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RURAL WATER SUPPLY AND SANITATION PROGRAMS
ASSISTED BY THE
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)
IN
TUNISIA

A Report to The

DIVISION OF INTERNATIONAL HEALTH PROGRAMS

AMERICAN PUBLIC HEALTH ASSOCIATION

1015 Eighteenth Street, N.W.

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RURAL WATER SUPPLY AND SANITATION PROGRAMS IN TUNISIA

Prepared by: F. Eugene McJunkin

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ENVIRONMENTAL SERVICES CORPORATION

April 30, 1976

Dr. Malcolm H. Merrill
Director
Division of International
Health Programs
American Public Health Association
1015 Eighteenth Street, N.W.
Washington, D.C. 20036

Sir:

Transmitted herewith is my report on "Rural Water Supply and Sanitation Programs Assisted by the United States Agency for International Development (USAID) in Tunisia", based on my consultancy in Tunisia from April 4 to April 17.

I briefed AID/Tunisia on this report on April 16 and am tentatively scheduled to brief AID/Washington on May 4.

I appreciate this opportunity to be of service.

Respectfully,

F. Eugene McJunkin

F. Eugene McJunkin
Vice President

Attachment

ACKNOWLEDGEMENTS

I wish to express my appreciation to all those who gave so generously and graciously of their time and knowledge during this consultancy and especially to John Alden, AID/Washington, John W. Macdonald, AID/Tunisia, and George H. Radcliffe, CARE/Tunisia.

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EXECUTIVE SUMMARY

This report is a consultant's review, analysis, and recommendations regarding Tunisian rural water supply and sanitation programs assisted by USAID/Tunisia through operational program grants (OPG's) to CARE/MEDICO/Tunisia, a private voluntary organization (PVO).

The report evaluates and approves the appropriateness of the technology used in these projects. The water sources used are protected springs and rehabilitated dug wells equipped with hand pumps. A new hand pump, developed, manufactured, and successfully used in Tunisia is described. Problems and methods of hand pump maintenance are described in detail.

Eight possible rural water supply and sanitation activities are recommended as components in a rural development project under consideration in the newly formed Siliana Governorate.

Past performance of CARE/MEDICO/Tunisia on similar Tunisian projects is reviewed and CARE is recommended as a potential grantee on the Siliana project and a possible similar project in Kairouan Governorate. CARE has rehabilitated some 500 Tunisian wells and springs and installed 400 hand pumps over the past 4 years. AID/Tunisia has contributed 1/3 of the $1.3 million capital costs.

A Tunisian foundry, SOFAMECA, was found to be capable of manufacturing the AID/Battelle hand pump, now in the prototype stage and needing field testing.

Pit and aqua privies were found to be the most appropriate excreta disposal alternatives in rural areas in Tunisia. When sewers are provided in villages and wastewater treatment is required, oxidation ponds and land disposal of wastewaters are appropriate alter-

natives.

Six annexes provide technical information in some detail.

INTRODUCTION

Background

By letter of March 16, 1976 from Dr. Malcolm H. Merrill, M.D., Director, Division of International Health Program, American Public Health Association (APHA), F. Eugene McJunkin was commissioned as an APHA consultant to assess "rural environmental sanitation in Tunisia" under terms of an APHA contract with the Agency for International Development (Contract No. AID/csd 3423).

Scope of Work

The scope of work for this consultancy of approximately two weeks as outlined by Dr. Merrill and reflecting earlier communications with AID/Washington and AID/Tunisia included the following:

1. "To assess the appropriateness of technology tried in village water supply programs in Tunisia in relation to costs, operating issues, maintenance, replication, making observations and where appropriate recommendations as to how these programs might be extended and improved."
2. "To examine alternate approaches to waste disposal that can best be adapted to the Tunisian village conditions."
3. "To ascertain if there is capability, private or public, in Tunisia to cast and machine the Battelle hand pump."*
4. "To investigate the possibility of health components of other programs projected by USAID."

The consultant's scope of work and itinerary** were more specifically defined at the consultant's initial briefing session with AID/Tunisia staff, including the acting mission director, program officer, rural development officer, material resources officer and

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* The "Battelle hand pump" was developed at Battelle Memorial Institute, Columbus, Ohio, with AID/TA/H funding. AID/TA/H seeks to identify possible sites for field testing.

** The consultant's itinerary is outlined in Annex A.

others.* The following mission needs were emphasized, in approximate order of priority:

1. Because of the prospects of an AID-assisted rural water supply and sanitation component in the proposed Siliana Province Rural Development Project, the consultant's findings and recommendations should focus on this project, including specific recommendations.

2. Because **CARE/Tunisia is under consideration for an Operational Program Grant (OPG) to undertake the rural water supply and sanitation component in the proposed Siliana Project and is also seeking support for similar activities in Kairouan Province (or Governorate), the consultant's assessment of CARE/Tunisia's ability to successfully carry out such a project is sought.

3. Implicit in the preceding is an evaluation of CARE/Tunisia's performance in previous rural water supply and sanitation projects. These include projects in the following provinces (governorates): El Kef, Bizerte, and Sfax.***

4. Similar evaluation of CARE/Tunisia for an operational program grant in Kairouan governorate.

5. Evaluation of Tunisian ability to manufacture the Battelle pump as previously outlined.

6. Evaluation of oxidation ponds as an appropriate waste water treatment technology for Tunisia, including, if time allowed, an inspection of the ponds at Maxula-Rades. (Time did not allow this visit.)

During the course of the consultancy, certain needs of CARE and the Ministry of Public Health for technological information arose. Most answers were provided on the spot and several are supplemented or amplified in this report. Because of its limited interest to general readers this information is reproduced in the Annexes as

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* Complete names, titles, affiliations, dates and locations of all individuals contacted are listed in Annexes A and B.

** Cooperative for American Relief Everywhere, headquartered in New York. CARE operations in Tunisia also include a medical component, MEDICO.

*** English and French transliteration of Arabic names varies greatly. Sfax, for example, is also spelled Safaquis; El Kef as Al Kaf; Siliana as Silyanah, etc.

follows:

Annex C: Maintenance of Hand Pumps

Annex D: Local Manufacture of Leather Cup Seals

Annex E: Jar Type Well Chlorinators

Annex F: Sanitary Survey Checklist

Annex G: Pneumatic Measurement of Water Levels in Deep Wells

Annex H: Measurement of the Health Benefits of Investments in Water Supply

APPROPRIATE TECHNOLOGY

The consultant was directed "to assess the appropriateness of technology tried in village water supply programs in Tunisia in relation to costs, operating issues, maintenance, replication, making observations and where appropriate recommendations as to how these programs might be extended and improved."

Costs

Limited funding is the major constraint on expansion of rural water supply services in Tunisia. This limitation is compounded by the wide dispersement of the rural population, thereby denying economies of scale. A third important limitation is the nonavailability of electric power in many areas.

These limitations constrain the level of service provided, the water quality standard to be met and the quantity of water to be provided.

The level of service chosen by CARE/Tunisia in its water supply projects has provided for central water points consisting of a protected spring or dug well equipped with a hand pump.* These installations serve an average user population of 100 to 250 (CARE estimate) to 650 (Ministry of Public Health estimate) and cost about $2,500 each, on the average. Using a conservative population estimate (250), a capital cost of about $10 per capita results. This can be compared with a 1970 World Health Organization (WHO) estimate of per capita costs for rural water supply in Tunisia of $13.** The average per

---

* Sixteen motorized pumps were installed in the Sfax project.

** The same survey estimated that only 17 percent of the rural population had "reasonable access to safe water" as of 1970. 91 percent of the urban population were served by house connections or public health hydrants.

