sand or gravel will be more difficult to excavate because the sides of the excavation are more likely to collapse back into the excavation.
2.) Stony soil will be more difficult because cobbles and boulders may be difficult to excavate.
3.) Clayey soils may be more difficult because the cohesive properties of clays tend to keep the soils together and more difficult to excavate. Furthermore, clayey soils are more likely to break along fractures and block the karez.
4.) Mixed soil with some clay content is considered good for karez excavation.

For most engineering applications, engineers will need to know whether soils are coarse or fine grained, and whether the soils have cohesion (also called plasticity).

A common mistake in field classification is to call all fine grained soils "clay." True clay has cohesion/plasticity that effects its engineering properties. For example, the following table shows how clay can be more difficult to erode than sand in some cases:

Channel Material	Critical Velocity for Scour in Clear Water (m/s)
Fine Sand	0.45 m/s
Silt Loam	0.60 m/s
Fine Gravel	0.75 m/s
Stiff Clay	1.2 m/s
Coarse Gravel	1.2 m/s

(Linsley and Franzini, 1987)

B. Soil Classification

Many systems of soil classification exist. Engineers tend to classify soils differently than agronomists because engineers tend to be interested in the soil mechanics properties of soils rather than the plant nurturing ability of the soil (e.g. AASHTO vs. USDA systems of classification [see PCA soil primer, Portland Cement Company, 1956; Fig.1. p.17]).

Much can be judged about the texture of a soil by rubbing it between the thumb and fingers. Usually it is helpful to wet the soil sample to estimate plasticity more accurately. The way a soil "slicks-out" or develops a continuous ribbon when rolled between the thumb and forefinger gives a good idea of the amount of clay present. Furthermore, clayey soil will be sticky when wet and hard when dry.

Sand particles are gritty. Silt particles have the feel of talcum powder or flour, and are only moderately plastic and sticky when wet.

The following is a rough classification of soil particle sizes (in millimeters):

<0.002	0.002	0.08 fine	0.2 medium	0.6 coarse	>2.0
CLAY	SILT		SAND		GRAVEL

(From PCA Soil Primer, Portland Cement Company 1956; Fig. 1; p.17)

RAP suggests using the following rough classification of soils adapted from a representative sample of soil:

1.) If more than half the particles are distinguishable with the naked eye (i.e. sand and gravel particles), the soil is coarse grained, go to step b.

If more than half the particles appear as matrix (i.e. with individual particles indistinguishable with the naked eye), the soil is fine grained, go to step c.

Note: A particle about 0.8 mm in diameter is about the smallest particle distinguishable with the unaided eye (i.e. sand).

2.) For coarse grained soils determine whether half the particles are greater than 6 mm in diameter. If so, the soil is gravel. If not, the soil is sand.

3.) Soils that can be rolled into cylinders 5 mm across without cracking is plastic and contains appreciable concentrations of clay.

(Adapted from OFWM Volume V).

A flow diagram showing these relationships is shown in Figure 5.

IV. MEASURING FLOW

A. Introduction

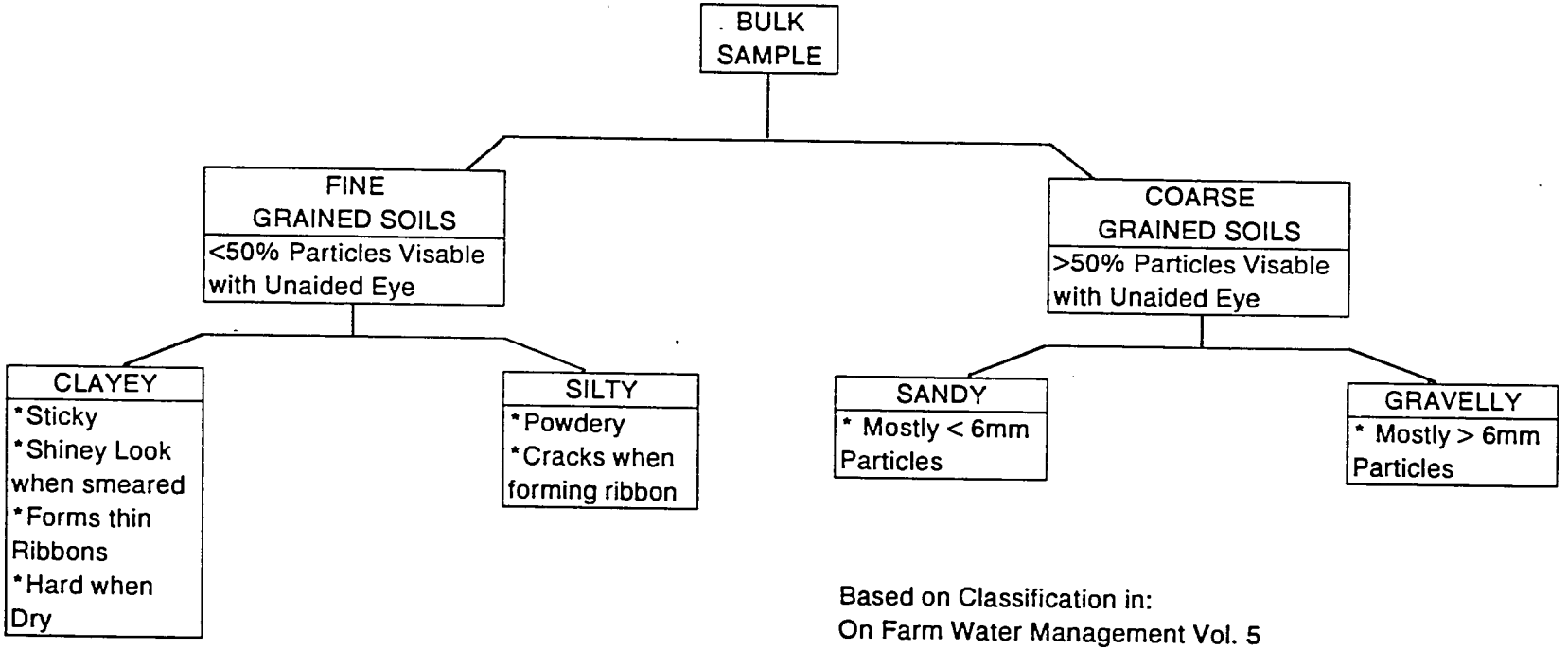
RAP requests that PVOs measure flow. RAP realizes that measuring flow is of questionable value for the following reasons:

1.) Flow changes greatly throughout the season (e.g. see Figure 6). In fact, the flow at any one season may change year to year.

2.) The quality of water courses varies greatly. Some water courses are permeable. Others are impermeable. Some water sources are far from the fields. Others are near the fields. For this reason, the volume of flow at the source of the irrigation system may have little bearing on the water that actually reaches the field.

Still, flow is another indicator of increased irrigation. All other things being equal the amount of water flowing from a karez should increase because people have cleaned it. The following are possible ways of determining flow.

FIGURE 5
FLOW DIAGRAM SHOWING SIMPLE SOIL CLASSIFICATION



Based on Classification in:
On Farm Water Management Vol. 5

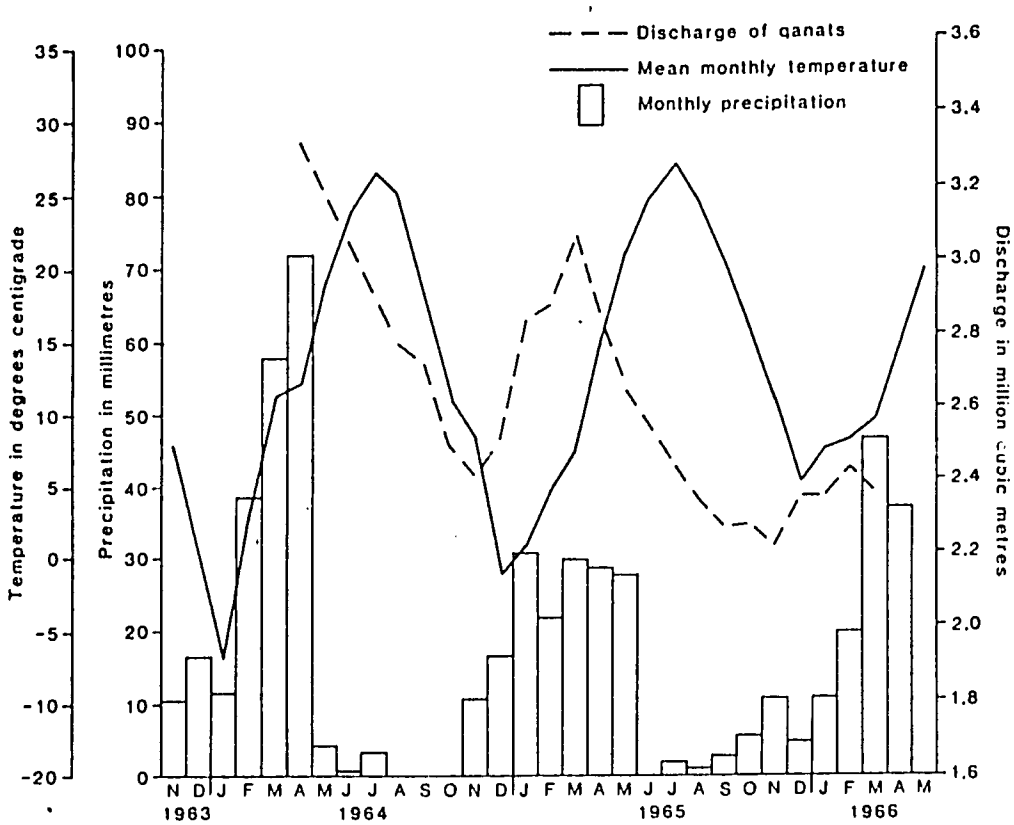


Figure 6: Monthly discharge variations of selected qanats around Mashhad
Source: Beaumont P., 1971

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B. Float Method

Approximate time: 5 Minutes

Requirements: Watch with capability to measure seconds, measuring tape, piece of wood, steel ruler (at least 1 meter long).

Methodology:

a.) Measure the velocity of the flow by doing the following:

i.) Select a section of the canal leading from the karez that is straight with few obstructions.

ii.) Measure off a length of relatively uniform section (e.g. 2 to 10 meters).

iii.) Drop a twig (or other float) in the center of the channel and measure the time it takes for the float to flow from the upstream end of the measured portion to the downstream end.

iv.) Divide the distance by the time to get velocity.

b.) Measure the cross-section of the ditch by doing the following:

i.) Measure the width of the ditch at each end of the measured portion.

ii.) Find the average depth of the flow by measuring the deepest portion of the ditch.

iii.) Calculate the area approximated as a triangle (i.e. 1/2 width x depth).

c.) Calculate flow by multiplying the velocity x area

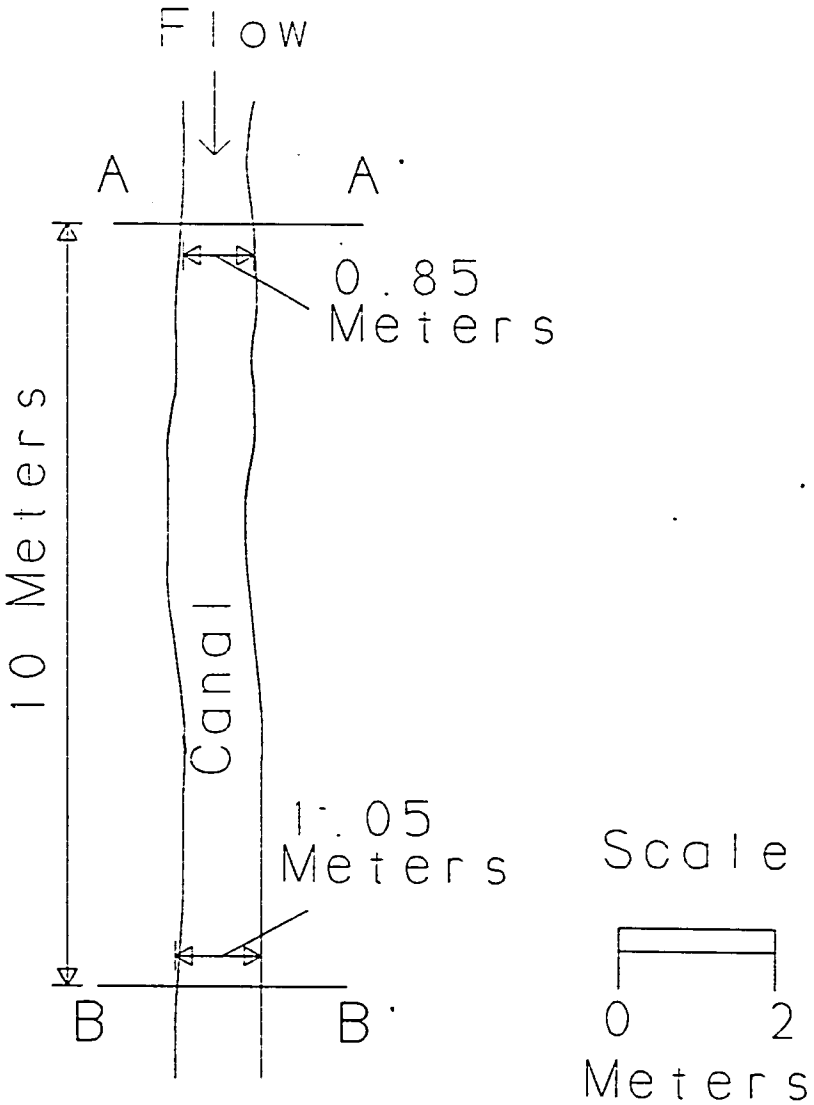
This method is illustrated in Figure 7.

Note: The above method overly-simplifies the actual flow relationships. However, the method underestimates cross-sectional area and overestimates velocity resulting in a reasonable approximation. The method underestimates cross-sectional area by approximating a channel that is more ellipsoidal shaped as a triangle. Furthermore, the velocity measured by the float in the center of the stream is faster than the velocity near the perimeter of the channel where the roughness of the channel slows the flow of water. Mean velocity of a channel is usually taken as 0.8 x surface velocity.

For channels that are nearly rectangular, this method will greatly underestimate flow (because a triangle will be 1/2 of that rectangle). In such cases, RAP suggests that the surveyor/monitor measure the cross-sectional area more accurately.

RAP discourages the use of "average depth" because it is not reproducible. During a recent training RAP found that participants measured similar values for deepest section, but had different values for "average depth." If a surveyor/monitor chooses to figure out the cross-sectional area of a channel more accurately, they should take measurements of depth at known widths (e.g. 20cm deep at 30cm across, 30cm deep at 50cm across).

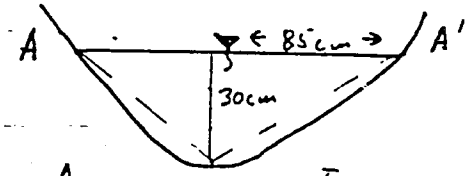
Figure 7: Float Method



HEC 8/31/91
WMM 9/1/91

Flow = Velocity · Area

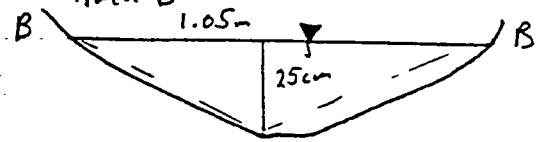
Area A



Approximate as Triangle

$A = \frac{1}{2}\ 0.85m \cdot 0.3m = \underline{0.13m^2}$

Area B



$A = \frac{1}{2}\ 1.05m \cdot 0.25m = 0.13m^2$

Average Area $= \frac{0.13m^2 + 0.13m^2}{2}$

$= \underline{\underline{0.13\ m^2}}$

Velocity

1) 10m in 16sec = 0.63 m/s
2) 10m in 14sec = 0.71 m/s
3 10m in 15sec = 0.67 m/s

Avg = $\underline{0.67\ m/s}$

Flow = $0.67\ m/s \cdot 0.13m^2 = \underline{0.087\ m^3/s}$

$0.087\ m^3/s \times 1{,}000\ l/m^3 = 87\ l/s \Rightarrow \boxed{90\ l/s}$ say

C. Determining Flow using a V-Notch Weir.

A V-Notch Weir is a quick and simple method of calculating flow, but must be done carefully.

Approximate time: 10 minutes

Requirements: V-Notch Weir in 60 or 90 degree openings.

Methodology:

a.) Install V-Notch Weir in the ditch. Seal the sides of the weir with mud and stones so that the flow goes only over the notch in the weir.

b.) Wait several minutes until the flow has stabilized in its movement over the top of the weir.

c.) Measure the height of the water going over the weir. PVOs often find that it is best to mark the height of water on the weir itself, so that they will not have to measure with a ruler or other device.

Calculated flow values for 60 and 90 degree V-Notch Weirs are included in Tables 2 and 3.

Difficulties:

a.) A small error in measurement may make a large error in calculating flow. This problem is more apparent with a 90 degree V-Notch than with a 60 degree V-Notch.

D. Other Methods to Measure Flow

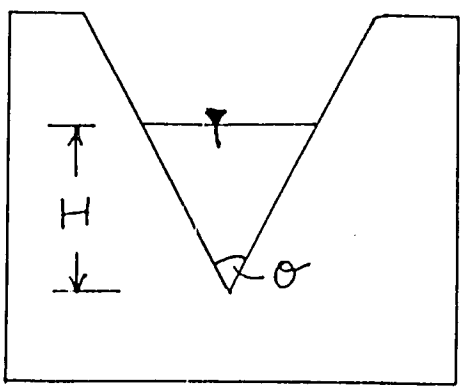
Other methods to measure flow not currently commonly used, that a surveyor/monitor might consider, are as follows:

1.) Syphon Tubes (see OFWM, vol I. pp 256-260).
2.) Submerged Orifice Plates (see OFWM vol I pp. 262-267).
3.) Cut-throat Flume (see OFWM, vol I. pp 273-277).

Table 2 Measurement of Flow using ' Degree V-Notch Weir

Depth cm	Flow l/s	Depth cm	Flow l/s	Depth cm	Flow l/s
0.5	0.00	20.5	14.6	40.5	85.3
1.0	0.01	21.0	15.5	41.0	87.9
1.5	0.02	21.5	16.4	41.5	90.6
2.0	0.04	22.0	17.4	42.0	93.4
2.5	0.08	22.5	18.4	42.5	96.2
3.0	0.12	23.0	19.5	43.0	99.1
3.5	0.18	23.5	20.5	43.5	102.0
4.0	0.25	24.0	21.6	44.0	104.9
4.5	0.33	24.5	22.8	44.5	107.9
5.0	0.43	25.0	24.0	45.0	111.0
5.5	0.54	25.5	25.2	45.5	114.1
6.0	0.68	26.0	26.4	46.0	117.3
6.5	0.83	26.5	27.7	46.5	120.5
7.0	0.99	27.0	29.1	47.0	123.7
7.5	1.2	27.5	30.4	47.5	127.0
8.0	1.4	28.0	31.8	48.0	130.4
8.5	1.6	28.5	33.3	48.5	133.8
9.0	1.9	29.0	34.7	49.0	137.3
9.5	2.1	29.5	36.3	49.5	140.8
10.0	2.4	30.0	40.3	50.0	144.4
10.5	2.7	30.5	42.0		
11.0	3.1	31.0	43.7		
11.5	3.4	31.5	45.5		
12.0	3.8	32.0	47.3		
12.5	4.2	32.5	49.2		
13.0	4.7	33.0	51.1		
13.5	5.1	33.5	53.1		
14.0	5.6	34.0	55.1		
14.5	6.1	34.5	57.1		
15.0	6.7	35.0	59.2		
15.5	7.3	35.5	61.3		
16.0	7.9	36.0	63.5		
16.5	8.5	36.5	65.8		
17.0	9.1	37.0	68.0		
17.5	9.8	37.5	70.4		
18.0	10.5	38.0	72.7		
18.5	11.3	38.5	75.1		
19.0	12.1	39.0	77.6		
19.5	12.9	39.5	80.1		
20.0	13.7	40.0	82.7		

Reference:
Fluid Mechanics
and Hydraulics
by
Ranald V. Giles
p.135, 150



Formula for Triangular Weir

$$Q = (8/15) \times c \times \tan(\theta/2) \times \sqrt{2g} \times H^{5/2}$$

For $H < 30$ cm ($c = 0.563$)

$$Q = 0.767\ H$$

For $H > 30$ cm ($c = 0.60$)

$$Q = 0.817\ H$$

Where:

Q is in m/s

c is a coefficient (experimentally determined)

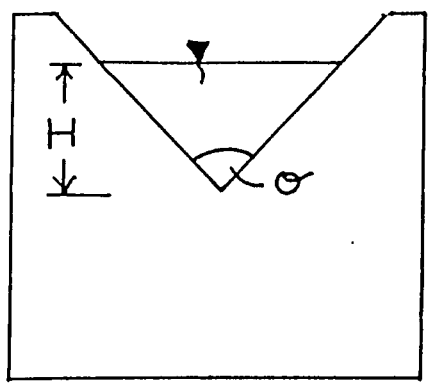
H is head on the weir in meters

g is gravitational force 9.8 m/s

Table 3 Measurement of Flow using 90 Degree V-Notch Weir

Depth cm	Flow l/s	Depth cm	Flow l/s	Depth cm	Flow l/s
0.5	0.00	20.5	25.12	40.5	148.2
1.0	0.01	21.0	26.68	41.0	152.8
1.5	0.04	21.5	28.29	41.5	157.5
2.0	0.07	22.0	29.97	42.0	162.3
2.5	0.13	22.5	31.70	42.5	167.2
3.0	0.21	23.0	33.49	43.0	172.2
3.5	0.30	23.5	35.34	43.5	177.2
4.0	0.42	24.0	37.25	44.0	182.4
4.5	0.57	24.5	39.22	44.5	187.6
5.0	0.74	25.0	41.25	45.0	192.9
5.5	0.94	25.5	43.34	45.5	198.3
6.0	1.16	26.0	45.50	46.0	203.8
6.5	1.42	26.5	47.72	46.5	209.4
7.0	1.71	27.0	50.00	47.0	215.0
7.5	2.03	27.5	52.35	47.5	220.8
8.0	2.39	28.0	54.76	48.0	226.7
8.5	2.78	28.5	57.24	48.5	232.6
9.0	3.21	29.0	59.78	49.0	238.7
9.5	3.67	29.5	62.39	49.5	244.8
10.0	4.17	30.0	70.0	50.0	251.0
10.5	4.72	30.5	73.0		
11.0	5.30	31.0	76.0		
11.5	5.92	31.5	79.1		
12.0	6.58	32.0	82.3		
12.5	7.29	32.5	85.5		
13.0	8.04	33.0	88.8		
13.5	8.84	33.5	92.2		
14.0	9.68	34.0	95.7		
14.5	10.57	34.5	99.3		
15.0	11.50	35.0	102.9		
15.5	12.49	35.5	106.6		
16.0	13.52	36.0	110.4		
16.5	14.60	36.5	114.3		
17.0	15.73	37.0	118.2		
17.5	16.91	37.5	122.3		
18.0	18.14	38.0	126.4		
18.5	19.43	38.5	130.6		
19.0	20.77	39.0	134.9		
19.5	22.16	39.5	139.2		
20.0	23.61	40.0	143.7		

Reference:
Fluid Mechanics
and Hydraulics
by
Ranald V. Giles
p.135, 150



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$$Q = (8/15) \times c \times \tan(\theta/2) \times \sqrt{2g} \times H^{5/2}$$

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$$Q = 0.767\ H$$

For $H > 30$ cm ($c = 0.60$)

$$Q = 0.817\ H$$

Where:

Q is in m/s

c is a coefficient (experimentally determined)

H is head on the weir in meters

g is gravitational force 9.8 m/s

PART 5 - DATA COLLECTION FOR IRRIGATION PROJECTS

I. THE WATER RIGHTS SHARE SYSTEM

In most of rural Afghanistan, land holders have allotted water rights. Every 8 to 12 days, a land holder will receive a share of irrigation water based on his land holdings. This water right is also an obligation. Land holders must supply labor for irrigation system maintenance proportional to their water rights.

The existence of these water rights users groups limits the PVOs' organizational responsibilities for repairing a traditional irrigation system. Usually a person with the title "Mir Ab" will oversee the water rights share system and the maintenance of the irrigation system. Irrigation system repair can be organized through the appropriate water-rights users' group (e.g. karez owners' group).

Usually water rights are given in time increments (e.g. six hours every 12 days). But, land closer to the source of water will receive more water in the same amount of time as land further away. In other words, an hour of irrigation water near the source of the water will irrigate more land than an hour of irrigation near the end of the water distribution system, because of water losses along the water course.

Of course, this system varies greatly throughout Afghanistan. In Herat one study showed that a karez had an irrigation cycle of 8 days rather than 12 days (McLachlan, 1989). Khorassan Assistance Group (KAG) has found that rotation on karezes in Qarabagh, Ghazni Province varies between 5 and 25 days depending on water availability and crop type (KAG, 1991).

In some areas, land may be graded according to agricultural productivity and water application. For example, a Mir Ab in Logar said that on his canal three grades of land existed. The best grade of land gets water every 12 days, the worst grade gets water every 25 days. Each grade had a proportional maintenance obligation for the canal with the best grade of land requiring more labor than the worst grade of land.

Some people have found that farmers will not use the additional irrigation water to irrigate more land, but to irrigate the same land better. Often near the source of the water (e.g. at the offtake of a canal from a river), farmers will have well-irrigated land. However, near the outlet of the canal most of the water will have been used, and farmers at that end of the canal may be able to irrigate only occasionally. So, providing more water to the canal will assure farmers at the end of the canal of getting water more regularly. Under such conditions, while no additional land is irrigated, this additional water will allow farmers at the end of the canal to get better yields.

Areas with much water and little land will put more premium on land and less on water. Areas with much land and little water may be more likely to structure a water-rights share system with some areas receiving water less regularly. In some areas with much land, people will let some land lay fallow every year, cultivating any given piece of land only once every two to three years.

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ERCON (1974) identified two grades of land in the Hari Rud basin of western Afghanistan. The villagers irrigated one part of their land every year and used it for wheat cultivation ("Mahwatte"). Villagers used the second grade of land for other crops, which they cultivated in rotation, with any portion of the land being irrigated every three to four years ("Aishe").

Wheat is the most common cereal crop in Afghanistan, and many water-rights systems cater to wheat requirements. Yet, a farmer may choose to grow another crop with greater water requirements (e.g. maize). In this case, the farmer will use his water right to irrigate less land, or purchase water rights from a farmer who is not cultivating his whole plot.

PVOs should make an effort to understand the water-rights share system applicable in the project area. In addition, they should evaluate the success of their project based on the primary crop and the primary grade of land (usually the 12-day land for wheat). In project design, project planners should make sure that the project will not undermine this water-rights share system.

II. KAREZES

A. Introduction

Currently the largest share of RAP funds go to repair karezes. Pre-War Afghan Government figures suggest that karezes are used in only 7% of rural Afghanistan. Some people estimate that karezes supply irrigation water to approximately 40% of the irrigated land in Afghanistan (RAP has seen no data to support this estimate). McLachlan, (1989), believes that the Afghan Government has systematically under-estimated the number of karezes and amount of land irrigated by karezes. This underestimation may account for the perception that karezes supply 40% of the irrigation water in Afghanistan while Afghan Government figures suggest a much lower number. McLachlan speculates that the primary reason for underestimation is that the Government viewed karezes as a backward technology at a time when Afghanistan was trying to appear more technologically advanced.

In some cases karez irrigation benefits more wealthy land-owners than canal irrigation. For this reason, some people have argued that organizations should not do projects that benefit wealthy karez owners (Report of a UNOCA Paktika Mission in 1989). But, even in ancient times karez owners sometimes needed outside money to repair their karez after a war or period of neglect (Lambton, 1989).

RAP has been able to identify two major karez types as follows:

1.) Karezes located on the Slope of Alluvial Fans (TYPE I). These karezes have the following characteristics:

a.) They tend to have deeper mother wells (e.g. deeper than 20 meters).

b.) They are subject to damage by spring run-off. Temporary streams on the slopes tend to migrate from year to year. The migrating channel may one year erode into a karez shaft sending water cascading down the karez and destroying part of the underlying tunnel.

c.) Karez shafts usually are covered to protect the karez from damage of flooding. Sometimes the local people will put a stone slab at the base of the shaft and back-fill to protect the karez.

2.) Karezes located in Agricultural Lands on a Plain (TYPE II). These karezes have the following characteristics:

a.) They tend to have shallower mother wells (e.g. 20 meters or less).

b.) Shafts may remain open. With a small risk of damage from flooding, people do not need to cover the shafts, though they may.

c.) They are subject to damage from bombing. Because karezes on plains are somewhat shallow, bombing is more likely to damage the karez.

d.) They are more likely to have higher sediment accumulation rates for the following reasons:

i. Irrigation water from overlying agricultural land seeps into the karez bringing with it sediment.
ii. Sediment washes into the open shafts during rain storms.

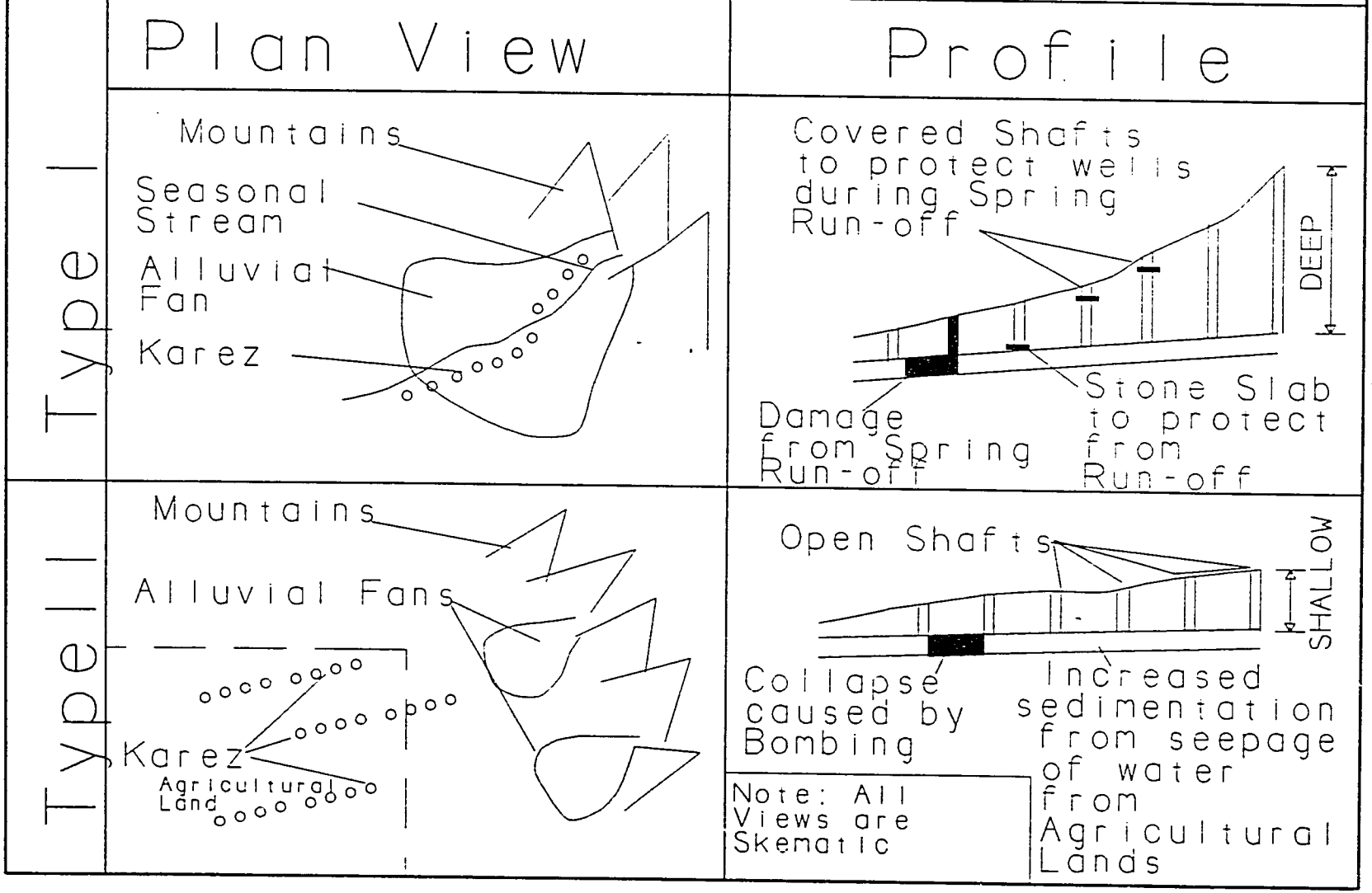
These two types of karezes are illustrated in Figure 8.

Generally, people clean karezes every one or two years with karezes on agricultural lands (TYPE II) requiring more frequent cleaning. Lack of maintenance during the war is perhaps the greatest single reason for karez repair. Karez experts seem to agree that most of the karezes needing repair in Afghanistan need cleaning rather than new digging. Of course, in areas of more bombing, some karez tunnels have collapsed and will require new digging.

RAP favors karez rehabilitation projects in which the community will require some assistance, but that do not require extensive repairs. RAP feels that selecting karezes that will irrigate the most amount of land with the least amount of money will provide the community with the best opportunity to produce its own wealth.

In some areas springs with a covered canal are called "jar karez," "chow," or "chowk." To date, RAP has not funded the repair of many of these structures, so they will not be discussed here.

Figure 8: Types of Karez



B. Determining Degree of Damage to a Karez:

PVOs will need to assess the degree of damage to the karez in order to develop a cost estimate. Some areas will require only cleaning. Other parts of the karez may have collapsed requiring digging a new tunnel. RAP feels that karez kans, traditional karez experts, are the people most-skilled in these assessments.

Some PVOs assess damage to a karez based entirely on length. These people assume an average sediment accumulation rate and multiply by length to figure out the amount of work required. This approach might be appropriate in areas requiring mostly cleaning. Other PVOs try to assess damage by determining damage to each part of the karez. In areas with minimal collapse of the tunnel, the first method may be appropriate (e.g. with TYPE I karezes). Still, in areas with blockages in the tunnel, PVOs will almost certainly have to calculate by volume (e.g. TYPE II karezes).

PVOs might use the following methods to figure out degree of damage:

1.) Entering the karez and examining the condition.

Approximate time: Many hours
Precision: As precise as possible before actually beginning work.
Requirements: Skilled person able to recognize and assess damage (usually a karez kan).
Methodology:
a.) Karez kan enters the karez, and working with a surveyor/monitor, describes which portions of the karez will need cleaning, which portions need re-digging etc.
Difficulties:
a.) Damaged karezes may contain poisonous gasses that must be removed so that karez kan is safe.
b.) Well covers may have to be removed to enter the karez. It is possible to miss the most damaged part of the karez completely if the karez kan has not looked in the correct wells.
c.) Some areas will remain inaccessible.
d.) Many PVOs do not employ karez kans or other people willing to go into the karez to assess damage.

2.) Walking along the surface and looking in open wells.

Approximate time: If wells are open, approximately one hour for a 3 km karez (i.e. same as pacing). If wells are closed, some wells must be opened, so assessment will take much longer.
Precision: Imprecise
Requirements: Surveyor/monitor

Methodology:

a.) Walk along the wells looking for signs of damage such as:

i.) Collapsed wells.

ii.) Water backed up behind collapsed wells.

b.) Make visual assessment of which areas appear to be badly damaged and may require re-digging.

c.) Go into the karez at one location to get some assessment of the thickness of soil to be cleaned.

Difficulties:

a.) Large portions of the karez will remain unknown. Surveyor/monitor will have to trust their judgement.

b.) If wells are not open, they must be opened to examine the karez.

c.) This method may only be appropriate for TYPE II karezes, which are shallow enough to see collapses from above and, which may have open wells.

3.) Geophysical Techniques.