1970 capita estimate for rural water supply for 17 countries in WHO's Eastern Mediterranean Office was about $17. While direct comparison of gross data can be wildly misleading, true estimates place the CARE unit costs with the realm of reasonability. Taking water supply as a health measure, some perspective might be obtained by comparing CARE's $10 per capita capital cost to the WHO World Health Statistics estimate of 1971 Tunisian government expenditure on health; about $8 per capita. This is a recurring expense, capital cost of well or spring construction is a one-time expenditure with a much lower annual operating cost.

Inasmuch as most users of CARE water points are widely dispersed and 0.5 to 5 kilometers distant from the well or spring, provision of a level of service that would provide house connections is obviously impractical.

The groundwater used in rural Tunisian water supplies requires no treatment other than disinfection (chlorination). Some wells are saline, in which instance it is cheaper to find another, more suitable well than to remove the salt. The principal quality standard then is bacteriological. Worries about (and measurements of) other water quality parameters, for example, iron and manganese, are fruitless in an operational setting because no additional treatment is feasible. This again is an appropriate course of action for protected groundwater sources.

The quantity requirements (unmeasured but probably less than 10 liters per capita) have not been a problem to date, possibly because the labor requirements to overpump the wells by hand make water usage self-limiting. To paraphrase Adam Smith's "invisible hand", the marketplace at the pump is guided by an "invisible back"? In Sfax where 16 motorized pumps were installed on very deep wells, a water demand by large users developed. Some of these even sold water from their own tanks. While free water can be justified as a consumer health measure or a reflection of the high cost of collecting fees, wholesale consumption cannot and may have detrimental effects on the well. In these instances water charges have been imposed. By increasing the rates, the level of use by large consumers can be restricted if necessary.

Operating Issues

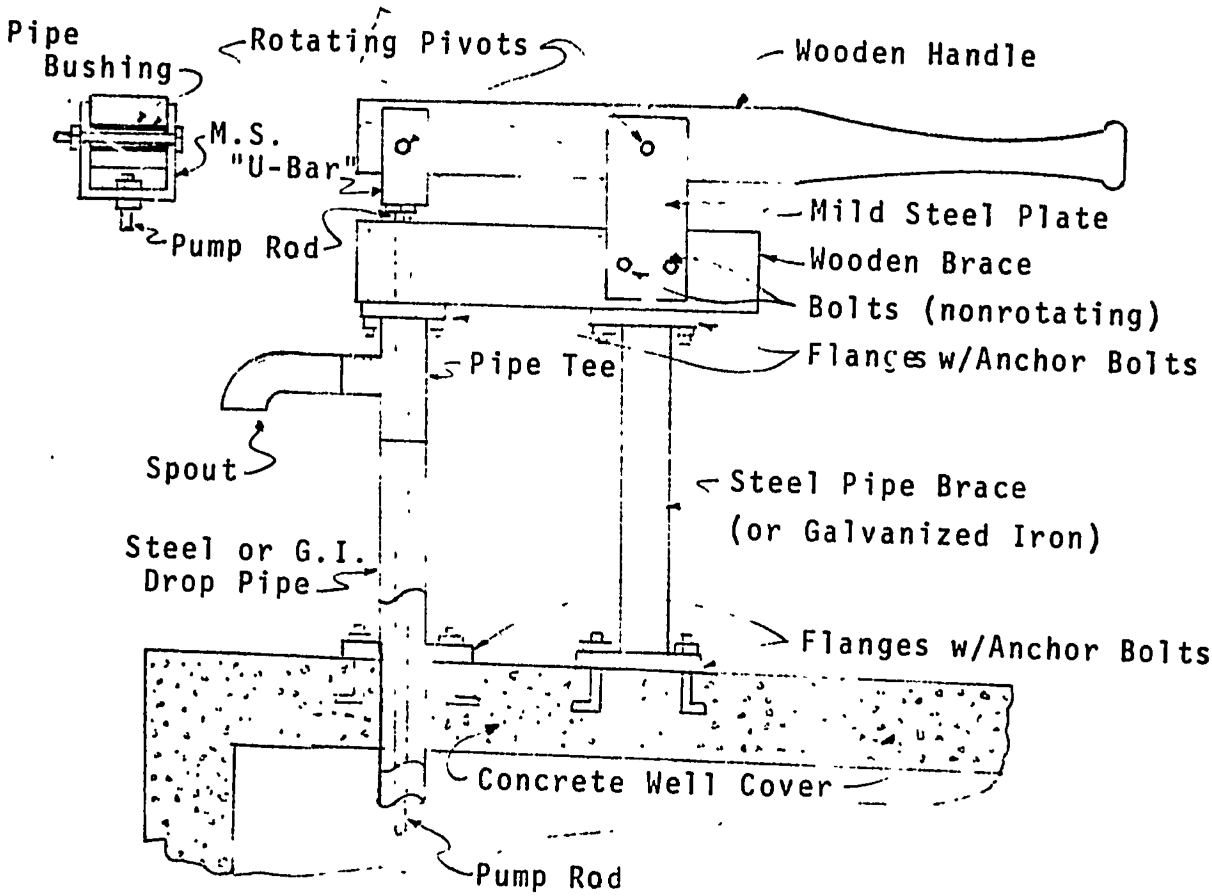
Hand Pump. The major mechanical component of the CARE installed water systems is the hand pump placed atop the reconstructed and covered dug wells. The pump used in the first project at El Kef was the American manufactured Dempster Model 23 Export Model. This is probably the most widely exported American hand pump and gives adequate service under moderate use, when installed at moderate depths, and when provided with preventive maintenance. Imported equipment, when AID-financed, usually must be of American manufacture. The performance of the Dempster pump in El Kef was unsatisfactory. At one time in 1973, over half of those installed were inoperative. (In fairness to Dempster, all 36 French-made pumps provided by UNICEF to the Ministry of Public Health and installed by CARE in El Kef broke down within a month.)

These difficulties led CARE/Tunisia to seek to develop an idigenous hand pump better suited to local conditions. Such a pump might also have potential for:

(1) lower cost of production,
(2) transportation savings,
(3) foreign currency savings,
(4) stimulation of local industry, and
(5) better access to replacement parts.

Such a pump was developed and is shown in Figure 1 . It incorporates a massive, sturdy wooden handle, and a durable, rigid pump stand made of steel pipe and a wooden cross bar. The wear at the handle fulcrum pivot and at the pump rod connection pivot is minimized by the large bearing surface provided by pipe bushings between the wood of the handle and the steel bolt rotating pivots. The top part of the pump assembly is manufactured in Bizerte, for CARE, and at a cost of $36. The 1 3/4-inch diameter open top, brass cylinder, brass plunger assembly, leather cup seals, and brass suction and discharge valves are still imported from the United States (manufactured by Clayton Mark) at a cost of $60. The total cost of $96 compares favorably with the Dempster's $100 to $125, and with English and French pumps, and has outperformed all imported pumps in its price range.

Although its cylinder diameter is somewhat small, the pump operates easily at high stroke frequency, thereby equalizing its delivery rate with other pumps with larger cylinders. The small diameter, open top cylinder means that the plunger assembly and its leather cup seals can be withdrawn from the top of the well without disassembling the drop pipe, an aid to maintenance. In hand pumps the leather cup seals rub against the cylinder wall by design and their inevitable wear means that they must be periodically replaced. Annex D suggests methods for manufacture of cup seals by local pump maintenance teams. Recent experimentation in other countries with cup seals made of polyvinyl chloride (PVC) also shows promise. The major maintenance problem with the CARE pump appears to be at the point where the pump rod connects to the mild steel "U-Bar" on the handle. The thinness of the "U-Bar" means that only 2 to 3 turns of



Not to Scale

FIGURE 1

SKETCH OF INDIGENOUS HAND PUMP STAND
AND HANDLE DEVELOPED BY CARE/TUNISIA

thread are holding the pump rod to the "U-Bar". If the "U-Bar" were thickened on its bottom by welding an additional thickness of plate thereto, the number of threads would be doubled. Another, easier measure worth trying, would be to add lock washers between the pump rod nuts and the "U-Bar". The CARE pump is the only model observed by the consultant to have been repaired in the field by its users, rather than the pump maintenance team.

All new hand pump installations in Tunisia where use and depth are moderate should use the CARE pump in preference to currently available import models.

Chlorination. CARE has organized well and spring chlorination teams at each of its projects. This is laudable and sufficiently unusual that one hesitates to criticize it. The chlorination teams should be instructed in sanitary surveys (Annex F) and required to make them formally and periodically (at least once a year) on visits to the sites. Prevention is preferable to cure. Secondly the chlorination teams need to switch from "javelle water" to a more slowly diffusing chlorine compound such as calcium hypochlorite. The effect of the javelle water is dissipated long before the return of the chlorination team. Annex E describes jar or pot type chlorinators developed in India for disinfection of dug wells.

Study of Health Benefits. As part of its Bizerte program, CARE has been required by AID to undertake a questionnaire study of health benefits from improved drinking water supplies. This study is worse than useless; not only are its premises, controls, and methodology of dubious value, it is diverting the health education teams from more fruitful work. This issue and the exorbitant cost of definitively resolving it are outlined in Annex H.

Sociology of Domestic Water Supplies. A study of this nature has been suggested in connection with the Siliana project. Before investing in it or undertaking it, several questions should be asked and answered: are the data sought needed to carry out the project; are the data worth the cost of their collection; how will the answer affect operations; is this study necessary or will it only provide information that is "interesting" or "nice to know"? How many additional people could be provided water with the funds required for the study?

Maintenance

For ease of maintenance, protected and covered springs are ideal. Wells themselves require little maintenance. However their pumping apparatus, whether motorized pump, hand pump, or pulley, windlass rope and bucket, requires frequent attention. The maintenance program for community pumps must be formalized; reliance on "the villagers" will not work - everybody's pump is nobody's pump. Similarly for latrines, whether in Siliana or Yellowstone Park. Remember that the villager can find alternative sources of water which to his uneducated eye may appear safe.

As described earlier the lack of an organized hand pump maintenance program in the first El Kef program virtually destroyed its effectiveness until later remedied.*

Hand pump maintenance has been a key factor in the success of CARE water supply projects in Tunisia. Detailed requirements for hand pump maintenance and trouble shooting are outlined in Annex C.

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* Inadequate maintenance is a common failure in developing countries. A recent World Bank study of Indian water supplies estimated that 36 million hand pumps were currently out of order.

The motorized pumps and the heavily used deep well hand pumps in Sfax governorate are attended by full time operators. These pumps are also periodically inspected by maintenance and repair teams from the Governorate (Genie Rural). This practice should be extended to Kairouan if the deep well project is initiated.

Replication

The technology developed in the AID-assisted, CARE-initiated rural water supply projects in El Kef, Bizerte and Sfax has now been "debugged" and proven suitable for replication in other areas. Perhaps the best evidence of this is the strong desire of the Governorates of Bizerte and Kairouan for extension of these programs, the substantial monetary input by Tunisian agencies, and the continuation by Tunisian agencies of pump maintenance, disinfection and health education teams initiated by CARE projects.

Introduction of New Technology

Appropriate technology, although sometimes called "intermediate", "traditional", "labor-intensive", or "village" technology, does not foreclose adoption of new technology that shows promise.*

Rural water supplies in Tunisia are heavily dependent on traditional springs and dug wells. Indeed at many sites of "ains" and "birs", there is evidence of their use since Roman times.

The most promising new technology for rural water supplies in Tunisia is that recently developed elsewhere for rapid, inexpensive, drilling of wells. Recommendation 7 in the Siliana project outlines a suggested program for introduction of new well drilling technology.

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* Dramatic examples include the "Green Revolution" and chemical birth control.

SILIANA RURAL DEVELOPMENT PROJECT

Background

Economic development in Tunisia is not evenly distributed. The central and southern governorates have lagged behind governorates along the northern and eastern coasts where industrial development and tourism have spurred local economies. Even in agriculture, the backbone of the Tunisian economy, the central and southern governorates have been handicapped by inadequate water resources, dispersed populations, and fewer governmental services.

AID/Tunisia is presently considering the possibility of a pioneer or prototype rural development project to be centered in the "high tell" governorate of Siliana, approximately 120 kilometers (75 miles) southwest of Tunis. Siliana governorate was recently created from the easternmost delegations (subgovernorates) of El Kef governorate. (See Figure 2.) The AID-assisted rural development project in Siliana would focus primarily on the Makthar and Ruhia delegations. (See Figure 3.)

These two delegations have a combined population of about 55,000 scattered over an area of mountains and valleys about 35 miles long on a north-south axis by about 25 miles on an east-west axis, about 75 persons per square mile. The project area contains only two municipalities: Makthar, population about 6,500, and Ruhia, population about 1,150.

Two urban areas have populations in excess of 500; Kesra with about 2,000 and Snad el Haddad with about 800 in El Garaa Cheikhat (subdelegation). Nine urban centers have populations between 200 and 500; twenty-three have populations between 100 and 200. In summary, the project area is characterized by small, widely scattered population clusters and dispersed housing.

Population Data:

Siliana Province: 185,048/192,668
Siliana, municipal: 7,302/6,982
Makthar Delegation: 39,191/40,385
Rohia Delegation: 16,201/17,040
Rohia, municipal: 1,134/1,181

Kessra, sector: 3,534/3,895
Kessra, village: 1,875/2,104
Hababsa, sector: 4,814/4,965

(The first number is population "present", the second, population "resident". Census of 5/75)