Yet untried, geophysical techniques such as Ground Penetrating Radar (GPR) or Resistivity, may be able to locate blockages in a karez. These techniques are rapid, but complex. They may be more appropriate for highly damaged karezes that are currently not a priority for RAP. Still, these tools may be valuable when peaceful times come to Afghanistan.

Surveyors might want to augment data collected by measurement with verbally-acquired data. RAP has the following suggestions regarding verbally-acquired data:

a.) Develop a rapport with a local farmer. RAP monitors feel that a poor local farmer will be less likely to exaggerate damage than a wealthy land owner.

b.) Gather 3 to 4 farmers together to reduce the likelihood of exaggeration.

c.) Ask the farmer to describe damage to the karez.

Difficulties:

a.) Very Imprecise.

b.) Need to find older people who have an intimate understanding of the karez.

C. Calculating Work Quantities

PVOs tend to calculate work either by length or volume. TYPE I karezes are less likely to collapse, and therefore tend to need only cleaning. So, PVOs might calculate work quantities on TYPE I karezes in length (i.e productivity norm [m-day/meter] x length [meter] = man-days labor required). Anderson's (1991) study of karez repair in Afghanistan indicated that PVOs estimate that a team can clean between 4 and 28 meters of karez in a day - 11 meters/day being an average value.

RAP's experience to date suggests that a team of 4 ought to be able to clean and repair between 7 and 12 linear meters in a day in karezes that do not have extensive collapsed portions. Limiting factors are the following:

1.) Depth of wells: Deeper wells require more lifting of soil. This slows the process of cleaning.
2.) Soil types: Hard clay or rocky soils require more work.
3.) Depth of sediment: Of course, removing deeper sediment requires more work.
4.) Number of collapsed portions.

TYPE II karezes are more likely to have collapsed portions from bombing or collapse of wells. Therefore, it may be appropriate to calculate work by volume for these collapsed portions. At present, RAP suggests using ACBAR's karez norms which are:

New Tunnel:

2 linear meters of new tunnel per 4-person team per day in normal soil (i.e. 1.2 cu.m./team day for a tunnel 0.6m by 1.0 m.).

1 linear meter of new tunnel per 4-person team per day in hard clay or rocky soil (i.e. 0.6 cu.m./team day for a tunnel 0.6 by 1.0m).

New Shaft:

1 vertical meter per man-day for normal soil for an 80cm/diameter shaft (0.5 cu.m./man-day)

1/2 vertical meter per man-day for hard clay or rocky soil (0.25 cu.m./man-day)

III. CANAL REPAIR

A. Introduction

Surface irrigation from canals diverted from rivers is still the primary source of irrigation in Afghanistan. In many parts of Afghanistan organizations are conducting canal repair projects. Many canals have been neglected, so sediment chokes the canal so that it no longer transports water as easily.

PVOs have taken three different approaches to the problem of surface irrigation repair as follows:

1.) **They pay for cleaning of the canal.** This is the most common approach. The Mir Ab system provides a mechanism for organizing cleaning activities. This approach is good where the community has enough labor to provide maintenance in future years.

2.) **They design and build structures along the length of the canal.** Some PVOs feel that building structures such as culverts, aqueducts and wash crossings will improve the irrigation for years to come. By building these structures, the PVO often finds that the community will clean the canal themselves. Furthermore, these structures reduce maintenance in some of the most troublesome parts of the canal, therefore reducing the total maintenance of the canal - an important consideration if a reduced local population is unable to maintain the irrigation system.

3.) **They design and build intakes.** Intakes are a high-maintenance part of surface irrigation systems. Flood discharges destroy traditional intake structures several times a year, so that people spend much time and energy rebuilding intake structures. PVOs should approach intake construction with caution. These structures are not particularly cost-effective (e.g. Anderson, 1990) and may be a source of water-rights disputes.

Even a well-designed intake can be a source of water-rights disputes. People downstream may rely on intakes upstream being incapacitated for part of the year. A permanent structure may be the source of a dispute. Also, designing intake structures requires river hydrology data that is usually not available. Engineers designing intake structures will often have to make assumptions about such design considerations as High Flood Level (HFL).

RAP feels that if PVOs want to build intakes and other structures, they should insist on some community contribution. If the community desires to improve its irrigation for years to come by building structures, it should be willing to contribute some labor and materials.

B. Canal Cleaning

1. Introduction

Canal cleaning was previously a task done every year in most communities. Though removing sediment from a ditch is a very low technology operation, engineers have difficulty costing out the project for the following reasons:

a.) Canals may be very long.
b.) Length and width of the canal may vary. Canals tend to be wider at the intake from the river and narrower at the end.
c.) The amount of sediment to be removed varies greatly from one part of the canal to another.

While most canals have an existing watercourse, the general aim of canal alignment is to keep the water moving as fast as possible without scouring the bed of the canal. Water losses due to infiltration tend to be less in faster moving water (see Figure 9).
Generally, organizations will just remove accumulated sediment from the canal. But, some may choose to re-align a canal using engineering survey equipment. Using a level, engineers can design a canal that will transport water more efficiently by keeping the slope of the canal uniform. However, design engineers should make sure that surveyors understand where to take measurements. Surveys collected on regular spacing may not be adequate (e.g Anderson, 1990).

When a canal scours its bed, it picks up finer sediment that will be deposited further on down the canal when the velocity of the water slows. Also, erosion of this finer sediment may expose coarser-grained sediment that is more subject to seepage losses. So, people may need to level the canal to minimize erosion in some places and deposition in others.

Engineers might consider re-designing the canal using the Manning equation to increase the efficiency of the canal. Long term, this also will reduce maintenance because the canal will be less likely to scour or silt up if water is flowing more efficiently.

Other sources of losses of water that people noted were as follows:

a.) **Vegetation.** Vegetation in a canal slows the velocity of water and increases losses.
b.) **Animal Burrows.** Mice and other animals also may burrow into the sides of the canals causing losses.
c.) **Poor Tertiary Distribution Structures.** Usually farmers divert water by blocking off a canal with soil and opening another canal. These soil diversions are extremely inefficient.

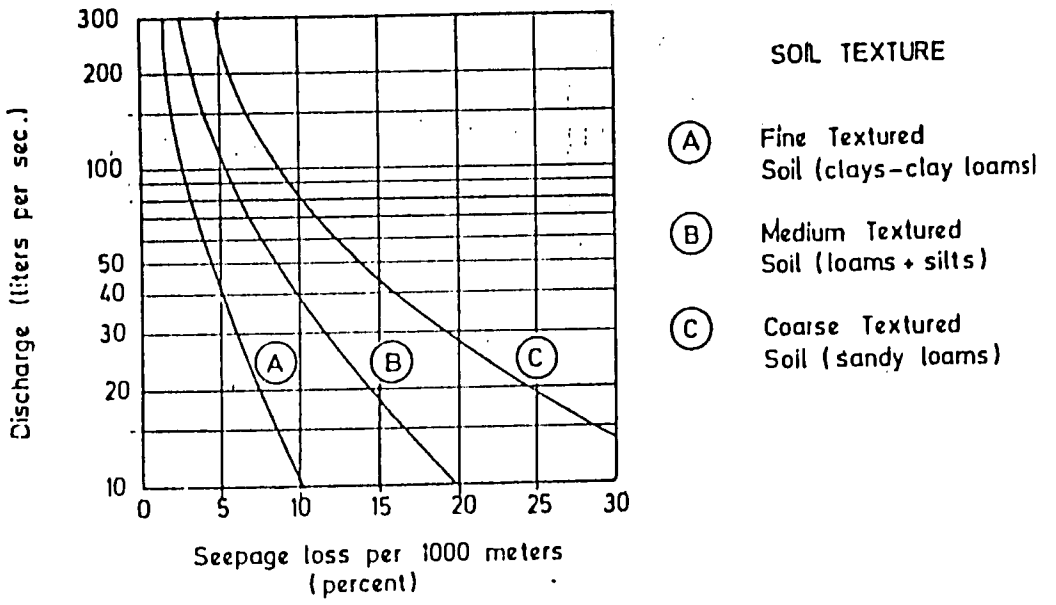
2. Estimating the Amount of Sediment to be Removed

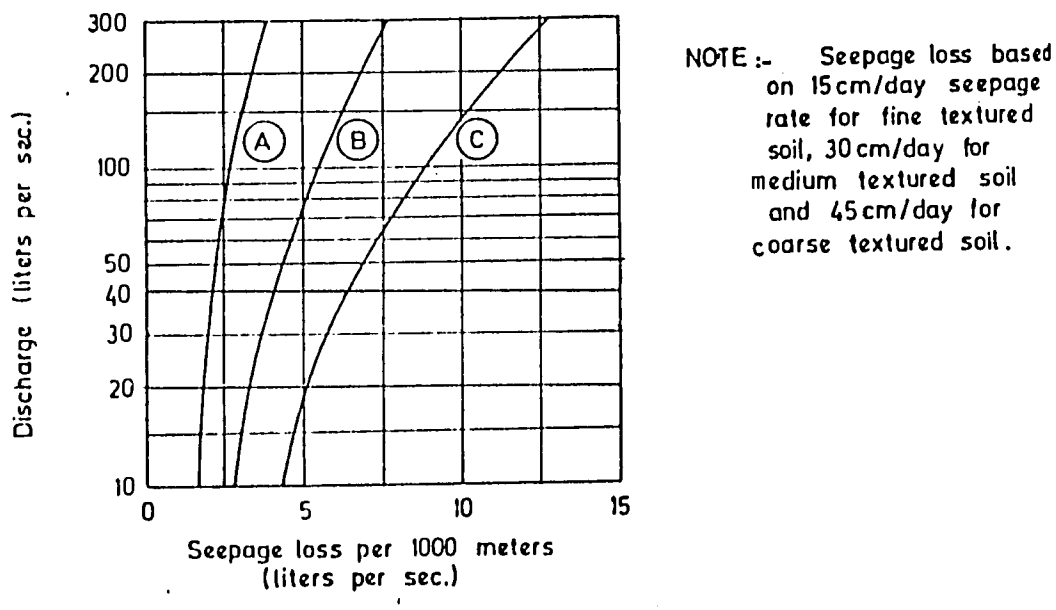
PVOs can rely on a combination of technical and traditional methods when determining the amount of soil to be removed from a canal. Surveyors should consider the topography and slope of the canal during survey. They should measure depth and width at enough locations to get a reasonable estimate of average sediment volume to be removed. Uniform canals will require fewer measurements. Canals with many changes in slope will require more surveying.

Surveyor/monitors will have to take measurements along the length of the canal in the following locations:

a.) In reaches where the slope of the canal changes.
b.) In reaches where the dimensions of the canal change (i.e. it narrows or becomes deeper).
c.) Where the canal crosses a wash, stream, road or similar structure.
d.) In reaches that clearly will require work.

Figure 9





SEEPAGE RATES OF DIFFERENT SOIL TEXTURES

51

The width and depth of sediment to be removed depends on the slope of the canal as well as the surrounding topography and the distance along the canal. Generally, the cross-sectional area (width x depth) reduces going from the intake to the end of the canal. Flatter slopes will tend to cause the canal to deposit sediment. Steeper slopes encourage erosion.

a.) **Engineering Estimates.** In order to estimate the volume of soil to be removed, PVOs must measure the cross-sectional area of soil to be removed from the canal. If engineers want to improve the efficiency of the canal, they may choose to use a level.

Requirements: 1-2 trained surveyors, a shovel, a ruler or measuring tape, level and rod.

Methodology:

a.) Measure the width of the canal with a measuring tape.

b.) Use a shovel to cut down to virgin soil.

c.) Measure the thickness of the sediment above the virgin soil. Take several measurements along the length of the canal.

d.) Multiply the width by average thickness of sediment to determine soil to be removed.

If the canal is to be re-aligned using the Manning formula to improve flow, engineers will need to calculate volume estimates based on the difference between designed cross-sections and slopes and existing field conditions.

b.) **Mir Ab Estimates:** PVOs sometimes consult traditional canal maintenance experts, Mir Abs, to aid in assessing damage to a canal system. These people may also provide valuable information about water rights share systems.

C. Structures for Canals

1. Introduction

Usually engineers will need at least ten years of hydrology data on a strea to begin to design structures on streams. With few exceptions, these data are not available for Afghanistan. Also, in areas of deforestation, historical data cannot be used in a predictive way, because streams become choked with sediment and run-off from slopes increases.

Field data on cross-sections of a river upstream, downstream and at the point of construction, are also usually needed. Many PVOs do not have trained surveyor staff who understand the principles in gathering this information.

With the complexities of designing structures in a changing hydrologic environment, PVOs should not attempt to build structures such as intakes unless they have competent surveyors and engineers who understand the complexities of design. Also, design engineers should use conservative safety factors because they do not have good hydrologic information.

Engineers should also discuss any structures with the community to make sure that the project will function within the political and social constraints. Angry neighbors have destroyed some structures, because they claim that the structures have resulted in less water for downstream users.

Because RAP is not able to fund surveys, PVOs who come to RAP for funding of structures that require technical survey must have done the following:

a.) Obtained funding from another source for a survey.
b.) Performed the survey from operational costs on a previous RAP-funded project.

Project planners should keep the following in mind when considering building structures for surface irrigation:

a.) **Improvements to one irrigation system and not another may result in water rights disputes.** Intakes/Diversionary structures especially tend to be a source of disputes. In some areas, water users downstream from a canal intake depend on intakes upstream being inoperable for part of the year. Sometimes these users downstream will object to the construction of more efficient intakes upstream. This is such a source of tension that downstream users have sabotaged some of these structures.

b.) **River training structures may change the course of a channel causing erosion.** Groins, retaining walls and more-efficient intakes may change the course of a channel causing erosion in areas that were previously stable. This possibility is especially prevalent in meandering streams.

2. Sample Diversion Designs

RAP has included two sample designs for constructing gabion diversions to replace traditional diversion structures. These are included in Appendices I and II.

PART 6 - CEREAL CROP PRODUCTION

I. INTRODUCTION

A. Background

RAP supports a number of seed and fertilizer projects. The PVOs receiving RAP assistance for the distribution of the seeds and fertilizer need to follow up with the people receiving the seed and fertilizer to determine their success and effectiveness. Follow-up information is needed to ensure proper use of materials, determine effectiveness of the current program and to help determine the direction of future programs.

B. ACBAR/SWABAC NGO/DONOR Agreement on Guidelines for the Distribution of Agricultural Inputs in Afghanistan

RAP has signed the above-mentioned agreement. PVOs wishing to get funding for commodities from RAP should read this agreement before asking RAP to fund agricultural commodities. A copy of this agreement is included in Appendix III.

II. IMPROVED WHEAT SEED AND FERTILIZER

A. Introduction

Wheat is a member of the grass family which includes cereal crops such as maize, oats, barley and rice. Winter wheat constitutes the backbone of the Afghan agricultural economy. Wheat flour is the main staple of the Afghan diet. The wheat straw by-product is also an important source of animal fodder.

According to the Agricultural Survey of Afghanistan, irrigated winter wheat is approximately five times as important as rain-fed wheat, the second most important crop. Wheat is typically sown using broadcast techniques and covered with soil by re-plowing. Yields can be improved by planting in close-spaced rows and banding the fertilizer with the use of a seed drill. This will result in more consistent planting depth resulting in improved germination and providing for better utilization of fertilizers. The following are some of Afghanistan's agricultural needs:

1.) Agricultural equipment such as tractors, draught animals, plows, tillage and harvesting tools to cultivate the land.

2.) The use of genetically improved wheat strains which demonstrate increased disease tolerance and give greater yields of wheat.

3.) The use of fertilizers will improve and stabilize crop yields.

4.) Extension service by agriculturally trained personnel to assist farmers in improving their skills in the selection of better crop varieties, improved cultivation methods, and the detection and treatment of plant pests and diseases.

B. General Cultivation Guidelines for Wheat

1.) The seed bed should be tilled thoroughly, 15-20 cm. deep. It is best to plow 2-4 weeks prior to planting to loosen soil and hold down competing vegetation.

2.) Prior to planting the soil should be tilled again, 5-10 cm. deep to break up large pieces of soil and again kill any competing vegetation. If planting machinery is not to be used the fertilizer can be applied just before tillage. If planting machinery is used that has fertilizer application attachments all phosphate and potassium fertilizer (e.g. DAP) and a portion of the nitrogen (e.g. Urea) should be applied at the time of planting.

3.) Wheat seed should be planted at a depth of 2-3 cm. Typical seeding rates for improved seed are 20-35 kg/jerib.

4.) Seed should be planted after soil has been watered to field capacity ("watr"), or immediately after planting if the field has not been previously watered.

5.) The second application of urea (15 kg/jerib) is to be applied when the wheat plant reaches the 4 to 5 leaf stage or the booting stage. The urea should be broadcast on the soil surface and immediately irrigated. This should not be done on a day when temperatures are cool. It is better to be done as temperatures are falling. When the urea fertilizer becomes wet it breaks down and goes to a gaseous form and much will escape into the atmosphere if the temperature is above 20 degrees C.

III. CROP-CUT METHODOLOGY/CEREAL CROP PRODUCTION FOLLOW-UP

A. Introduction

At harvest time field technicians should return to the farmers to determine the following:

1.) If farmers followed guidelines provided by field technicians (i.e. if agricultural extension was effective).

2.) Yields (crop cuts).

Analysis of 1990 crop cut data suggests that a field worker should be able to collect crop data at about 15 farms in one week. For a distribution plan, surveyors should try to visit at least 5 percent of the farmers receiving improved seed. Of course, the higher percentage of farmers, the more useful the information will be. For a multiplication program with few farmers, PVOs should be able to collect data at almost every farm in the multiplication program.

B. Crop-Cut Methodology

RAP has decided to concentrate on a crop-cut program that relies on three meter-square samples gathered from each field.

Requirements: Meter by meter frame, altimeter, balance scales accurate to 0.05 kg.

This methodology is intended as a simple assessment technique. Should PVOs wish to prepare seed trials, RAP suggests they use more precise measurement methods (e.g. a triple balance rather than a bazaar balance).