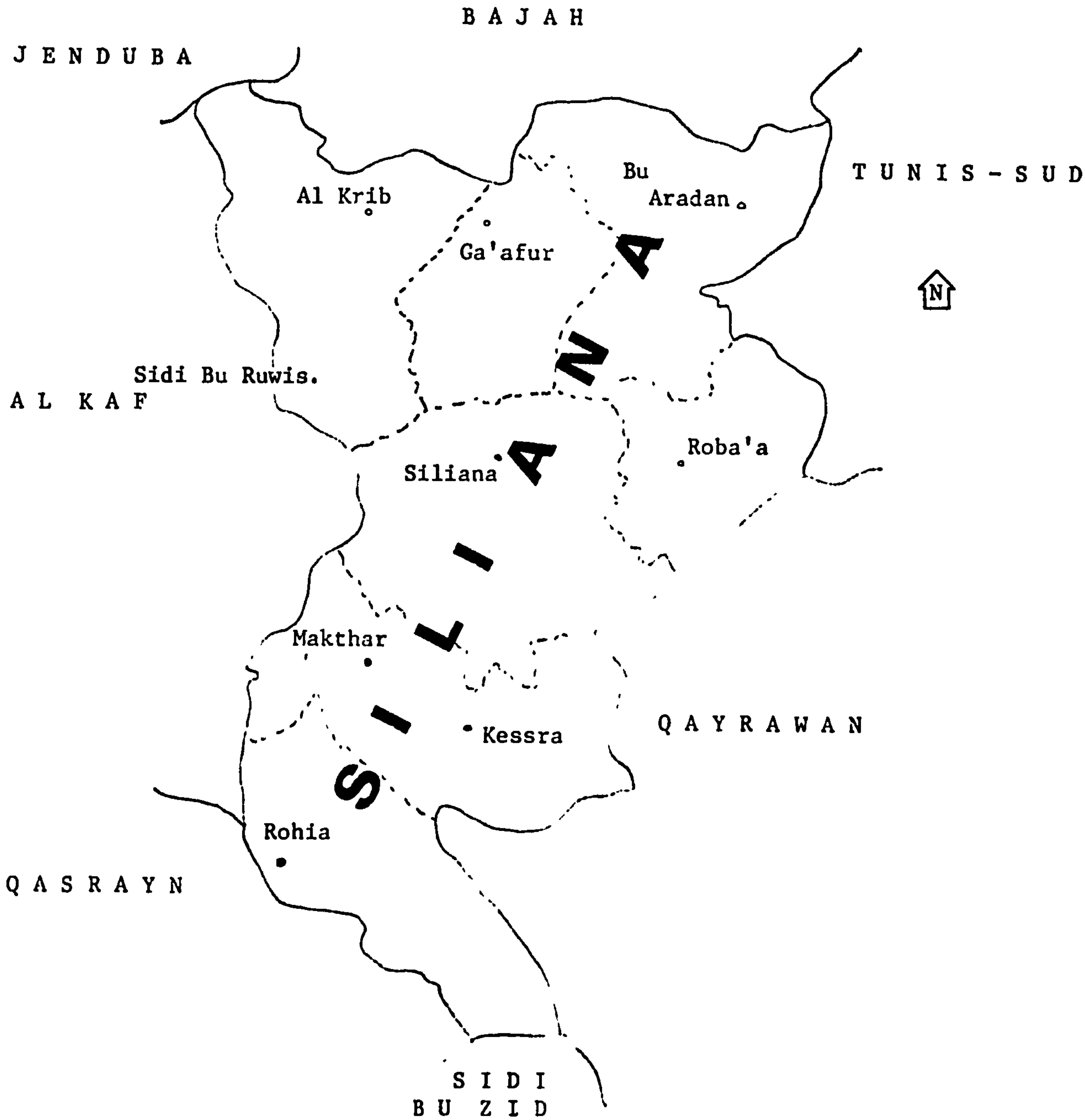


FIGURE 2

SILIANA GOVERNORATE, TUNISIA

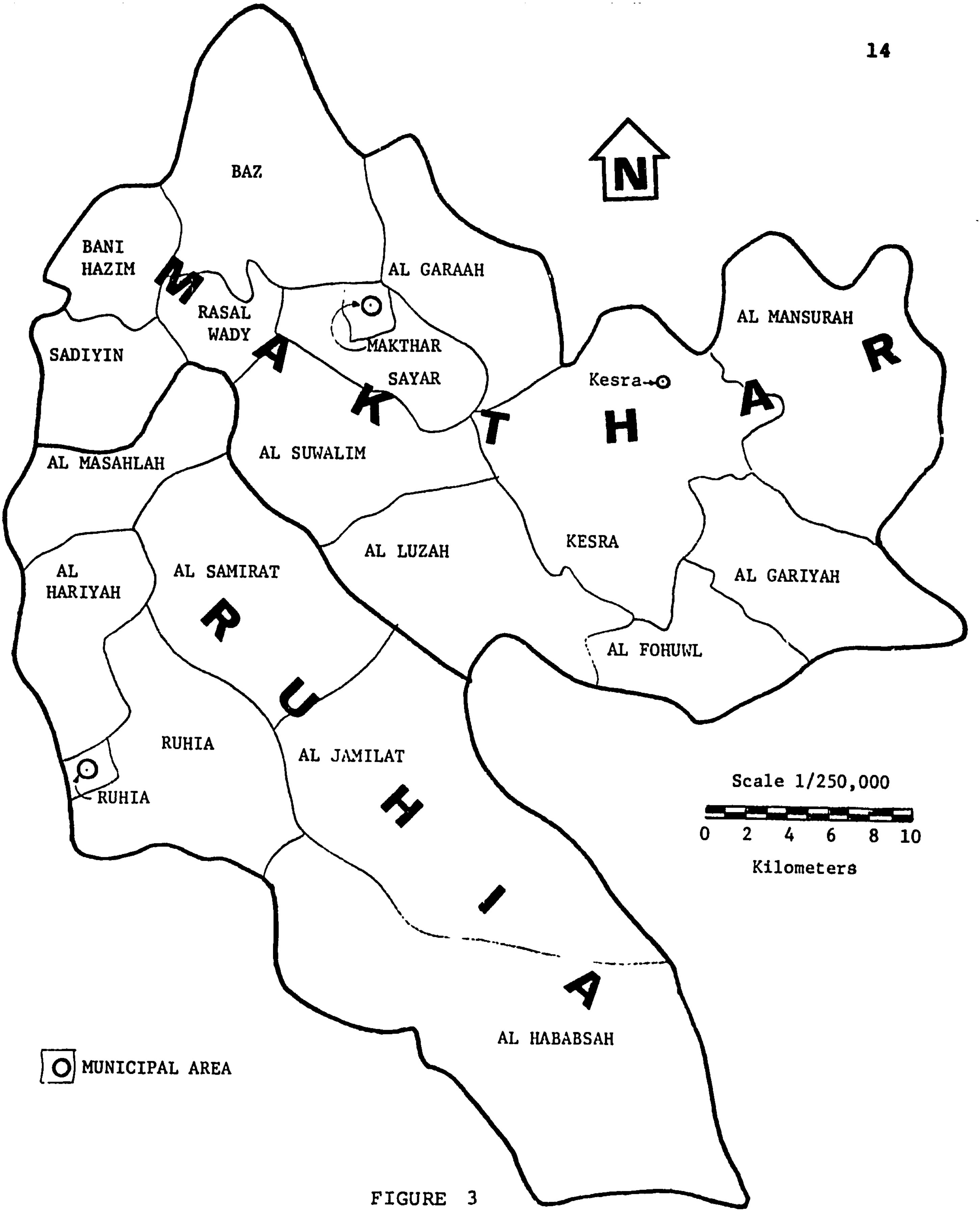


FIGURE 3

DELEGATIONS OF MAKTHAR AND RUHIA (SILIANA GOVERNORATE, TUNISIA)

Possible activities under consideration in the Siliana rural development project include:

(1) Research in the Tunisian setting on rural development.

(2) Provision of adequate, safe, and convenient rural water supplies.

(3) Development of rural road network with year-around accessibility.

(4) Improvement of agricultural productivity.

(5) Strengthening of community organization including possible regrouping of population, new markets, public buildings, etc.

(6) Soil/water reclamation.

(7) Strengthening urban infrastructure of principal urban centers including "mini-industrial parks", government offices and housing, hotels, etc.

(8) Establishment of co-educational agricultural secondary school.

Implicit in several of the above activities are changes in the role of Silianian women including reduction of isolation: less drudgery in obtaining water and more free time for child care, cottage industry, poultry raising; education; and other activities.

Rural Water Supply and Sanitation in Siliana

Following his review of previous AID and CARE rural water supply programs in Tunisia, the consultant spent two days on site in Makthar and Rohia delegations. All paved roads were traversed as well as the existing "T" piste (road) between Makthar and Al Hababsah cheikhat or sector (Rt. 77) and between Al Hababsah and Sbiba, 13 kilometers south of Ruhia (Rt. 85). Also in this party were John W. Macdonald and Ben Salem Tarhar of AID and George H. Radcliffe and Brian J. Cavanagh of CARE.

Objectives of the Rural Water Supply and Sanitation Component of Siliana Rural Development Project

(1) To provide adequate, safe, and convenient drinking water to as many people as possible. Note that the objective is not a perfect supply for a few. In operational terms this means that the standard of service must be the minimum consistent with protection of health and with resource available. Thus in selecting sites for improvement, priority should be given those sites with lowest per capita cost.

(2) To reduce waterborne or water related disease. The role of water supply in transmission of cholera was proven as long ago as 1854. A massive body of presumptive evidence and informed opinion supports this objective. To state it should not imply a necessity for undertaking a research project to substantiate it. Such research, with adequate staff, vigor, and controls would cost more than the water supply project itself. See Appendix H.

(3) To improve living conditions of the rural population. Many rural Tunisians, primarily women and girls, are spending several hours each day walking to, drawing, and carrying unsafe water.

(4) To encourage rural development. Improved human productivity through reduction of time and energy necessary to draw water for human and animal consumption. Promotion of self-help and self-improvement concepts. One claim often made but unsupported by hard evidence is that provision of drinking water will reduce urban migration.

(5) To redistribute income. Provision of free drinking water represents a subsidy. Under conditions in rural Tunisia, however, the expense of collecting drinking water charges would be prohibitively

expensive and unworkable - to the water user, a free substitute, contaminated water, exists.

(6) To change society. Quoting from UNICEF's Potable Water Supply Program Manual:

> "The provision of village water supplies can be one of the catalytic elements in a widening circle of health-oriented and other co-operative, self-help, community efforts, such as sanitation activities, family food production, reforestation for domestic fuel supply, and local support of health and education supply, and local support of health and education services. Such efforts could contribute greatly to the delivery of simple preventive health care by giving the community the capacity to maintain a healthy environment for all its members.
>
> For the integration of women in development thus the provision of safe water at convenient reach is one of the important measures recognized and recommended by Governments and Agencies alike. The results to the economy of the families and the communities are equally important in this process. They may not always be easy to measure but nevertheless are there very tangible. The economical benefits, at the side of those for health and for social welfare, furthermore are among the stronger arguments in the course of the health/sanitation education, which should accompany any environmental sanitation project."

Recommended Rural Water Supply and Sanitation Components of Siliana Rural Development Project (In Order of Priority)

(1) Rehabilitate approximately 50 wells and hand pumps. These wells were originally rehabilitated and equipped with hand pumps of U.S. manufacture (Dempster Model 23EX) during the first AID-assisted CARE project carried out in El Kef Governorate. With the partitioning of El Kef to form the new Siliana Governorate, the pump maintenance team remained in El Kef where it maintains some 200 hand pumps. Thus the pumps now in Siliana Governorate have had no maintenance for several years. Doubtless few, if any, are still operative. (None observed during the consultant's

field visit to Siliana were working.) If the Siliana project is not implemented, these pumps should be removed and sent to El Kef for cannibalization for spare parts for the Dempster pumps used there. The steel well covers should be removed (most already have been by the users) to allow the users to return to using their bucket and rope methods. At the least the AID hand clasp emblems should be removed!

(2) Organize local teams for pump maintenance, well and spring chlorination, and health education. These teams should be organized early on. The pump installation phase is an excellent opportunity for training the maintenance team. Similarly the well and spring construction phase offers training opportunities for the chlorination team. Early recruitment and training means that the crucial, formative stages will occur while CARE, Peace Corps, or other personnel are still readily available.

(3) Survey Possible Water Points in Makthar and Ruhia Delegations. This is an obvious early task. If possible it should begin during this summer's dry season, the critical time of year for source evaluation. If begun promptly, CARE may be able to use an Arabic-speaking Peace Corps Volunteer with similar experience in the Bizerte project. The water point evaluation should include an assessment of the adequacy and dependability of the source, a sanitary survey, an estimate of the number of users, an estimate of the cost of development, proximity to users, including schools, markets, clinics and other public activities, an estimate of livestock usage, and assessment of accessibility.

(4) Development of a Public Fountain Water Supply for Kesra (Population 2,000). Kesra is a picturesque Berber village at over

3,200 feet elevation with a commanding scenic view of the surrounding countryside. More than any other site in Makthar or Ruhia delegations, Kesra has potential for (a) tourism and (b) an epidemic outbreak of typhoid or cholera.

Kesra draws its water from a large, bountiful spring at the base of a sheer cliff and mesa which overlooks the town. Several niches in the rock wall above the spring show evidence (numerous fresh fecal deposits) of being favored nocturnal "latrines". The spring itself doubles as a laundry. The brook leading from the spring flows through the middle of the upper village and is the source for some users. The force of the spring suggests possible fissuring in its rock aquifer and the need for a sanitary survey of the top of the mesa. Fluorescein dye could be introduced at doubtful points on top of the mesa and the spring observed for traces of the dye. A weekly regional market and occasional tourists increase the probability of carrier introduction of waterborne pathogens.

Kesra's own charm and its convenience to Tunis and to Roman ruins at Dougga, Makthar, and Sbeitla suggest potential growth in tourism and a need for a restaurant, if not a hotel, with a safe water supply.

The size of Kesra's population makes it eligible for consideration for drinking water provision by the Societe Nationale d'Exploitation et de Distribution des Eaux (SONEDE) or National Water Corporation. SONEDE provides water for Makthar and Ruhia which are organized as municipalities. SONEDE generally supplies water through house connections. Its plans, if any, and schedule for water service for Kesra should, of course, be ascertained.

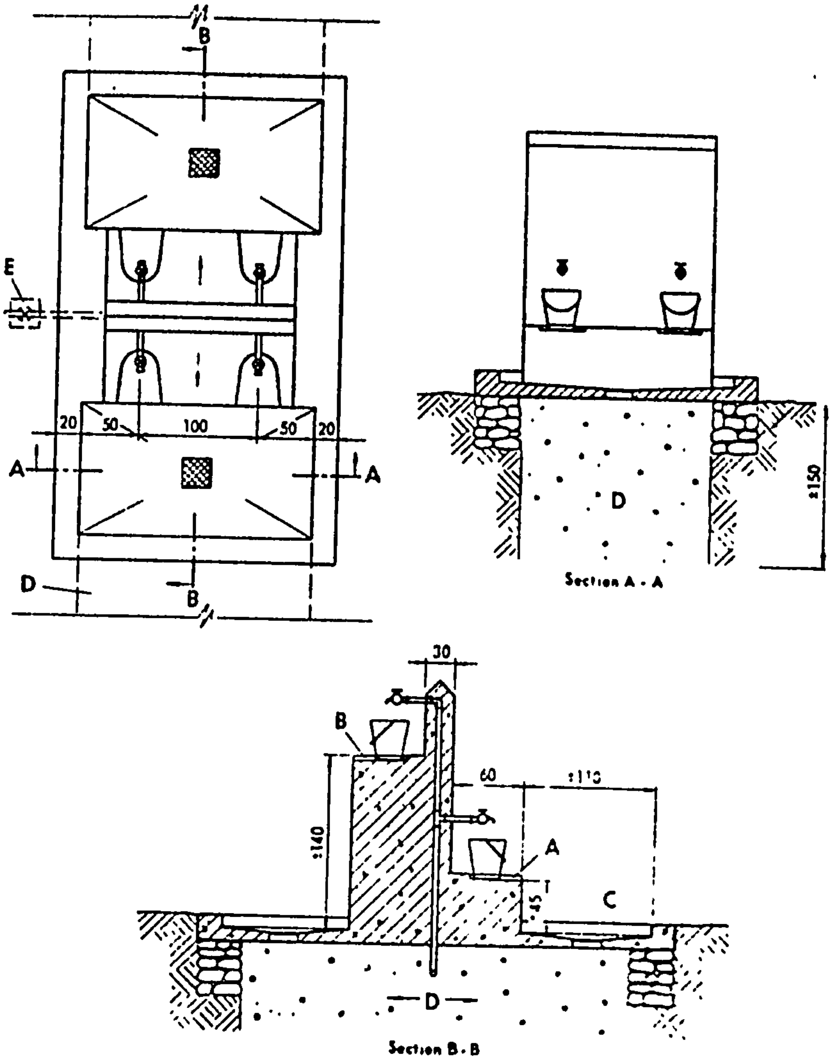
Whoever develops Kesra's water supply, its spring is the obvious source. It is also Kesra's raison d'etre. Any development of the spring must be carried out in close cooperation with the village.