Field workers should use the following guidelines for collecting data:

1.) **Random Selection of Farmers.** From the distribution records, surveyors should randomly select farmers for follow-up. One method of random selection might be to use a random-number table and count down from the top of the list of recipients.

When comparing performance of improved seed with local seed, it is best to minimize the number of variables. If at all possible, surveyors should select farmers who cultivate both improved and local varieties of wheat. These farmers will most likely have cultivated their fields in the same fashion, so that results on improved and local varieties can be compared.

2.) **Determination of Cultivation Practices.** Upon arriving at the farmers home, the surveyor/monitor should question the farmer to determine what cultivation practices were used on the fields. RAP has prepared a form with appropriate questions (see the attached form: **Follow-Up Information for Crop Production (Table 4).**

3.) **Determination of Elevation.** RAP is asking PVOs to gather data on elevation. To RAP's thinking there are two ways to gather data on elevation:

a.) **Topographic Maps.** (As mentioned previously, political features such as villages may not be located accurately on the topographic maps, while geographic features are more likely to be accurately located.)

b.) **Altimeter.** Altimeters are based on atmospheric pressure and must be calibrated before each use. However, if the altimeter is calibrated at the same location every time, (e.g. the field office), the PVO can develop a calibrated system appropriate to its field area.

4.) **Selecting Sample Locations.** Sample locations, like farmers sampled, should be selected randomly. RAP suggest taking at least three sample per field. A recent FAO course suggested taking five samples per field. RAP suggests using the following method:

TABLE 4

FOLLOW-UP DATA FOR CEREAL CROP PRODUCTION

A. Background

1.) Date:_____ 2.) Technican Name:_____ 3.) Province:_____

4.) District:_____ 5.) Village:_____ 6.) Elevation:_____

7.) Farmer:_____ 8.) Crop:_____ 9.) Variety:_____

10.) Number Jeribs Planted:_____ 11.) Does Farmer own Draught Animals: _____ Yes _____No

12.) If Yes to #11, How many: _____ Oxen _____ Donkeys _____ Horses

B. Cultivation Practices

1.) Seed bed prepared by: ____ Tractor ____Draught Animals

2.) Was the work hired? _____ Yes _____ No

3.) How much seed was planted? _____ kg/jerib 4.) Date Planted:_____

5.) Fertilizer Applied: DAP _____ kg/jerib Urea _____ kg/jerib Local _____ loads

6.) Date and Number of applications: DAP_____ Urea_____ Local_____

7.) Source of Irrigation water: _____ Karez _____ River _____ Spring _____ Well _____ Other

8.) Date Irrigation Started: _____ 9.) How many applications: _____

10.) Irrigation cycle: _____ (days) 11.) Farmer's water right: _____ (hours)

C. Analysis

1.) Problems: a.) Disease: _____ What Kind: _____

b.) Insects: _____ What Kind: _____

c.) Weeds: _____ What Kind: _____

d.) Birds: _____

e.) Other: _____ What Kind: _____

2.) Did the farmer like the crop? _____ Yes _____ No

Comment: _____

_____

3.) Other Comments: _____

_____

4.) Weight of Unthreshed crop (composite of 3 or more meter by meter samples) _____ Kg

5.) Weight of Threshed crop (composite of 3 or more meter by meter samples) _____ Kg

(weights should be determined to the nearest 0.05 kg)

6.) Yield _____ kg/jerib

(Average kg. per meter square) x 2000 sq.m./jerib

a.) Surveyor/monitor stands with their back to the field, in the south west corner of the field, for example, and throws a stick over his shoulder. The surveyor/monitor might attach a flag to the stick to make it more easy to locate.

b.) Surveyor/monitor drops the meter by meter frame over the stick and cuts the wheat close to the ground. Surveyor/monitors should include only wheat that grows in the area inside the frames. Surveyor/monitors should not force wheat up into the frame as this will bias the results.

c.) Surveyor/monitor walks a pre-determined number of steps in the north-easterly direction (e.g. 50 paces). The surveyor/monitor locates the frame immediately in front of his feet and takes another sample.

d.) Surveyor/monitor takes a third sample after a pre-determined number of steps in the north-easterly direction.

e.) Should additional samples be desired, the surveyor/monitor should continue walking in a north-easterly direction taking samples at a pre-determined number of paces.

5.) **Weighing the Wheat.** The composite sample of un-threshed straw and grain is weighed on a scale accurate to within 0.05kg. RAP suggests that surveyor/monitors use a balance scale if they have accurate weights and they can be sure that the value they get is accurate. People in Afghanistan are used to balance scales and will be less likely to make errors with these scales than other scales.

6.) **Threshing the Wheat.** When the grain on the wheat is dry enough to crack between the teeth, it is dry enough for storage. This is the correct time to thresh the wheat. In some areas (e.g. Kandahar) wheat may be dry enough at harvest to be threshed. In other areas (e.g. Panjshir) the PVO may have to wait a week or so for the wheat to dry before threshing and weighing.

7.) **Weighing the Grain.** Surveyors should weigh the grain to an accuracy of 0.05 kg as described in step 5.

8.) **Calculating Yield.** Surveyors should divide the weight of the grain by three (or the number of samples taken in the field if it is greater than three) to get yield per meter square of land. This number can be multiplied by 2,000 to get kg/jerib. Agriculturalists should keep in mind that a farmer's take-home yield may be as much as 25% less than the calculated yield, because of losses in harvesting, threshing etc.

PART 7 - MINOR ROAD REPAIR

I. INTRODUCTION

RAP tends to fund only minor road repair projects including culvert construction, retaining wall construction and ditching. RAP will not fund road re-surfacing for PVOs who do not have road repair equipment.

In general, other kinds of projects more directly achieve RAP's objectives of increasing food availability and cash incomes. For road repair projects submitted to RAP for funding, PVOs should use the following:

A.) UNDP's standard culvert designs. RAP sees no need to design new culverts for every road.

B.) Plans of any retaining walls.

C.) Survey data supporting the volume of road repair being requested.

II. CULVERTS

A. Introduction

Field engineers should study field conditions before selecting the appropriate culvert for the site. The following are types of culverts used in Afghanistan:

1.) **Box Culverts:**

This is the most commonly used type of culvert in Afghanistan. There are different versions of this culvert as far as its design is concerned. Slab culvert, fully boxed culvert (reinforced from all directions), and partially boxed (with no reinforcement in the base of the culvert).

a.) **Slab Culvert.** Some type of masonry structure is used as side support walls. A concrete slab usually 12 cm to 18 cm in thickness is used for the top portion. Earth to a thickness of 50 cm should be placed on the top of the concrete slab in order to prevent any stress action on the slab due to the application of external loads. Prior to covering the top portion of the slab, ample time should be given for the concrete to be cured (normally between 20 to 28 days).

b.) **Fully-Boxed Culvert.** This type is usually used in areas where a greater reinforcement is desired. Concrete and steel is used for the structure.

2.) **Pipe Culverts:**

Pipe culverts are used when there is not enough space, difficult curves on the road, and narrow paths. A short period of construction is required for this type compared to box culverts. One of the draw-backs of pipe culverts in Afghanistan may be the shortage of pipes.

B. Selecting the Correct Culvert Size

1. Introduction

For costing purposes, engineers must determine which standard culvert sizes is appropriate for each wash requiring a culvert. In order to do this they should do the following:

a.) **Determine width of wash.** During initial surveys, surveyors may be able to guess at the necessary span of a culvert for costing purposes. During actual construction engineers should check to make sure that the width will be suitable.

It is not advisable to restrict the waterway when constructing a culvert. A restricted waterway increases the velocity and will result in scour, thus necessitating deeper foundations and also training works. The culvert should be designed for the maximum flood discharge as determined from the HFL apparent at the site.
Engineers should use the Manning equation to determine the quantity of water that the culvert will have to pass. For working out the discharge three cross-sections should be taken at the stream site where a culvert is proposed to be built. The first cross-section should be taken at the selected site, one upstream and one downstream. (For an example of Manning Equation calculations, see Appendix I.)

For natural streams in alluvial beds and having undefined banks, the linear water way (i.e. necessary span of the culvert) may be determined from the following formula:

$$L = C \times \sqrt{Q}$$

where:

L = The effective linear water way i.e. span of the culvert (meters)

Q = The design maximum discharge (cubic meters per second)

C = A constant usually taken as 4.8 for regime channels. However, C may be as low as 4.5 in controlled conditions (e.g. culverts passing an irrigation ditch under a road) or as high as 6.3 in extremely destructive flow conditions.

(a)

If necessary span width is greater than the width of the typical culvert, PVOs might want to construct double culverts (i.e. two culverts sharing the middle wall). For example, if the maximum typical culvert span is 1.5 meters, and the effective linear water way is 2.0 meters, the engineer might design a double culvert with two 1.0 meter span sections.

2. Free Board

Culverts should be constructed to pass most storm flows. Surveyors should determine the apparent High Flood Level (HFL), and construct the culvert so that there is some distance between the HFL and the underside of the culvert slab (i.e. freeboard). The following freeboard is suggested:

Discharge in Cubic Meters per Second	Minimum Vertical Clearance in Centimeters
up to 0.3	15
0.3 up to 3.0	45
3.0 to 30	60

(Indian Practical Civil Engineer's Handbook, 1990)

III. RETAINING WALLS

A. Introduction

Retaining walls are often used to prevent erosion or slope failure. Because stone is generally the most readily-available building material in Afghanistan, PVOs tend to construct retaining walls of gabions or stone masonry.

For Retaining walls, surveyors should gather the following information:

1.) Necessary height of wall.
2.) Necessary length of wall.
3.) Whether wall will bear live load.
4.) Soil types concerned.

B. Design Data for Retaining Walls for Level Fills:

The following are guidelines for retaining wall construction using stone masonry. Top width of retaining walls should be about 60 cm for stone masonry.

K : is the ratio of weight of wall masonry to weight of soil material per cu. m.

P : is the max. toe pressure in kg/sq. m. at the base.

The resultant falls on the edge of the middle-third and the wall will have a factor of safety of between 2 and 3 against overturning.

The following tables relates these design factors:

Average Angle of Repose	Base width B, given as ratio of height h.				
	Type A	Type B	Type C	Rectangular	Wall that will withstand earth pressure only.
K = 1.00 (e.g. Gabion [1.85 g/cc]/Clean Gravel [1.84 g/cc])					
20 (wet clay)	0.68	0.65	0.73	0.73	0.40
27 (dry clay)	0.57	0.55	0.62	0.62	0.35
33 (dry sand)	0.48	0.47	0.54	0.53	0.31
37 (sand/gravel)	0.46	0.45	0.50	0.50	0.28
p =	600 h	800 h	1000 h	1000 h	
K = 1.25 (e.g Stone Masonry [2.4 g/cc]/Silt [1.6 g/cc])					
20 (wet clay)	0.61	0.62	0.73	0.65	0.36
27 (dry clay)	0.51	0.52	0.62	0.55	0.31
33 (dry sand)	0.43	0.44	0.53	0.47	0.28
37 (sand/gravel)	0.37	0.41	0.42	0.50	0.25
p =	750 h	950 h	1100 h	1200 h	

(above figures from the Indian Practical Civil Engineer's Handbook, 1990 are approximate and meant as guidelines)

C. Additional Considerations

Many additional considerations may come into play at any one construction site. The following are a few additional considerations for designing retaining walls:

1.) **Drains.** Engineers should always include a drain at the base on the back side of the wall to relieve water pressure that might cause the retaining wall to fail. Of course, gabion walls, being permeable, will not require drains.

2.) **Weep Holes.** Weep holes are also necessary every square meter to allow the drainage of sub-soil water to prevent build-up of pressure behind the wall.

3.) **Walls that Support Uneven Fills.** Should the wall support soil or rock that is filled higher on the up-hill side, engineers will have to design the wall to support this extra load.

4.) **Live Load.** Should a wall support a road or other live load, engineers should calculate what portion of that live load will be borne by the retaining wall.

5.) **Scour.** Retaining walls built in a river channel will need to be built deep enough to resist scour.

The following is an EXAMPLE of the design steps that engineers should do. It is not a design to be applied to all locations. Engineers should do proper design and estimating for their particular location. Furthermore, this design only includes the weir itself. In the sample location as well as other locations, retaining walls will be necessary. In addition, some may choose to construct head regulating structures at the intake to the canal.

I. PROBLEM STATEMENT

The people of the Nisarabad area of North Malestan have requested that a diversion weir be constructed for their irrigation canal. The people argue that they spend a substantial amount of their time rebuilding the diversion for their canal. The traditional diversionary structure, constructed of stones and sticks, is washed out several times a year during high flows. Because of a reduced population, this has become a daunting task for the local population.

The Rural Irrigation Program (RIP) discusses this problem with the village elders. RIP proposes to design and construct a gabion diversion weir. RIP will provide engineering expertise, skilled labor, and manufactured materials, while the local people agree to contribute half of the unskilled labor and stones.

II. FIELD SURVEY

A. Introduction

The RIP design engineer considers the situation before sending a field team to survey. He decides to gather enough information to design a structure using traditional engineering design considerations.

RIP sends two field engineers to examine and survey the site of the dam. A traditional diversion structure is present in the stream which raises the water high enough to deliver adequate water to the canal without flooding surrounding fields. Based on this, the field engineers know that:

1.) The new dam needs to be approximately the same height as the traditional structure, and

2.) A dam built at this height will supply adequate water to the fields.

B. Survey Equipment

The field surveyors bring the following equipment:

1.) A level and rod to determine elevations.
2.) A measuring tape to determine short lengths.
3.) A chain for measuring longer distances.
4.) A camera for taking photos of the field conditions.

C. Data Collected

The field surveyors collect the following information:

1.) A sketch map of the project area showing the locations of the cross-sections and the canal. (figure 1)

2.) Cross-Sections of the stream at three locations, noting the following (figure 2):
   a.) Soil types. Surveyors especially note particle size and whether the soils are plastic/cohesive.
   b.) The High Flood Level (HFL) of the stream. Surveyors look for visual indications such as the following:
      i.) High water marks on the stream.
      ii.) Water-borne debris, high on the bank.
   They also get verbal estimates of highest water level from the local people.
   c.) Normal Supply Level (NSL) of the river.

3.) Slope and Cross-Sections of the irrigation canal.

4.) Details of the elevations of the traditional diversion dam.

III. WATER REQUIREMENT

A. Introduction

The design engineers will have to be sure that the weir, when constructed, will supply enough water to irrigate the command area. In order to do this, surveyors will have to determine the amount of land under irrigation by this canal, and make sure the canal will supply enough water to irrigate this land.

Of course, since a diversionary weir is already present that supplies enough water to the field, RIP engineers have some idea about water requirement. However, the following method provides a check on the traditional system, and allows the engineers to more accurately design to meet the water requirement of the command area.

B. Determining Area Irrigated

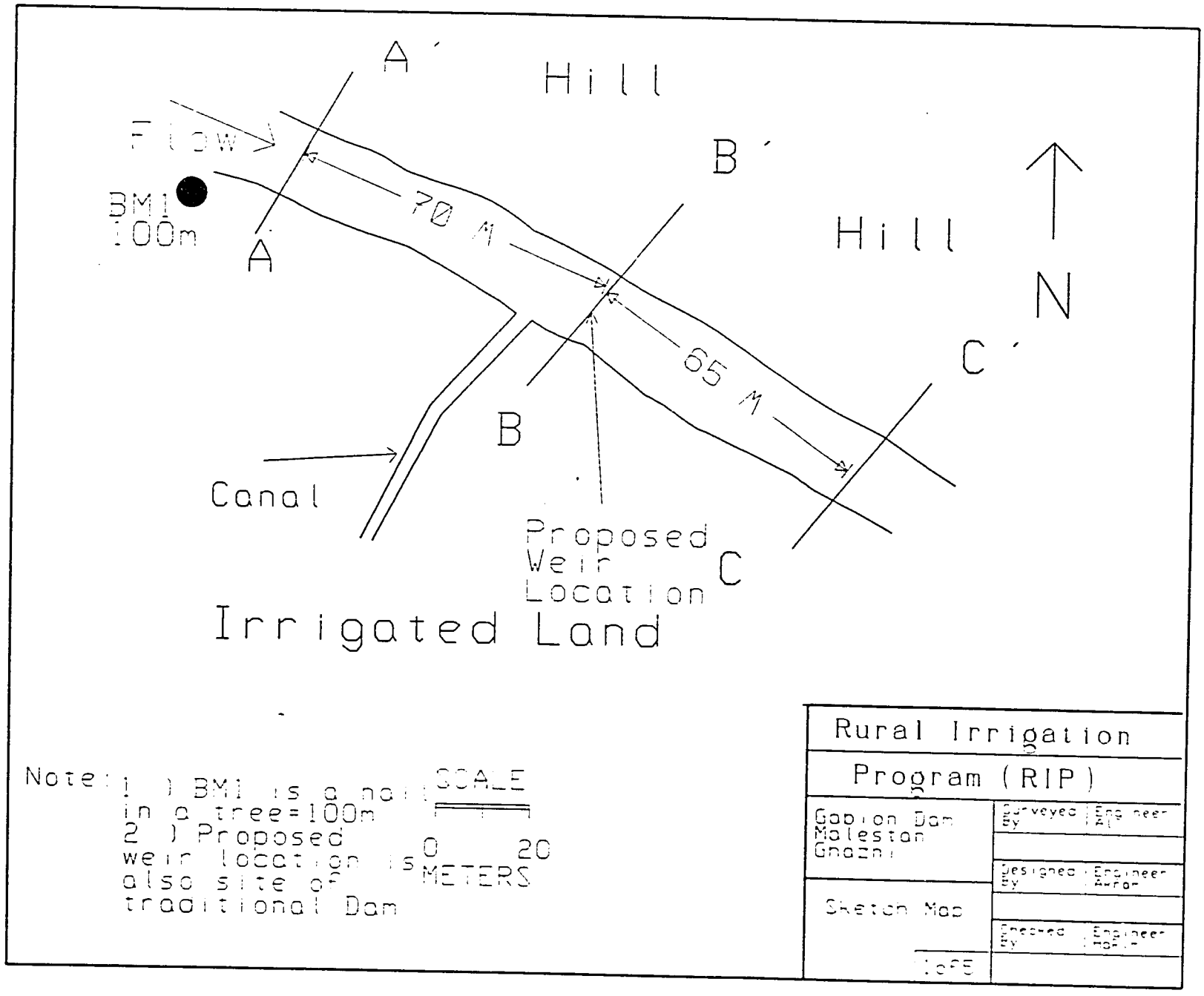
The surveyors walk the length of the canal with the Mir Ab of the canal as a guide. As a base-map of the area, the surveyors have a 1:100,000 scale map enlarged so that it is approximately 1:50,000 scale. As the surveyors walk, they sketch the location of the canal on the topographic map (figure 3).