As an interim measure to a water supply with house connections, the topography of Kesra and its spring seems ideally suited to a gravity pipe line, from a chlorinated reservoir fed by the spring, through the village and which could feed 3-6 public fountains and 3-4 public laundries. One electric motor powered centrifugal pump could lift water about 75 feet from the reservoir to the top of the mesa. The spring seems to have sufficient flow to continue flow in the brook without significant diminishment. (This can be checked with the gaging station observed near the community building.) The system would require a local operator for maintenance and chlorination. The system could be designed to be compatible with later expansion to individual house connections. The additional water provided by house connections might inundate existing latrines (much of the village is built directly on rock) and could require a sewer system - an amenity presently lacking in both Makthar and Ruhia delegation.

(5) Development of Existing Sources. Based on the waterpoint survey and the priority criteria outlined previously, the program should include rehabilitation and development of enough wells and springs and provision of hand pumps (at least 100) to justify permanent employment of the pump maintenance, chlorination, and health education teams by the governorate.

(6) Development of New Sources. Along much of the highlands traversed by Rt. 77 between Makthar and El Hababsah, water points are apparently few and widely scattered. A number of rainwater runoff traps have been constructed; most are ineffective (empty), those that do have water are grossly unsanitary. Geological conditions apparently are detrimental to digging wells by hand, the usual Tunisian practice in this area. Lack of drinking water for man and livestock may be a binding constraint for development of this area.

(7) Pilot New Well Construction Technology. Tunisian well construction for drinking water purposes appears to be highly traditional. The most common well observed by the consultant was a poorly constructed, masonry lined, dug well, 2 to 3 meters in diameter. Where geologic conditions are favorable, perhaps in the Ruhia plain, small, inexpensive hydraulic rotary jetting and drilling rigs offer considerable potential. The Ministry of Public Health has recently purchased one of these ("Hydradrill") and offered it for use by CARE. These wells should utilize 4-inch (10 centimeter) diameter polyvinyl chloride (PVC) pipe well casing and the CARE hand pump (up to moderate depths). The potential low cost of these wells offers an opportunity for experimentation with single family hand pump installations, maintained by the owner. These pumps would receive much lighter wear, much better care, and could be located much closer to the users. Provision would have to be made for user purchase of replacement parts and repair service. A minimum number, at least 100, would be needed to justify a merchant stocking the parts.



Measures are in centimetres.
A = Platform level at about knee height
B = Platform level at about shoulder height
C = Hard-surface floor
D = Soakage pit : length may extend beyond limits of fountain
E = Control valve

Public fountains should be constructed of the most durable materials possible because no part of the water system will be required to take so much abuse. It is usually possible to construct the platform and faucet support so that only the most excessive abuse will damage it The weakest part is the faucet itself. This should be the strongest available.

FIGURE 4

POSSIBLE ARRANGEMENT OF PUBLIC FOUNTAIN IN KESRA

(8) Pilot Latrine Programs. The success of CARE's pilot latrine self-help program in El Kef suggests its extension and expansion into Siliana.

Budget for Rural Water Supply and Sanitation Component in the Siliana Rural Development Project

The capital budget for this component has to be sufficiently large to justify permanent development of the governorate infrastructure and personnel. Based on past cost experience in Tunisian projects, the total budget from all sources for capital investment should be not less than $300,000, preferably not less than $500,000.

REVIEW OF CARE RURAL WATER SUPPLY PROJECTS

Background

Over the past four years CARE/Tunisia, with assistance from AID/Tunisia, the Peace Corps, and various Tunisian government agencies including the Ministry of Public Health (MOPH), has rehabilitated over 400 wells and equipped them with pumps, rehabilitated and protected over 80 springs, and constructed about 25 latrines in a pilot program. AID/Tunisia has invested about $450,000 in these projects, about one-third of the $1.3 million dollars spent to date. These data are summarized by project in Table 1.

The consultant visited these projects on-site and reviewed records and reports on file in the AID/Tunisia and CARE/Tunisia offices.

El Kef Projects

The first AID/CARE/MOPH rural water supply project was undertaken in El Kef Governorate, which then included the delegations that now make up Siliana Governorate (Province). This project was a learning experience for all involved. Partly because of the arrival of the hand pumps late in the project, the need for a strong maintenance program was not fully appreciated. At one time, over half of the hand pumps were inoperative. With development of the pump maintenance program, over 90 percent of the hand pumps are in working order at any given time. (Of about 15 pumps visited by the consultant, all were working well with all top of the well pivot points properly lubricated; however many stuffing boxes and glands exhibited signs of hard wear - whether this component, like the human appendix, could be omitted from the Dempster 23 Ex hand pump in El Kef is worth testing.)

TABLE 1

"AVERAGE" COST PER WELL OR SPRING REHABILITATED BY CARE/TUNISIA

Project (Governorate)	AID Funds U.S. $	AID Funds % of Total	Total Project Cost	Rehabilitated Wells	Rehabilitated Springs	Average Unit Cost Per Well or Spring
El Kef I	$122,000	33%	$368,000	200	43	$1,510
Sfax	115,000	41%	280,000	29	0	9,330
Bizerte I	56,000	23%	242,500	30	30	4,040
Bizerte II	154,000	40%	381,400	90	10	3,810
El Kef II	8,000	15%	52,000	56	0	1,060
	$455,000	34%	$1,323,900	405	83	$2,720

Notes:

(1) Costs shown are primarily capital costs. Some costs for health education and operating expense are included in Bizerte II and El Kef II projects. Overhead costs are crudely approximated.

(2) Non-AID funds came from the Government of Tunisia (Ministry of Public Health), the Governates, Peace Corps and CARE

(3) Wells were existing uncovered dug wells approximately 6 to 10 feet (2 to 3 meters) in diameter and 15 to 50 feet (5 to 10 meters deep) except in Sfax where wells were from 50 to 125 feet (15 to 40 meters deep). All wells were equipped with hand pumps except for 16 diesel-powered pumps in Sfax Governorate.

(4) Spring rehabilitation included concrete "Captage", concrete hydrant and watering trough, and 50 to 100 feet (15 to 30 meters) of pipe.

(5) Projects listed in chronological order.

(6) El Kef II project is still in progress and is primarily rehabilitation of pumps and wells from El Kef I. It also includes 25 latrines.

(7) AID contribution to El Kef II through "Monies gained in currency fluctuations"; El Kef II is a training project with no formal AID agreement.

The physical design of the well covers, hatches, steps, pedestals, and drains went through several evolutionary improvements as did the spring "captages", fountains, and troughs.

Despite early difficulties, this project has been successfully completed and is now operated and maintained by the regional health office headquartered in El Kef.

Sfax Project

This project rehabilitated some 29 wells, most 80 to 100 feet in depth, provided each site with a storage tank, and provided 16 wells with diesel-powered pumps and 13 wells with Godwin wheel-driven, geared, deep well hand pumps. Because of the expense of these wells and pumps, their greater sophistication of operation, the dire need for reliability of these supplies, and the large number of users, including many who remove water by tanker, each site is equipped with a full time pump operator-guardian. (Paid 1.0 to 1.2 Tunisian dinar per day, about $2.50.)

Four different Tunisian and Sfaxian agencies are now responsible for operation, maintenance, financing, and sanitary surveillance of these wells. Their now smooth functioning is no small tribute to CARE's persistance, tact, diplomacy, and powers of persuasion.

Bizerte Project

The two Bizerte projects incorporated the lessons learned in El Kef, utilizing pump maintenance, disinfection (chlorination), and health education teams from early on. The operation and maintenance of these water supplies is currently being turned over to Tunisian authorities.

The major difference between these projects and those in El Kef is the development of a new, indigenous hand pump described in the section on Appropriate Technology.

Kairouan Project

This is a potential project which the Governorate of Kairouan has asked CARE and AID to consider. In its southern reaches, Kairouan water supplies are similar to those in Sfax; in its northern area, Kairouan borders Siliana Governorate.

El Kef Latrines

On its own, CARE installed 4 demonstration latrines in a "hamlet" near the municipality of El Kef and offered technical assistance, a latrine floor slab, and a corrugated steel sheet roof to those household heads who agreed to dig the hole (in rocky soil) and assist CARE masons in constructing the building. 21 additional latrines have since been constructed in this area. They are readily accepted, used, kept clean, and seem to be a source of pride.

The principal problem at the moment is their cost, about $64, half of which represents the price of the roof. CARE is experimenting on ways to bring down costs.

Assessment of CARE's Ability to Undertake Rural Water Supply and Sanitation Programs in Tunisia

CARE/Tunisia has brought all its projects to successful completion without undue delay, and within budgetary estimates. CARE has the confidence of Tunisian agencies and has demonstrated its ability to work constructively with them in establishing permanent infrastructures for managing, operating, and maintaining project facilities after CARE's departure from the project. CARE/Tunisia has shown initiative, resourcefulness, and managerial ability under trying circumstances.

CARE has made mistakes; however it has acknowledged them, corrected them, and learned from them. CARE personnel do not have engineering backgrounds; however their recognition of their limitations, the type of technology being practiced, and their alertness, inquisitiveness, and open-mindedness have overcome this deficiency. If the Kesra project outlined in the Siliana recommendations should be implemented by CARE, some engineering expertise would be advisable. This might be obtained from the MOPH, CARE/New York, or CARE/Nigeria, or from a Peace Corps Volunteer with suitable background.

CARE's one deficiency apropos future projects is its frequent personnel turnover, leaving CARE/Tunisia with a short memory. Lest the hard-won experience gained in previous projects be lost, it should be mandatory in all programs that CARE prepare detailed project documentation, particularly operating and maintenance manuals and drawings.

Based on its past record and its present staff, CARE/Tunisia is fully qualified to operate rural water supply and sanitation programs in Tunisia.

TUNISIAN CAPABILITY TO MANUFACTURE THE AID/BATTELLE HAND PUMP

Background

Almost 10 years ago AID contracted with Battelle Memorial Institute in Columbus, Ohio, for development of a dependable hand pump for rural water supply in developing countries. The new pump should be rugged, dependable, long-lived, easily operated and maintained, and capable of being manufactured within developing countries. The Battelle pump development program was planned for three stages: (1) examination of existing conditions and practices in developing countries; (2) development and laboratory evaluation of prototype shallow well and deep well hand pumps; and (3) field evaluation of the prototype design. Stages (1) and (2) were successfully carried out and this work has influenced all subsequent hand pump development throughout the world. Stage (3), field evaluation, including overseas manufacture, has never been carried out.*

In a meeting with AID Sanitary Engineer A. Dale Swisher, the consultant learned that AID has been in contact with UNICEF and CARE/New York regarding possible field testing of the AID/Battelle pump. Although several serious discussions were held, no agreement was reached. AID is now negotiating with the Industrial Experiment Station at Georgia Institute of Technology for field evaluation studies, including manufacture, of the AID/Battelle pump in perhaps three countries. Georgia Tech has considerable experience and contacts abroad, under an AID 211-D institutional grant, in development

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* A few prototypes were tested under uncontrolled conditions in Thailand, Bangladesh, and Nigeria. Some pumps, of apparently poor quality, were also cast in Nigeria.

of small industry. Field evaluation of the AID/Battelle pump is still planned; the questions are where and by whom.

SOFAMECA

Within the time limitations imposed, the consultant was able to visit but one of Tunisia's 30-plus founderies; therefore he chose the largest, and perhaps the best, conveniently located in Tunis, under the assumption that if this foundry was unable to cast and machine the AID/Battelle pump, no other was likely to be able to either.

The foundry visited was Societe de Fonderies et de Mechanique or SOFAMECA. Its President, A. Ben Cheikh, incidentally, spent six months of 1958 studying centrifugal pumps in the western United States under sponsorship of an AID predecessor agency. This foundry, of German design and built in 1962, represents current state of the art practice. It utilizes an electric-induction furnace, automated machine molding (and cores), mechanized pouring ladles, casting conveyors, and grinders, lathes, and drill presses of sufficient size to easily handle pump stands. The plant has its own pattern shop and works in wood, metal, and plastic. The plant also has its own metallurgical and quality control laboratories. It processes both Tunisian and imported metals.

Among the products manufactured are iron body, bronze mounted gate valves and other hydraulic equipment for SONEDE, the National Water Corporation; high velocity centrifugal pumps; and castings for railroad cars, trucks, mines, sanitation, and agriculture. About 40 percent of SOFAMECA's output is exported, some of it to Europe.

SOFAMECA's president and technical director reviewed the plans for the AID/Battelle pump with the consultant and stated that they could manufacture the pump without serious difficulty. (The drawings would have to be converted from English units to metric or full scale drawings furnished or patterns furnished.)

The consultant agrees with SOFAMECA's assessment. Indeed if the AID/Battelle pump cannot be satisfactorily manufactured in the plant visited, there would be few developing countries where it might be.

The most serious obstacle is not technological but economic. Asked how many pumps would constitute an economic lot size, SOFAMECA proposed 1,000. At current rates this one production would meet Tunisian demand for 5 to 8 years. Alternatives include (1) willingness to pay higher unit prices for small runs, (2) provision of patterns and molds, (3) development of export market, say, in francophone Africa, or (4) selection of a smaller foundry.

The consultant discussed with CARE/Tunisia its willingness to field test a Tunisian-manufactured AID/Battelle hand pump. CARE is interested, but with two caveats: having learned from its past experience, such a grant or contract should allow for (1) replacement of the AID/Battelle hand pumps if they prove unsatisfactory in the field; and (2) the fulltime assignment of one staff member, perhaps an experienced Peace Corps volunteer to the pump evaluation program - assuming the AID/Battelle pump field evaluation is a component or add-on to larger programs.

Conclusion

SOFAMECA/Tunis is capable of casting and machining the AID/ Battelle hand pump.

ALTERNATE APPROACHES TO WASTE DISPOSAL IN TUNISIAN VILLAGES

The basic technological options may be categorized as those which use water to carry away wastes and those which do not require water.

Waterborne Systems

The waterborne sewer systems do not themselves eliminate the wastes; they simply move them to a location remote from their sources. These systems also bring together the wastes of many contributors and mix them with large volumes of water. Then their convenience to the populace at large may also lead to severe localized degradation of receiving streams and shores.

Many standard texts present such well known biological treatment methods as the activated sludge and the trickling filter processes. However, where land is inexpensive, currency restrictions on imported equipment are in force, and trained operating personnel in short supply, other biological methods such as oxidation ponds and land disposal of wastewaters are more appropriate and offer potential economies in both capital and operating costs. These technologies of ancient origin have been developed and refined in recent years to an understanding such that their use now entails no more risk than do conventional designs.

An excellent summary of the potential use of oxidation ponds in Tunisia appears in the 1972 report to AID by Dr. William J. Oswald on "Treatment and Reclamation of Tunis Sewage". The National Office of Environmental Sanitation is presently constructing an oxidation pond at Maxula-Rades, a city of about 35,000 population about 10 kilometers east of Tunis.

Land disposal of wastewaters under controlled conditions is another promising alternative with extra potential in water short areas.