When the surveyors return to the office, they calculate the area using a planimeter. Alternatively, they could divide the area into triangles and rectangles and calculate the area by summing the total of all triangles and rectangles.

The planimeter indicates that the command area of the canal is 8.5 sq. km. Because a sq. km is 1,000,000 sq.m., the total area is 8,500,000 sq.m. In jeribs, this is the following area:

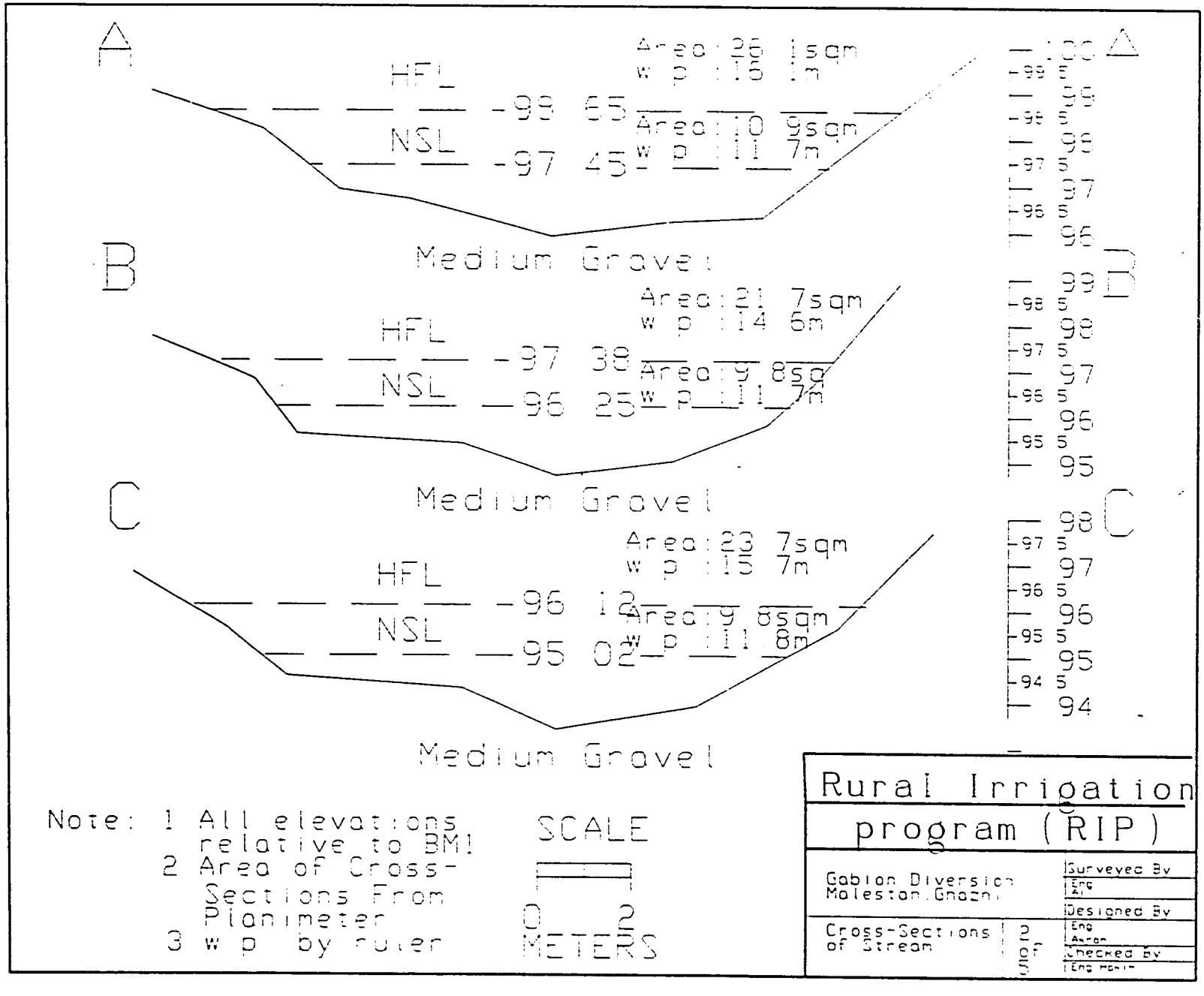
$$\frac{8{,}500{,}000 \text{ sq.m}}{2{,}000 \text{ sq.m./jerib}} = 4{,}250 \text{ jeribs}$$

Figure 1

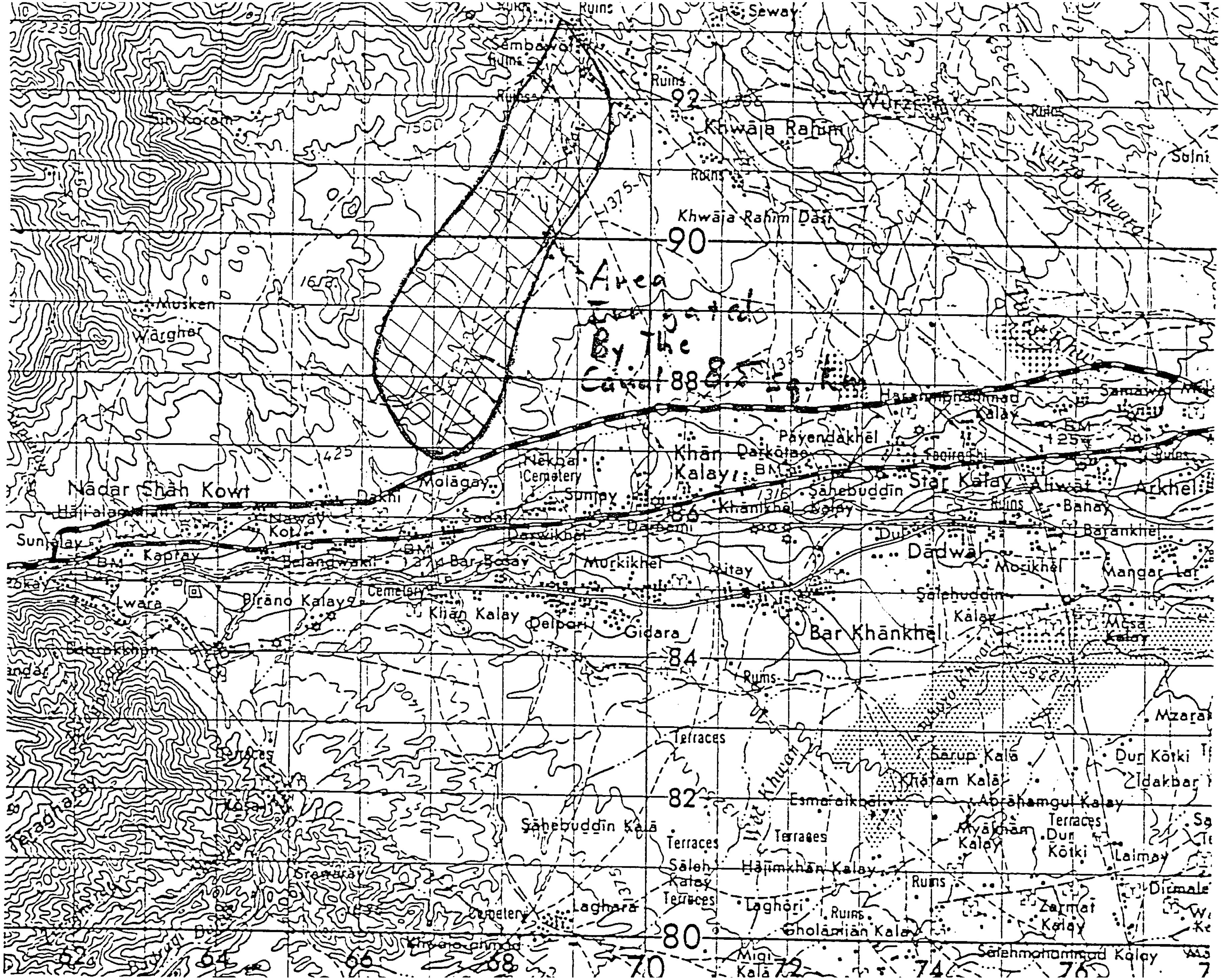

A
Hill
Flow
B
BM1
100m
20 M
Hill
N
A
C
65 M
B
Canal
Proposed
Weir
Location
C
Irrigated Land
Note: 1) BM1 is a nail in a tree=100m
2) Proposed weir location is also site of traditional Dam
SCALE
0 20
METERS
Rural Irrigation
Program (RIP)
Gabion Dam
Malestan
Ghazni
Surveyed By
Engineer
Designed By
Engineer
Sketch Map
Checked By
Engineer
1 of 5

66

Figure 2


A
HFL
NSL
-99 65
-97 45
Area: 26 1sqm
w p : 16 1m
Area: 10 9sqm
w p : 11 7m
Medium Gravel
B
HFL
NSL
-97 38
-96 25
Area: 21 7sqm
w p : 14 6m
Area: 9 8sq
w p : 11 7m
Medium Gravel
C
HFL
NSL
-96 12
-95 02
Area: 23 7sqm
w p : 15 7m
Area: 9 8sqm
w p : 11 8m
Medium Gravel
100
99 5
99
98 5
98
97 5
97
96 5
96
99
98 5
98
97 5
97
96 5
96
95 5
95
98
97 5
97
96 5
96
95 5
95
94 5
94
Note: 1 All elevations relative to BM1
2 Area of Cross-Sections From Planimeter
3 w p by ruler
SCALE
0 2
METERS
Rural Irrigation program (RIP)
Gabion Diversion Malestan.Ghazni
Cross-Sections of Stream
2 of 5
Surveyed By
Eng Ali
Designed By
Eng Amin
Checked By
Eng Mohin

68



Area Irrigated By The Canal 88 8.5 Sq Km
Ruins
Seway
Sembay
Khwāja Rahim
Khwāja Rahim Dasi
Wurz
Solni
90
92
88
86
84
82
80
62
64
66
68
70
72
74
76
Musken
Warghar
Nādar Shāh Kowt
Hāji alam
Sunjalay
Kaptay
Naway Kot
Dakhi
Molāgay
Nekbal
Cemetery
Sunjay
Khān Kalay
Darkotae
Payendakhel
Samawat
Sāhebuddīn
Star Kalay
Aliwāt
Arkhel
Khānkhel Kalay
Bahay
Bārankhel
Dadwal
Morikhel
Mangar
Murkikhel
Aitay
Selangwakil
Bar Bosay
Lwara
Pirāno Kalay
Khān Kalay
Delpori
Gidara
Bar Khānkhel
Sālehuddīn Kalay
Mūsa Kalay
Terraces
Sārup Kalā
Khorām Kalā
Dur Kōtki
Idakbar
Esmāʿīlkhel
Abrāhamgul Kalay
Sāhebuddīn Kalā
Myākhām Kalay
Kōtki
Laimay
Sāleh Kalay
Hājimkhān Kalay
Dirmale
Laghara
Laghōri
Gholāmjān Kalay
Zarmat Kalay
Sālehmohammad Kalay
Mzara
Sramaray
Cemetery
Miqi Kalā

Figure 3

C. Determining Water Requirement

Using a rough guideline of 1 liter/second per hectare (0.2 l/s per jerib) RIP engineers calculate the water requirement.

4,250 jeribs x 0.2 l/s per jerib = 850 l/s

This indicates that the diversionary weir should deliver at least 850 l/s of water when complete.

IV. CHARACTERIZATION OF RIVER

A. Introduction

In order to properly design the diversionary weir, the engineer will have to characterize flow in the river, and make sure that the structure will be stable under high flow conditions and design it to supply the necessary amount of water. The engineers use information about the HFL, NSL, soil types, and field observations to characterize the river.

B. Location of Structure

The structure should be located in a straight reach of river. Rivers tend to scour more in curved portions, so the proposed weir should not be constructed on a curve.

C. Flow at Normal Supply Level

RIP needs to determine the flow of the water in the river at normal supply level to make sure that the river is supplying an adequate amount of water to irrigate the command area. The flow equation is as follows:

$$Q = V \times A$$

where:
- Q = Volume of Flow in m^3/sec.
- V = Velocity in m/sec. (Determined from Manning Formula)
- A = Cross-Sectional Area of the Stream in m^2 (From Scale Cross-Sections)

The Manning Formula to determine velocity is as follows:

$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

where:
- R = Hydraulic Radius = $\frac{\text{Cross-section Area } (m^2)}{\text{Wetted Perimeter } (m)}$
- S = Slope of the River Surface in m/m
- n = Manning Coefficient of Roughness (from table)

Value of n	Channel Condition
0.016-0.017	Smoothest Earth channels, free from growth with straight alignment.
0.020	Smooth natural earth channels, free from growth, little curvature.
0.025-0.027	Small earth Channels in good condition, or large earth channels with some growth on banks or scattered cobbles in bed.
0.030	Earth Channels with considerable growth. Natural streams with good alignment, fairly constant condition. Large floodway channels, well-maintained.
0.035	Earth channels considerably covered with small growth. Cleared but not continuously maintained floodways.
0.040-0.050	Mountain Streams in clean loose cobbles. Rivers with variable section and some vegetation growing in brush or aquatic growth.
0.060-0.075	Rivers with fairly straight alignment and cross-section, badly obstructed by small trees, very little underbrush or aquatic growth.
0.100	Rivers with irregular alignment and cross section, moderately obstructed by small trees and underbrush. Rivers with fairly regular alignment and cross section, heavily obstructed by small trees and underbrush.
0.125	Rivers with irregular alignment and cross-section, covered with growth of virgin timber and occasional dense patches of bushes and small trees, some logs and fallen trees.

From: Design of Small Dams. 1973. U.S. Department of Interior. Bureau of Reclamation. U.S. Government Printing Office, Washington, D.C. 816p.

Calculating Flow at NSL using Manning Formula:

$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

Calculating Slope (S) from values shown in figures 1 and 2:

$$S \text{ (A to B)} = \frac{97.45 \text{ m} - 96.25 \text{ m (see fig.2)}}{70 \text{ m (see fig.1)}} = 0.017$$

$$S \text{ (B to C)} = \frac{96.25 \text{ m} - 95.02 \text{ m}}{65 \text{ m}} = 0.019$$

$$\mathbf{S \text{ (avg)}} = \frac{0.019 + 0.017}{2} = \mathbf{0.018}$$

n = 0.06 (from table) Rivers with fairly straight alignment
(since not particularly obstructed river use lower number)

$$R = \frac{\text{Cross-Sectional Area (see figure 2)}}{\text{Wetted Perimeter (see figure 2)}}$$

$$V_{A\text{-}A'} = \frac{1}{0.06} \times \left[\frac{10.9\ m^2}{11.7\ m}\right]^{2/3} \times 0.018^{1/2}$$

$$= 16.7 \times 0.95 \times 0.13 = 2\ m/s$$

$$V_{B\text{-}B'} = \frac{1}{0.06} \times \left[\frac{9.8\ m^2}{11.7\ m}\right]^{2/3} \times 0.018^{1/2}$$

$$= 16.7 \times 0.89 \times 0.13 = 1.9\ m/s$$

$$V_{C\text{-}C'} = \frac{1}{0.06} \times \left[\frac{9.8\ m^2}{11.8\ m}\right]^{2/3} \times 0.018^{1/2}$$

$$= 16.7 \times 0.88 \times 0.13 = 1.9\ m/s$$

Avg. V @ NSL = 1.9 m/s

Determining Cross-Sectional Area (areas from figure 2):

$$\text{Area (avg.)} = \frac{A_{A\text{-}A'} + A_{B\text{-}B'} + A_{C\text{-}C'}}{3} = \frac{10.9\ m^2 + 9.8\ m^2 + 9.8\ m^2}{3}$$

$$= 10.1\ m^2$$

$$Q_{NSL} = V_{NSL} \times A_{NSL} = 1.9\ m/s \times 10.1\ m^2 = \mathbf{19.3\ m^3/s}$$

Since only 850 l/s (0.85 m^3/s) is needed there is plenty of water available in the stream.

D. Flow at High Flood Level (HFL)

Flow at the HFL will be the most difficult condition for which the weir will have to be stable, so it necessary to calculate flow at HFL. The information will be necessary in future calculations.

Calculating Flow at HFL using Manning Formula:

$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

Calculating Slope (S) from values shown in figures 1 and 2:

$$S\ (A \text{ to } B) = \frac{98.65\ m - 97.38\ m\ (\text{see fig.2})}{70\ m\ (\text{see fig.1})} = 0.018$$

$$S\ (B \text{ to } C) = \frac{97.38\ m - 96.12\ m}{65\ m} = 0.019$$

$$S\ (avg) = \frac{0.019 + 0.018}{2} = \mathbf{0.019}$$

n = 0.06 (from table) Rivers with fairly straight alignment (since not particularly obstructed river user lower number)

$$R = \frac{\text{Cross-Sectional Area (see figure 2)}}{\text{Wetted Perimeter (see figure 2)}}$$

$$V_{A\text{-}A'} = \frac{1}{0.06} \times \left[\frac{26.1\ m^2}{16.1\ m}\right]^{2/3} \times 0.019^{1/2}$$

$$= 16.7 \times 1.38 \times 0.14 = 3.2\ m/s$$

$$V_{B\text{-}B'} = \frac{1}{0.06} \times \left[\frac{21.7\ m^2}{14.6\ m}\right]^{2/3} \times 0.019^{1/2}$$

$$= 16.7 \times 1.30 \times 0.14 = 3.0\ m/s$$

$$V_{C\text{-}C'} = \frac{1}{0.06} \times \left[\frac{23.7\ m^2}{15.7\ m}\right]^{2/3} \times 0.019^{1/2}$$

$$= 16.7 \times 1.32 \times 0.14 = 3.1\ m/s$$

Avg. V @ HFL = 3.1 m/s

Determining Cross-Sectional Area (areas from figure 2):

$$\text{Area (avg.)} = \frac{A_{A\text{-}A'} + A_{B\text{-}B'} + A_{C\text{-}C'}}{3} = \frac{26.1m^2 + 21.7m^2 + 23.7m^2}{3}$$

$$= 23.8\ m^2$$

$$Q_{HFL} = V_{HFL} \times A_{HFL} = 3.1\ m/s \times 23.8\ m^2 = \mathbf{73.8\ m^3/s\ \ say\ 75\ m^3/s}$$

E. Calculating Scour

Empirically-Derived Formula for the NWFP, Pakistan indicate that:

$$\text{Scour Depth} = 1.4 \times (Q/Cr)^{3/10}$$

where: Scour Depth = Maximum Scour Depth below NSL around the structure to be built
Q = Flow in m^3/s
Cr = Kennedy's velocity Ratio (from table)

This formula applies to rivers subjected to sustained floods. Other formula apply to other conditions.

Kennedy's Velocity Ratio (Cr)	**Nature of Bed Materials**
0.8	Fine Sand
1.0	Medium Sand
1.25	Coarse Sand
1.5	Fine Sand
2.0	Medium Gravel
2.5	Coarse Gravel
3.0	Small Boulders and Gravel
3.5	Medium Boulders and Gravel
4.0	Large Boulders and Gravel

At this site soils are Medium Gravel, so a value of 2.0 is used for Cr.

$$\text{Scour Depth} = 1.4\ (75\ m^3 \text{ per sec.}/2.0)^{3/10}$$
$$= 4.2\ m$$

Because NSL at B-B (location of structure) is 96.25 m,

Scour Depth = 96.25 m - 4.2 m = 92.05 m

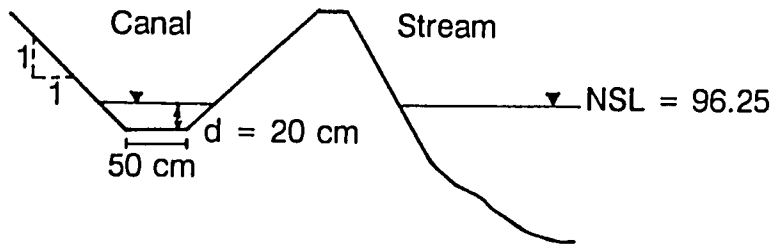
V. DETERMINING NECESSARY HEIGHT OF THE WEIR

A. Introduction

The weir must be constructed so that water is high enough in the canal to deliver the water requirement, 850 l/s.

B. Flow in Canal at NSL

At NSL the water level in the canal is 20 cm. deep. The canal most closely approximates a trapezoid with 1:1 sides. The relationships are as shown:



Because the slope of the sides is 1:1, the length of those sides will be:

$\sqrt{2}$ x depth, or 1.4 x depth

The surveyors determine the elevation of the water at the outlet (96.25 m) and at a point 50 m down the canal (96.10 m). Based on this information, the engineer determines that the slope of the canal is as follows:

$$S = \frac{96.25\text{ m} - 96.10\text{ m}}{50\text{ m}} = 0.003$$

this information is used to calculate flow using the Manning formula as follows:

$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

In this case:

S = 0.003
n = 0.027 for small soil canals

$$V_{20cm} = \frac{1}{0.027} \times \left[\frac{0.14\text{ m}^2}{1.06\text{ m}}\right]^{2/3} \times 0.003^{1/2}$$

V_{20cm} = 37 x 0.28 x 0.055 = 0.56 m/s

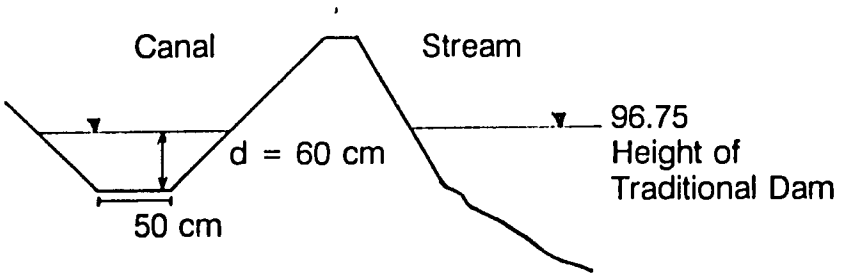
(velocity with float method = 0.60 m/s x 0.85 = 0.5 m/s - close to calculated value)

A = 0.14 m^2 so,

Q = V x A = 0.56 m/s x 0.14 m^2 = 0.079 m^3/s = 80 l/s

C. Flow in Canal if Water is as High as Traditional Dam Structure

At height of traditional dam, water will be 60 cm deep in the canal.



$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

In this case:

S = 0.003
n = 0.027 for small soil canals

$$V_{60cm} = \frac{1}{0.027} \times \left[\frac{0.66\ m^2}{2.2\ m}\right]^{2/3} \times 0.003^{1/2}$$

$$V_{60cm} = 37 \times 0.45 \times 0.055 = 0.9\ m/s$$

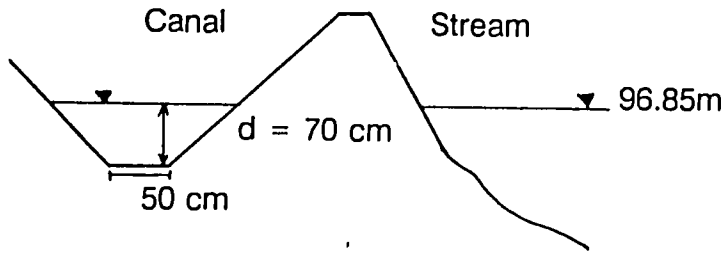
$A = 0.66\ m^2$ so,

$Q = V \times A = 0.9\ m/s \times 0.66\ m^2 = 0.60\ m^3/s = 600\ l/s$

Since 850 l/s is needed, building the traditional structure will not provide as much water as is needed.

D. Raising the Height of the Dam Slightly to Increase Flow to Obtain the Water Requirement

At height of traditional dam, water will be 60 cm deep in the canal. However, this is not deep enough to provide enough water to the fields. By raising the weir 10 cm. it may provide enough water without substantially altering any accepted water rights system.



$$V = \frac{1 \times R^{2/3} \times S^{1/2}}{n}$$

In this case:

S = 0.003
n = 0.027 for small soil canals

$$V_{70cm} = \frac{1}{0.027} \times \left[\frac{0.84\ m^2}{2.5\ m}\right]^{2/3} \times 0.003^{1/2}$$

$$V_{70cm} = 37 \times 0.48 \times 0.055 = 0.98\ m/s$$

$A = 0.84\ m^2$ so,

$$Q = V \times A = 0.98\ m/s \times 0.84\ m^2 = 0.83\ m^3/s = 830\ l/s$$

Since 850 l/s is needed, a structure built to raise the water to 70 cm. in the canal will approximately meet water requirement for the land to be irrigated. This will be a height of 96.75 m.

VI. DESIGN CONSIDERATIONS

A. Introduction

Based on the above-described field conditions and requirements, the engineers understand that their design will have to consider the following:

1.) Necessary height to divert water.
2.) Safety against scour.
3.) Stability against overturning.
4.) Stability against sliding.
5.) Safety against piping and seepage.

B. Necessary Height to Divert Water

The diversionary weir must be constructed to a height of 96.75 m which is 2 m above the base of the stream at the deepest point in cross-section B-B'

Taking into account height and the other design considerations, the design engineers propose the structure shown in figures 4 and 5.

C. Safety against Scour

Since the primary location of scour will be behind the diversionary weir as water comes over the weir. The design engineers propose to put a gabion apron on the backside of the weir. The dimensions of the apron will be governed by the following equations:

Thickness of the Apron = $3/50 \times (Q_{HFL})^{1/3}$

$= 3/50\ (75\ m^3/s)^{1/3} = 0.25\ m$

RIP's engineers decide to make the apron 50 cm thick as this will be easier to fill and the thickness is more easily available.

Length of Apron = 1.41 x (depth of scour below weir)

= 1.41 x (96.45m - 92.05) = 3.6 m

As gabions are not built in odd sizes, the engineers decide to make the apron 4m wide.

At worst conditions of scour on the backside of the weir, the river will scour to scour depth and the apron will be $\sqrt{2}$ x depth of scour. This governs the length of the apron.

Figure 4

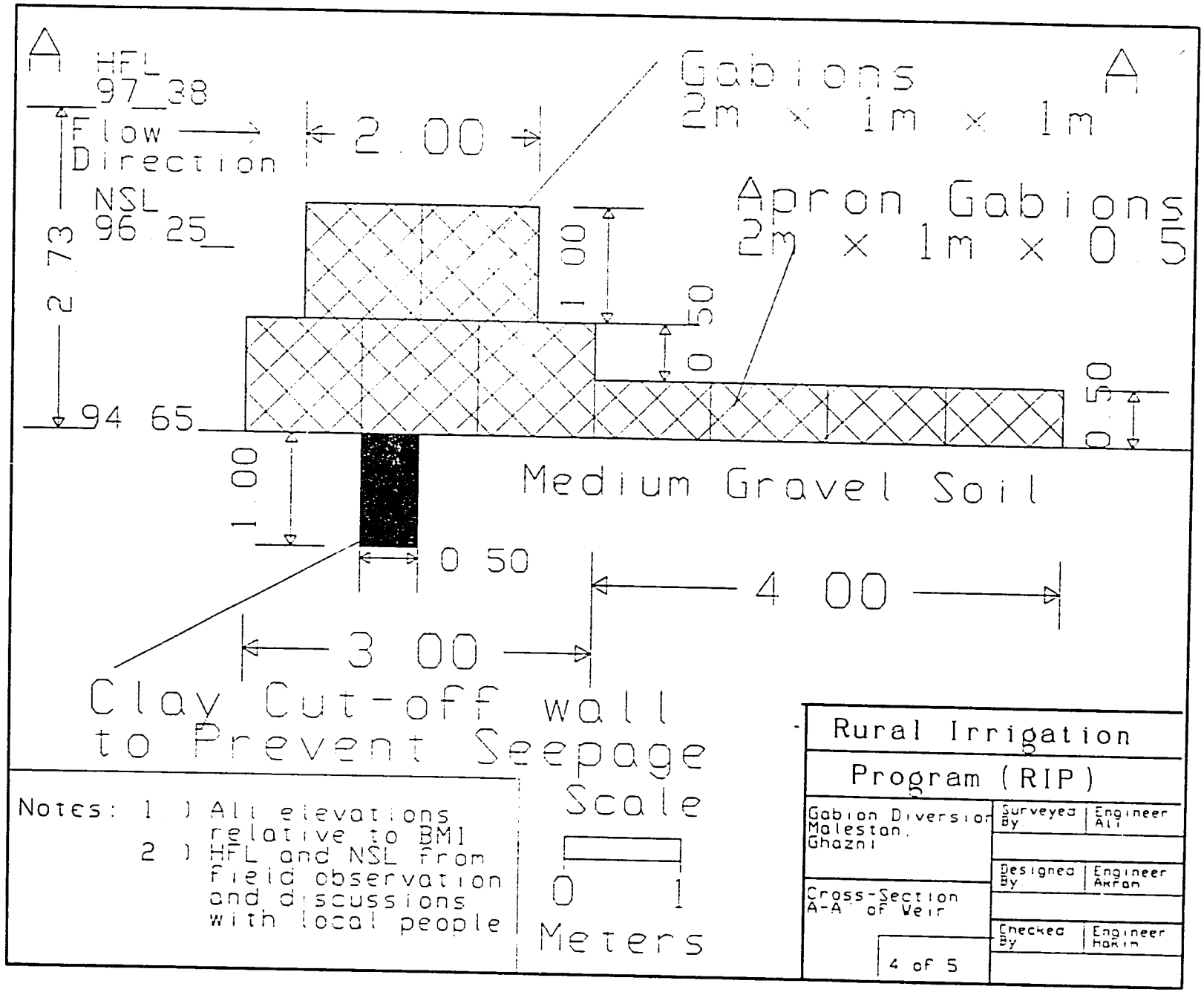
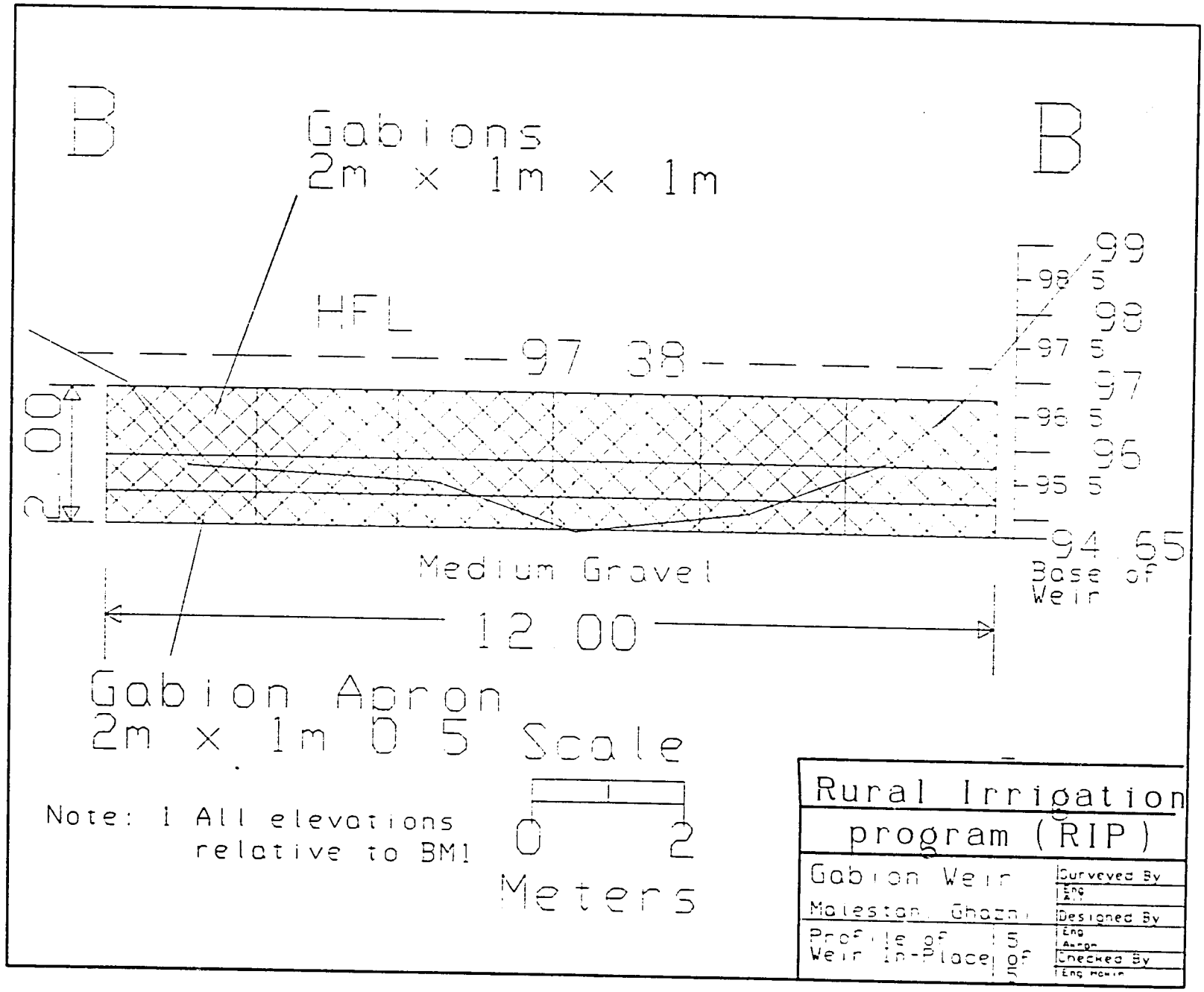

A
HFL
97 38
Flow
Direction
NSL
96 25
2 73
94 65
2 00
Gabions
2m x 1m x 1m
A
Apron Gabions
2m x 1m x 0 5
1 00
0 50
0 50
1 00
Medium Gravel Soil
0 50
4 00
3 00
Clay Cut-off wall
to Prevent Seepage
Notes: 1) All elevations relative to BM1
2) HFL and NSL from field observation and discussions with local people
Scale
0
1
Meters
Rural Irrigation
Program (RIP)
Gabion Diversion
Maleston,
Ghazni
Cross-Section
A-A of Weir
4 of 5
Surveyed By
Engineer Ali
Designed By
Engineer Akram
Checked By
Engineer Hakim

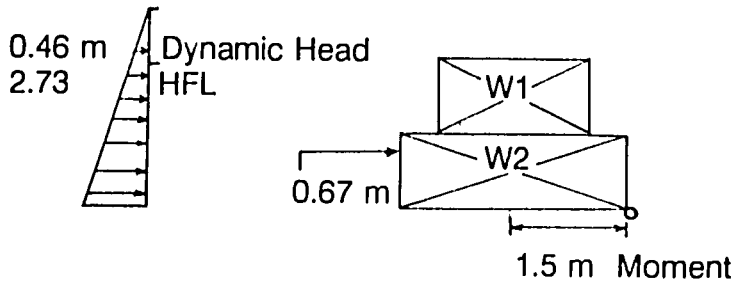
Figure 5


B
B
Gabions
2m x 1m x 1m
HFL
97 38
99
98 5
98
97 5
97
96 5
96
95 5
94 65
Base of
Weir
2 00
Medium Gravel
12 00
Gabion Apron
2m x 1m 0 5
Scale
0
2
Meters
Note: 1 All elevations
relative to BM1
Rural Irrigation
program (RIP)
Gabion Weir
Malestan, Ghazni
Profile of
Weir in-Place
5
of
Surveyed By
Eng
A.T.
Designed By
Eng
Aman
Checked By
Eng Hakim

D. Safety against Overturning

The structure should be safe against overturning during high flood conditions. RIP engineers feel that the design should have a safety factor of greater than 2.

Overturning Forces:



The overturning forces are caused by the static head of water and the dynamic head of water. The equation for this pressure is as follows:

$$P_o = w \times h^2/2$$

where:
P_o = Pressure of Overturning in kg-m
w = density of water (1,000 kg/m^3)
h = Total Head (static head + dynamic head)

In the worst case which occurs at HFL:

h static = 2.73 m (HFL-bed level)
h dynamic = $V_{HFL}^2/2g$

where:
g = 9.8 m/s^2
V_{HFL} = 3 m/s (from Q_{HFL} calculation)

$$h\ dynamic = \frac{9\ m^2/s^2}{2 \times 9.8\ m/s^2} = 0.46\ m$$

so,

$$P_o = \frac{1{,}000\ kg/m^3 \times (2.73\ m + 0.46\ m)^2}{2} = 5{,}100\ kg$$

This force is acting on a moment arm 1/3 x height of structure

= 1/3 x 2 m = 0.67 m

M_o = 5,100 kg x 0.67 m = 3,400 kg*m

Stabilizing Forces are due to the weig . of the Gabions which are as follows:

Density of Rock = 2,500 kg/m^3
with 25% voids in Gabion = 1,875 kg/m^3 say 1,850 kg/m^3

W_1 = 1 m x 2 m x 1 m (deep) x 1,850 kg/m^3 = 3,700 kg
W_2 = 1 m x 3 m x 1 m (deep) x 1,850 kg/m^3 = 5,550 kg

Total	9,250 kg

This force is acting on a moment arm at the center of the base of the gabion 1.5 m from the moment.

M_s = 9,250 kg x 1.5 m = 13,875 kg*m

So,

$$\frac{M_s}{M_o} = \frac{13{,}875 \text{ kg*m}}{3{,}400 \text{ kg*m}} = 4.1 > 2 \text{ SAFE AGAINST OVERTURNING}$$

E. Safety Against Sliding

According to Design of Small Dams, structures should have a safety factor of 1.25 against sliding under worst conditions and a safety factor of 2.0 under normal conditions. For this reason, we need to analyze for 2 cases.

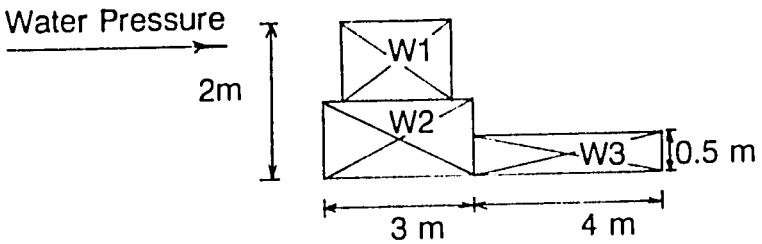
Under Worst Conditions:

$$\text{Safety against Sliding} = \frac{\text{Stabilizing Weight x Friction Coefficient}}{\text{De-stabilizing Weight}}$$

The Friction Coefficients are as follows:

Friction Coefficient	Condition Masonry or Concrete on:
0.65	Rock
0.60	Masonry or Concrete
0.50	Gravel
0.40	Sand
0.30	Clay

In this particular case we have gabion on gravel which most approximates masonry on gravel, so we assign a coefficient of 0.50.



Stabilizing Weights include the weir and the apron which are as follows:

W_1 = 1 m x 2 m x 1 m (deep) x 1,850 kg/m^3 = 3,700 kg
W_2 = 1 m x 3 m x 1 m (deep) x 1,850 kg/m^3 = 5,550 kg
W_3 =0.5 m x 4 m x 1 m(deep) x 1,850 kg/m^3 = 3,700 kg

Total 12,950 kg

Destabilizing Weights are the weight of water including dynamic head which is 5,100 kg.

$$\text{So } \frac{12{,}950 \text{ kg} \times 0.5}{5{,}100 \text{ kg}} = 1.27 > 1.25 \text{ SAFE AGAINST WORST CONDITION}$$

Under Normal Conditions: In this situation, water will reach to just the top of the weir, and the velocity of water will be 2 m/s @ NSL.

$P_o = w \times h^2/2$ Where:

P_o = Pressure of Overturning in kg-m
w = density of water (1,000 kg/m^3)
h = Total Head (static head + dynamic head)

In the normal case which occurs at NSL:

h static = 2.0 m
(Height of Structure because structure raises the water above NSL)
h dynamic = $V_{HFL}^2/2g$ where:
g = 9.8 m/s^2
V_{HFL} = 2 m/s (from Q_{NSL} calculation)

$$\text{h dynamic} = \frac{4 \text{ m}^2/\text{s}^2}{2 \times 9.8 \text{ m/s}^2} = 0.20 \text{ m}$$

so,

$$P_o = \frac{1{,}000 \text{ kg/m}^3 \times (2.0 \text{ m} + 0.2 \text{ m})^2}{2} = 2{,}400 \text{ kg}$$

$$\text{So } \frac{12{,}950 \text{ kg} \times 0.5}{2{,}400 \text{ kg}} = 2.7 > 2.0 \text{ SAFE AGAINST NORMAL CONDITIONS}$$

F. Safety Against Piping and Seepage

Because the soils at the site are gravelly, there will be some seepage and potential piping beneath the structure. In order to eliminate this problem, RIP will excavate down 1m by approximately 0.5 m wide and fill with compacted clay as shown on figure 4. This will serve as a cut-off wall to minimize piping and seepage.

VI. CONSTRUCTION SPECIFICATIONS

During Construction, the following should be considered:

a.) Soils should be excavated to the level indicated in figure 5. These elevations should be checked with a level before construction.
b.) The clay cut-off wall should be constructed of stiff clay in 20 cm lifts which are compacted individually.
c.) The cut-off wall should be built during the driest part of the year. If soils are not reasonably dry, it may be necessary to de-water with a pump.
d.) Gabion wire should be tripple-twisted during weaving.
e.) Gabion wire should be galvanized to prevent rust.
f.) Stones for gabions should be angular and hand-packed. Ideally, the structure should be able to keep its shape without the wire to hold it together.
g.) The weir should be plastered with mud and straw on the upstream side in the traditional way to make it less permeable.

VII. COSTING

Attached are a bill of materials, a labor estimate and a cost estimate for the proposed weir. For information about estimating and costing see:

Dutta, B.N.. 1985. **Estimating and Costing in Civil Engineering: Theory and Practice, Twenty Second Edition.** S. Dutta and Company, Lucknow. 906p.

Design Prepared By: Howard Evan Canfield, August, 1991
Checked By: Eng. Mohammad Hashem

Bill of Materials

Gabion Diversion Weir, Malestan, Ghazni

Item #	Details of Item	No.	Length meters	Width meters	Ht. or Depth meters	Quantity
A	Excavation					
1	Foundation of Weir (based on area of profile 10sq.m)	1	10	3	1	30 cu.m.
2	Foundation of Apron (based on area of profile 10sq.m)	1	10	4	1	40 cu.m.
3	Cut-Off Wall	1	12	0.5	1	6 cu.m.
	Total					76 cu.m.
B	Clay Cut-Off Wall					
1	Compacted Clay	1	12	0.5	1	6 cu.m.
C	Gabion Construction					
1	Stone Work in Gabion					
	a. Weir	1	12	3	1	36 cu.m.
		1	12	2	1	24 cu.m.
	sub-total					60 cu.m.
	b. Aprc.ı	1	12	4	0.5	24 cu.m.
	Total					84 cu.m.
2	Gabion Sheets					
	a. Weir	120	2	1		240 sq.m
	(30 2x1x1 gabions=60 cu.m.)	60	1	1		60 sq.m
	sub-total					300 sq.m
	b. Apron	48	2	1		96 sq.m
	(24 2x1x.5 gabions=24cu.m)	48	2	0.5		48 sq.m
		48	1	0.5		24 sq.m
	sub-total					168 sq.m
	Total					468 sq.m

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Labor Estimate

Gabion Diversion Weir, Malestan, Ghazni

Details of Item	Quantity	Productivity Norm	Man-Days
1. Excavation	76 cu.m.	2 cu.m./md	38
Unskilled, 1/2 Wage			
Excavation: 2 cu.m./man-day for Unskilled Labor in Difficult Soil (from UN)			
2. Compacting Clay	6 cu.m.	4 cu.m./md	1.5
Unskilled, 1/2 Wage			
Compacting Clay: Assume 4 cu.m./man-day for Unskilled Labor based on UN norm for Road Compaction			
3. Dry Masonry Stone Work (Includes Wiring Gabions Together)			
Skilled Labor, Full Wage	84 cu.m.	2 cu.m./md	42
Unskilled, 1/2 Wage	84 cu.m.	1 cu.m./md	84
Dry Masonry Including Tying Gabions Together: 1 skilled and 2 unskilled can construct 2 cu.m. in a day (VITA)			
4. Gabion Weaving			
Semi-Skilled, Full Wage	468 sq.m	2.5 sq.m./md	187.2
Gabion Weaving: A trained gabion weaver can make 2.5 sq.m. of Gabion in a day (IRC, Self Reliance Program norm)			

WMM 9-1-91

Cost Estimate for Gabion Diversion Weir, Malestan, Ghazni

	Item	No.	Unit	Unit Cost Rs	Total Cost Rs
A.	Labor				
	1. Unskilled Labor – 1/2 Wage				
	a. Excavation	38	man-days	25	950
	b. Compacting Clay	2	man-days	25	50
	c. Dry Masonry	84	man-days	25	2,100
	sub-total				3,100
	2. Semi-Skilled Labor				
	a. Gabion Weaving	187	man-days	50	9,350
	+ 10%	19	man-days	50	950
	sub-total				10,300
	3. Skilled Labor				
	a. Dry Masonry	42	man-days	100	4,200
	+ 10%	4	man-days	100	400
	sub-total				4,600
Total Labor Cost					18,000
B.	Materials				
	1. Clay for Cut-Off Wall (Community Contribution)	6	cu.m.	0	0
	2. Stones For Gabions (Community Contribution)	84	cu.m.	0	0
	3. Wire For Gabions	1,217	kg	25	30,425
	+ 10% Wastage	122	kg	25	3,050
	sub-total				33,475
	4. Wire for Tying	122	kg	25	3,050
Total Materials Cost					36,525
C.	Transport				
	1 Wire Transport to Malestan	1,360	kg	10	13,600
TOTAL COST OF CONSTRUCTION					68,125

Notes: 1.) Amount of Wire for gabion is 2.6 kg/sq.m
(From IRC Self-Reliance Program)
So, Total Wire is: 2.6 kg/sq.m. x 468 sq.m. = 1,217 kg.
2.) Wire for Tying Gabions Together is 10% of Total for Weir

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SAMPLE GABION OFF-TAKE DESIGN

The following is an EXAMPLE of the design steps that Engineers should do. It is not a design to be applied to all locations. Engineers should do a proper design and estimate for their particular location. Furthermore, this design only includes the off-take itself. In the sample location, as well as other locations, retaining walls will be necessary.

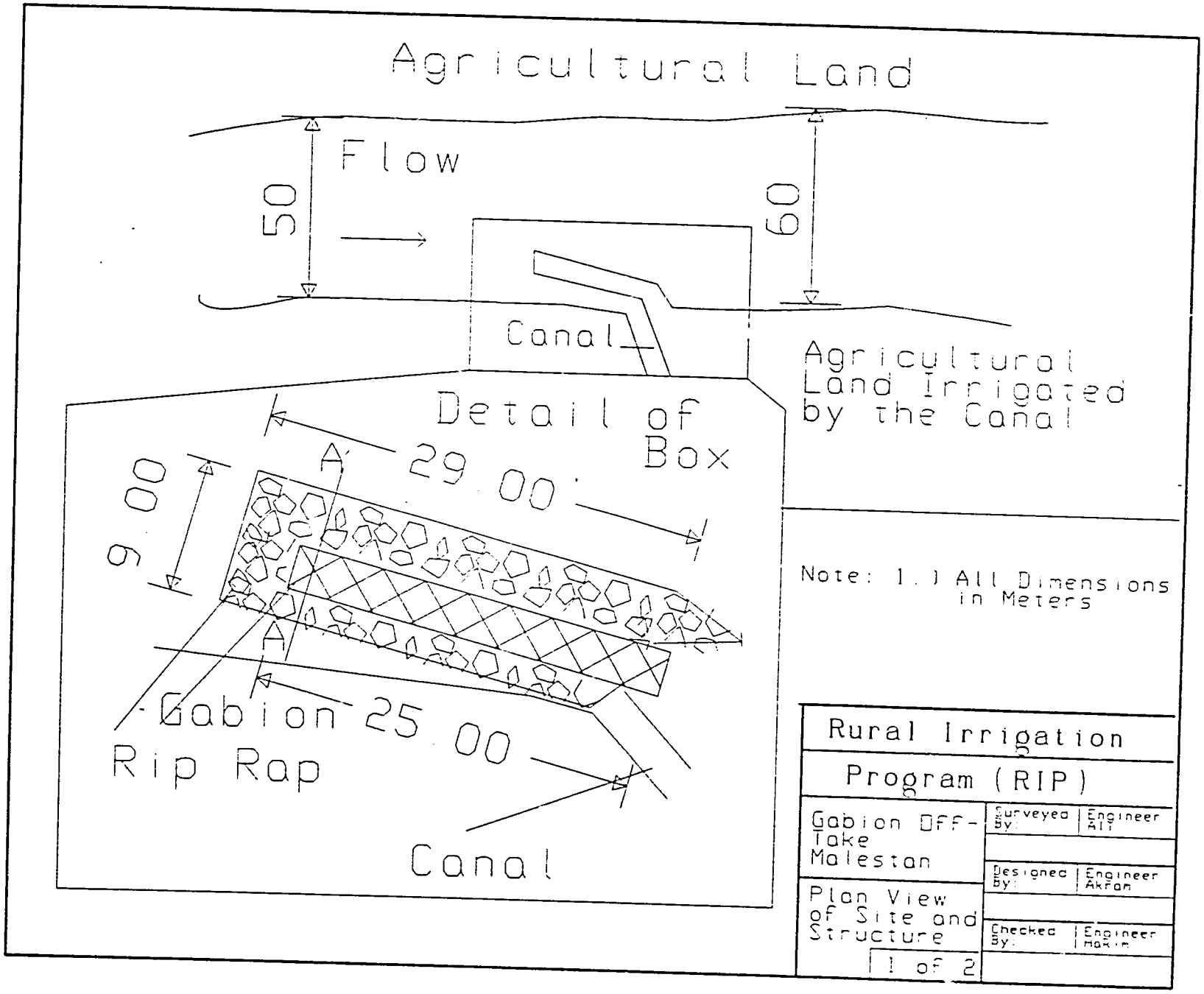
I. PROBLEM STATEMENT

Most of the Afghan farmers are using the traditional system of off-takes for diverting water to their lands. Off-takes are built of local materials that are available in the area. This type of off-take is very weak against heavy flooding and are frequently destroyed. The farmers from one/several villages would participate in the re-construction of the off-take each time it is destroyed. A more permanent structure would save the farmers much time and effort. They could use the saved time on some other agricultural activities. IRC/RAP is willing to consider proposals for construction of such structures. To assist NGO's in the design of gabion off-takes IRC/RAP prepared a sample design as a guide.

The Rural Irrigation Program (RIP) met with farmers, elders and shuras to discuss their community's problems. As a result, they decided to change the traditional irrigation system to a more developed system i.e. gabion with stone masonry. As the river was very wide and people used an off-take in the past, RIP wants to build an improved structure in the same location. It would not be possible to build a gabion weir across the river as it would be difficult due to its width and would need heavy machinery.

The proposed location of this structure is shown in figure 1.

FIGURE 1



Appendix II - Gabion Off-Take

II. FIELD SURVEY

A. Introduction

The RIP design engineer considers the situation before sending a field team to survey. He decides to gather enough information to design a structure using traditional engineering design considerations. He also decides to try some short-cut design methods suggested by the Maccaferri Gabion manufacturers.

RIP sends three field engineers to carry out engineering and agriculture surveys. A sign of the traditional off-take structure is present in the stream. This off-take does not raise enough water to the channel to irrigate the surrounding fields, except during the time of flooding. Based on this, the field engineers know that:

1.) The new off-take should be built a little higher than the traditional structure.

2.) An off-take built at this height will supply adequate water to the fields.

3.) It should not be higher than the surrounding area of cultivation.

B. Survey Equipment

The field surveyors bring the following equipment:

1.) A level and rod to determine elevation.

2.) Measuring tape to determine short lengths.

C. Data Collected

The field surveyors should collect the following information:

1.) A sketch map of the project area showing the channel and the location of the off-take (figure 1).

2.) The depth of the water in meters.

3.) Soil types. The surveyors especially note particle size and whether the soils are plastic/cohesive.

4.) The material of the bed of the river (i.e. clay, sand or slit...etc).

5.) The high flood level, H.F.L., or mark of the HFL on the surrounding area by:

a.) Asking from an elder.
b.) Sign of high flood during the past years.

III. WATER REQUIREMENT

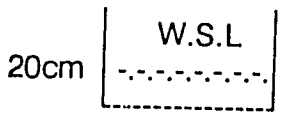
According to the FAO 1975 survey of Afghanistan, 1 litre/second can irrigate approximately 1 hectare of land. The RIP agriculture survey indicates the canal irrigates a command area of 5,000 jeribs which is equal to 1,000 hectares. (Please see Determining Area Irrigated in the Water Requirement of the Diversion Dam - Appendix 1)

The irrigation channel is 3 m wide and 1.5 m deep with a bed of sandy soil. The present water depth is 20 cm and the velocity of the flow is 0.2 m/sec. The velocity was determined using the float method. After calculation, the discharge was found to be 0.12 cu.m/sec. This is sufficient to irrigate 120 hectares of land.

An off-take built to increase the water depth to 120 cm will increase the velocity to 0.3 m/sec. This will give a discharge of 1.08 cu.m/sec which will irrigate 1,080 hectares of land. This depth was selected because the people indicated to the engineers that the traditional structure built to this height worked previously. The calculation to determine the water requirement follows:

A.) Water depth before construction of off-take.

Depth of water = 20 cm
Velocity of water = 0.2 m/sec (Float method)



$Q = V \times A$

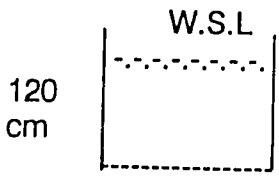
$A = 0.2 \times 3 = 0.6$ sq.m

$Q = 0.2 \times 0.6 = 0.12$ cu.m/sec

Q = 120 litre/sec which will irrigate 120 hectares of land.

B.) Water depth after construction of off-take.

Depth of water = 120 cm
Velocity of water = 0.3 m/sec



$Q = V \times A$

$A = 1.2 \times 3 = 3.6$ sq.m

$Q = 3.6 \times 0.3 = 1.08$ cu.m/sec

Q = 1,080 litre/sec which will irrigate 1,080 hectares of land.

IV. DESIGN AND ANALYSIS OF OFF-TAKE

A. Introduction

Based on the above-described field conditions and requirements, the engineers understand that their design will have to consider the following:

1.) Stability against overturning.
2.) Stability against sliding.

As the direction of water is not perpendicular to the face of the structure, the following design is extremely conservative. The proposed design is shown in figure 2.

B. Safety Against Overturning

The structure should be safe against overturning during high flood conditions. RIP engineers feel that the design should have a factor of safety greater than 2.

The overturning forces are caused by the static head of water and the dynamic head of water. The equation for this pressure is as follows:

$H = H_1 + H_f$ — H = Total head (Dynamic + static)

$H_1 = 1.74$ m — H_1 = High flood level. (H.F.L)

$H_f = 0.204$ m — $H_f = v^2/2g$ dynamic head

$H = 1.944$ m

$V = 2$ m/s — V = velocity from Q_{HFL} calculation

F = force acting on the up-stream side of the structure:

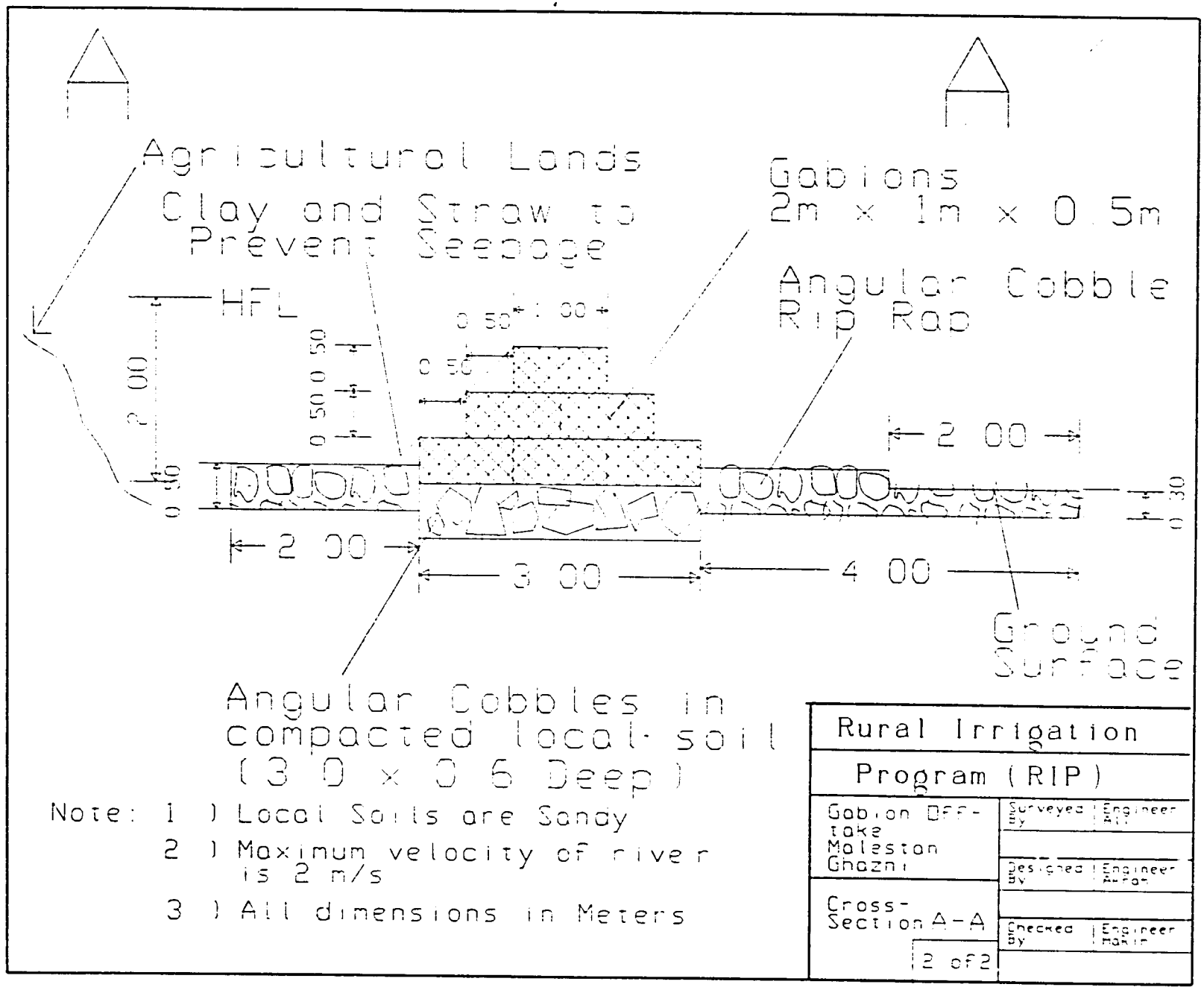
$F = W \times H^2/2$ — where W is the weight of water (1,000 kg/m^3)

$F = 1 \times (1.944)^2/2 \times 1 = 1.89$ tonnes

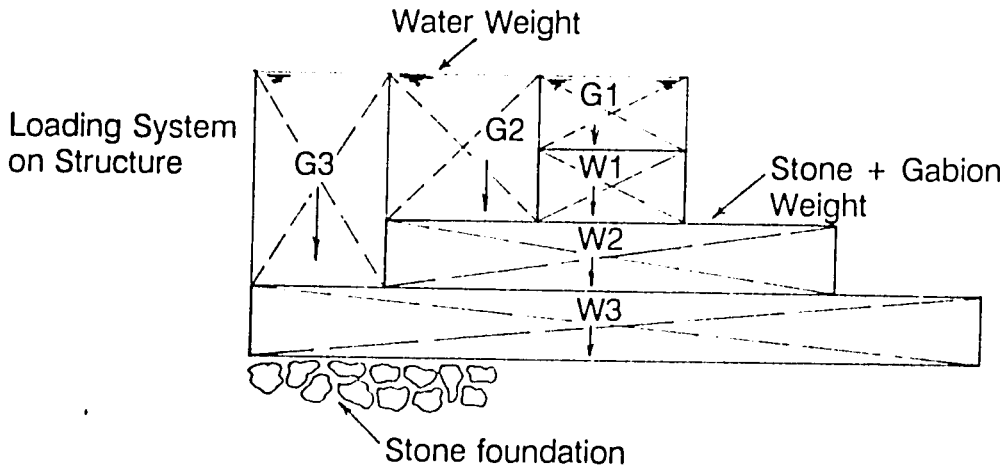
The force acting on 1/3 height of NSL (normal surface level):

$M_{fd} = 0.333 \times 1.74 \times 1.89 = 1.1$ tonne x M Overturning moment

Figure 2


Agricultural Lands
Clay and Straw to Prevent Seepage
Gabions 2m x 1m x 0.5m
Angular Cobble Rip Rap
HFL
2.00
0.50
0.50
0.50
0.50
1.00
0.50
0.30
2.00
2.00
3.00
4.00
Ground Surface
Angular Cobbles in compacted local soil (3.0 x 0.6 Deep)
Note: 1) Local Soils are Sandy
2) Maximum velocity of river is 2 m/s
3) All dimensions in Meters
Rural Irrigation Program (RIP)
Gabion Off-take Maleston Ghazni
Cross-Section A-A
2 of 2
Surveyed By
Engineer Ali
Designed By
Engineer Akram
Checked By
Engineer Makin

Now we should calculate the weight of the off-take:



Weight of Stone with Gabion = 2,400 kg/m^3

With 25% voids in Gabion = 1,800 kg/m^3

W_1 = 1 x 0.5 x 1 x 1.8 = 0.9 t G_1 = 1 x 1 x .2 x 1 = 0.2 t

W_2 = 2 x 0.5 x 1 x 1.8 = 1.8 t G_2 = 1 x 1 x 0.5 x 0.7 = 0.35 T

W_3 = 3 x 0.5 x 1 x 1.8 = 2.7 t G_3 = 1 x 1 x 0.5 x 1.2 = 0.6 t

Total weight 5.4 t 1.15 t

Note: G1, G2 and G3 are the water weight on the structure, which aids the stability of the off-take. As the structure will be sealed on the up-stream side with clay and straw, it will act as an impermeable structure. Therefore, the weight of water will also act as a stabilizing factor on the structure.

This force is acting on a moment arm at the center of the base of the gabion 1.5 m from the moment point.

M_d = 8.1 tm

Moment due to the water acting downward on the structure and has different lever arms as following:

M_{G1d} = 0.2 x 1.5 = 0.3 tm
M_{G2d} = 0.35 x 2.25 = 0.7875 tm
M_{G3d} = 0.6 x 2.25 = 1.65 tm

Total moment G1 = 2.74 tm

Grand total of stabilizing moment is = 10.84 tm

Check:

S.F. (overturning) = 10.84/1.1 = 9.8 > 2 safe against overturning.

Under worst conditions structure should have a safety factor of 1.25 against sliding.

$$\text{Safety against sliding} = \frac{\text{Stabilizing Weight x Friction Coefficient}}{\text{Destabilizing Weight}}$$

S.F. (sliding) = 0.5 x 6.55/1.89 = 1.7336 > 1.5 safe against sliding (m = 0.5 coefficient of friction).

Note: You should follow the steps of design. We are ignoring uplift pressure because MACCAFERRI GABIONS publication states that uplift pressure will not act on gabion and stone structures due to the porosity of the structure. We can say the foundation should be from stone masonry to increase the coefficient of friction against sliding and to prevent settlement of the structure.

V. CONSTRUCTION SPECIFICATION

For construction of a gabion with stone masonry structure the following procedure should be used:

1.) Before construction work in a river can begin, the stream flow must be diverted.
2.) A cofferdam is needed to keep the construction site dry.
3.) Collect angular stones near to square, rectangular or triangle shape.
4.) Galvanized wire should be used for the gabions.
5.) Excavate the foundations until hard soil is reached.
6.) Place stones in the excavated foundation.
7.) Place gabion sheets on top of the foundation.
8.) RIP engineers decided they need to build the off-take using 2 m x 1 m x 0.5 m and 1 m x 1 m x 0.5 m blocks whcih are filled with the angular stones.
9.) After completion of stone masonry works, handpicked rocks should be placed as Rip Rap on the upstream, downstream and front side of the structure according to the apron drawn in figure 1.
10.) A layer of compacted clay is necessary in the upstream Rip Rap voids to prevent piping and seepage.

Bill of Materials Gabion Offtake

Item #	Details of Item	No.	Length meters	Width meters	Ht. or Depth meters	Quantity
A	Excavation					
1	Foundation of Gabion	1	25	3	0.5	37.5 cu.m
2	Foundation of Rip Rap					
	Upstream	1	25	2	0.3	15 cu.m
	Downstream	1	25	4	0.3	30 cu.m
	Rip RAP	1	4	9	0.25	91.5 cu.m
	Total					82.5 cu.m
B	Foundation Stone Work	1	25	3	0.5	37.5 cu.m
C	Gabion Construction					
1	Stone Work in Gabion	1	25	3	0.5	37.5 cu.m
		1	25	2	0.5	25 cu.m
		1	25	1	0.5	12.5 cu.m
	Subtotal Stonework					75 cu.m
2	Gabion Sheets	144	2	1		288 sq.m
	(2x1x0.5 gabion)	144	1	0.5		72 sq.m
	72 gabions	144	2	0.5		144 sq.m
						504 sq.m
	(1x1x0.5 gabion)	24	1	0.5		12 sq.m
	12 gabions	12	1	1		12 sq.m
						24 sq.m
	Total All Gabion					528 sq.m
D	Rip Rap					
	Upstream	1	25	2	0.5	25 cu.m
	Downstream	1	25	2	0.5	25 cu.m
		1	25	2	0.25	12.5 cu.m
	Front side	1	9	4	0.5	36 cu.m
	Total Rip RAP					98.5 cu.m

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Labor Estimate
Gabion offtake Malestan, Ghazni

Details of Item	Quantity
1. Excavation	82.5cu.m
Unskilled 1/2 wage	
Excavation: 2 cu.m/man-day for Unskilled labor in difficult soil (from UN)	
2. Dry Masonry Stone Work	
(Includes Wiring Gabions Together)	
Skilled Labor, Full Wages	75 cu.m
Unskilled, 1/2 Wage	75 cu.m
Dry Masonry Including Tying Gabions Together:	
1 skilled and 2 unskilled can construct 2 cu.m. in a day (VITA)	
3. Gabion weaving	
Semi-Skilled, Full Wage	528 cu.m
Gabion Weaving: A trained gabion weaver can make 2.5 sq.m. of Gabio	m. of Gabi ion
in a day (IRC, Self Reliance Program norm)	
4. Rip Rap	
Skilled	98.5 cu.m./md
Bassed on ACLU norm 3. cu.m./man-day for skilled labor	
Unskilled	
Bassed on ACLU norm 1.5. cu.m./man-day for unskilled labor	98.5 cu.m./md

Cost Estimate for Gabion Offtake, Malestan, Ghazni

Item	No.	Unit	Unit Cost Rs	Total Cost Rs
A. Labor				
1. Unskilled Labor-1/2 Wage				
a. Excavation	42	man-days	25	1050
b. Dry Stone Wire	75	man-days	25	1875
c. Rip Rap	66	man-days	25	1650
Sub-total			457	4575
2. Semi- skilled Labor				
a. Gabion weaving	211	man-days	50	10550
+ 10 %	21	man-days	50	1050
Sub-total			116	11600
3. Skilled Labor				
a. Dry stone wire	38	man-days	100	3800
b. Rip Rap	33	man-days	100	3300
+ 10 %			71	710
Sub-Total			781	7810
B. Materials				
1. Stones For Gabions	173.	cu.m	0	0
(Community Contribution)				
2. Wire For Gabions	137[illegible]	kg	25	34325
+ 10 % Wastage	137	kg	25	3425
Sub-Total			1452	37750
4. Wire for Tying	137	kg	25	3425
Sub-Total Material Cost			1585	41175
C. Transoprt				
1 Wire Transport to Malestan	1647	kg	10	16470
Total Cost of construction			4617	81630

Notes: 1.) Amount of Wire for gabion is 2.6 kg/sq.m
(From IRC Self-Reliance Program)
So, Total Wire is:2.6 kg/sq.m. x 528 sq.m = 1,373 kg.
2.) Wire for Tying Gabions Togetgher is 10% of Total for Wire.

NGO/DONOR AGREEMENT

Guidelines for the distribution of agricultural inputs in Afghanistan

Drawn up in consultation with members of ACBAR and SWABAC, plus donors

The ACBAR Guidelines for the Planning and Implementation of Projects for Agricultural Rehabilitation in Afghanistan (January 1991) state that:

> "Free distribution of inputs should be discouraged as a general principle except in circumstances of emergency."
>
> "All agencies operating in a given area should follow similar policies..."

These principles were agreed by the ACBAR Agriculture Sub-Committee at the end of 1990. SWABAC had previously reached similar conclusions. However, the need for more specific guidelines became apparent and in June 1991 members of the ACBAR and SWABAC Agriculture Sub-Committees discussed and agreed the following:

1 **Local co-ordination of distribution methods and pricing policies is essential.** All agencies must co-ordinate on a local level (province, district or village level, depending on the circumstances). Where agencies are working in different provinces but still in neighbouring localities, they must still co-ordinate their pricing policies. No agency should work in a new area or start distributing different inputs without having first consulted fully with other agencies working in the same area.

2 **All inputs should be charged for.** Exceptions may be made in cases of emergency or for needy first time recipients.

3 **Inputs may be charged for in various ways:** cash or proportion of harvest or set amount of harvest or services rendered. The principle is to move away from providing inputs where the recipient 'pays' nothing in return.

4 **Greater understanding is needed of pricing strategies,** i.e. how agencies decide their charges. This is not in order to adopt one method only but to enable agencies to adopt the most appropriate one in co-ordination with others. Discussions should be held be early August 1991 to explain and set down different strategies.

5 **In principle, reflow money (i.e. the money received by agencies in return for inputs) should be ploughed back into the same local community for community assistance.**

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6 **Donor policy on reflow must be made explicit** in donor guidelines to potential and existing implementors. Where appropriate, project proposal forms and reporting forms should include sections for this.

7 **Agencies should be aware of the potential problems for field workers relating to reflow and take all measures possible to protect them.**

8 **Community participation must be encouraged.** Agencies should not pay recipients for doing essential work relating to receipt of their inputs: e.g. digging trenches for fruit trees.

9 **Agencies should explain their policies and their commitment to this agreement to donors** and ensure both donor and agency are working to achieve the same practical objectives.

10 **Donors should play a central role in helping to enforce this agreement,** taking responsibility for ensuring that potential recipients presenting project proposals are fully aware of the agreement and intend to adhere to it. Donors should ensure that sufficient consultation and co-ordination has taken place between agencies working or planning to work in the same locality.

11 **Donors should work to improve co-operation between themselves,** in relation to the inputs which they distribute themselves and to the funding of implementors.

12 **All agencies distributing agricultural inputs in Afghanistan should be made aware of this agreement** and be encouraged to adhere to it. This also applies to donor agencies.

13 **There should be a regular six monthly review of how agencies have worked with these guidelines.** The first one will be in December 1991.

ACKNOWLEDGEMENTS

The Following People Submitted Methodologies Used in the Document:

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