Inasmuch as none of the communities in Makthar and Ruhia delegations is presently sewered, the need for wastewater treatment plants as part of the Siliana project is still some years away.

Non-waterborne Systems

For the forseeable future, non-waterborne systems will be the technology of necessity if not of choice for rural Tunisians. The choices are basically:

(1) The pit privy. With minimal attention to location and construction there will be no pollution of soil or water. The excreta will not be accessible to flies if the hole is kept covered; but even when the hole is left open, the fly problem will not be severe since flies are not attracted to dark holes and surfaces. A superstructure, such as used by CARE in El Kef, also keeps light out of the pit. The pit privy is simple to construct and use, requires little maintenance, has negligible odor, and should last from 5 to 15 years.

(2) The aqua privy. Permanent but more expensive to construct than the pit privy, the aqua privy requires daily additions of water and occasional removal of its contents. Sometimes combined with a septic tank.

(3) Water-seal latrine. Modifications of (1) or (2) above in which the latrine slab or floor is modified to incorporate a water seal between the pit or tank and the slab. With proper operation it eliminates flies and odors and can be used indoors. More expensive than privies and highly susceptible to abuse or damage of the water trap or seal.

(4) Bore-hole latrine. Poor-man's pit privy.

(5) Bucket latrine or box-and-can privy. Works in theory, never in practice.

(6) Feuillees or trench latrines. Emergency use only.

(7) Overhung privy. Used over salt water as a last resort.

For water short, rural Tunisia, the pit privy, or if resources permit, the aqua privy are appropriate choices. The most common problem in introducing privies is obtaining consumer acceptance. CARE/Tunisia has demonstrated in El Kef that this need not be a problem in Tunisia. These systems work well when installed for individual households, poorly when installed for community use.

Guidelines for Location of Latrines (Privies)

Regarding the location of latrines with respect to sources of water supply, the following conclusions may be drawn from up-to-date information.

(1) There can be no arbitrary rule governing the distance that is necessary for safety between a privy and a source of water supply. Many factors, such as slope and level of ground water and soil-permeability, affect the removal of bacteria in ground water. It is of the greatest importance to locate the privy or cesspool downhill, or at least on some level piece of land, and to avoid, if possible, placing it directly uphill from a well. Where uphill locations cannot be avoided, a distance of 15 m (50 ft.) will prevent bacterial pollution of the well. Setting the privy off to either the right or the left would considerably lessen the possibility of contaminating the ground water reaching the well. In sandy soil a privy may be located as close as 7.5 m (25 ft.) from a properly constructed household well if it is impossible to place it at a greater distance. In the case of a higher-yielding well, not less than 15 m (50 ft.) should separate the well from a latrine.

(2) In homogeneous soils the chance of ground-water pollution is virtually nil if the bottom of a latrine is more than 1.5 m (5 ft.) above the ground-water table. The same may be said if the bottom of a cesspool is more than 3 m (10 ft.) above the level of the ground water.

(3) A careful investigation should be made before building pit privies, bored-hole latrines, cesspools, and seepage pits in areas

containing fissured rocks or limestone formations, since pollution may be carried directly through solution channels and without natural filtration to distant wells or other sources of drinking-water supplies.

Regarding the location of latrines with respect to dwellings, experience shows that the distance between the two is an important consideration in the acceptability of the sanitary facilities. The location of latrines, private or communal, at a considerable distance or away and uphill from the dwellings has been observed to mitigate against their regular use and proper maintenance. A latrine will more likely be kept clean if it is close to the house or other building which it serves.

Other considerations are as follows:

(1) The site should be dry, well drained, and above flood level.

(2) The immediate surroundings of the latrine - i.e., an area 2 m (6.5 ft.) wide around the structure - should be cleared of all vegetation, wastes, and other debris.

ENVIRONMENTAL HEALTH COMPONENTS OF OTHER PROGRAMS PROJECTED BY AID

Many of the other AID programs extant or proposed in Tunisia, for example, roads, and for certain, nutrition, implicitly promote health. With the possible exception of the health education teams associated with nutrition programs and regional centers, these programs are not directly related to environmental health.

One warning: one proposed agricultural development plan has suggested the possibility of recycling human wastes as fertilizer. This is a technology of questionable benefit at best but the limited nutrient value of human wastes from a sparse population such as Siliana's hardly justifies the health risk involved. It can be done safely but requires a composting discipline unlikely to be achieved in rural Tunisia where bucket conservancy is unheard of and latrines are built of rock and virtually immobile. (Annual alternation of two latrines with 8-12 months burial and storage of human wastes in the currently unused latrine generally destroys all pathogenic agents therein.)

ANNEX A

ITINERARY OF F. EUGENE McJUNKIN

Date	Activity	Contact*
April 1	Departed Chapel Hill, N.C. for Amsterdam	--
April 2 and 3	Reviewed information on Tunisia and on rural water supply and sanitation in developing countries.	International Reference Center for Community Water Supply, The Hague: van Damme and Hofkes
April 3	Departed for Tunis via Paris (overnight connection)	--
April 4	Arrived Tunis	Macdonald
April 5	Met with AID staff members, reviewed assignment, reviewed Siliana Project; met with CARE staff.	Macdonald, Ferguson, Carlson, Hirsch, Saddler, Amundson, Morrisey; Radcliffe, Zacharias, Cavanagh, Oppen
April 6	Visited CARE well and spring projects in Bizerte governorate.	Cavanagh, Oppen, Fatnassi
April 7	Visited CARE well, spring, and latrine projects in El Kef governorate	Radcliffe, Cavanagh, Mersenine, Coneau
April 8	Visited potential CARE deep well projects in Kairouan governorate	Radcliffe, McVey, Dhif
April 9, 10, and 11	Reviewed CARE/AID Reports, Siliana project documents, drafted notes	Macdonald, Radcliffe, O'Toole
April 12, 13	Visited Siliana governorate, particularly Makthar and Ruhia Delegations	Macdonald, Radcliffe, Cavanagh, Tahar
April 14	Reviewed AID documentation, set up appointments	Macdonald, El Ayoun
April 15	Visited SOFAMECA; visited Ministry of Public Health	El Ayoun, Ben Cheikh, Hadidane; Atullah

* Identification by full name, title, and affiliation appears on page

Date	Activity	Contact*
April 16	Debriefing	James, Macdonald, Carlson, Hirsch, Saddler, Amundson, Morrisey, Radcliffe
April 17	Returned to Chapel Hill	--
May 4	Briefing of AID/NE/TECH/ Washington	Alden, Turner, et al.

* Identification by full name, title, and affiliation appears on page

ANNEX B

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ANNEX C

MAINTENANCE OF HAND PUMPS

Periodic Inspection, Lubrication, and Repair

Although wise pump design or selection avoids many difficulties, regular maintenance is the key to successful pump operation. Table 1 describes the maintenance needed on simpler hand pumps such as the Dempster model 23F and the Godwin HLD. Table 1 is based on advice obtained from manufacturers and on the maintenance schedule recommended by SATA in Cameroun. Where other makes of pumps are used, Table 1 should be amended in the light of the makers' instructions.

Village pumps are often used very intensively; Table 1 recommends a correspondingly high level of maintenance. Pumps maintained on this basis rarely break down. In some instances, it could lead to pumps being over-maintained, but that is obviously preferable to the state of neglect found in many parts of the developing world.

Some projects have provided users with stamped and addressed postcards which they can use to summon an emergency repair team when necessary. This or some other arrangement for dealing quickly with breakdowns will always be necessary. In Thailand these cards carry a picture of the pump on which the sender can indicate the defective part. Not only does this alert the maintenance and repair team to the appropriate part(s) and tools but the cumulative card file gives an overall record of breakdowns by component and signals possible change in pump design or maintenance practices. The disinfection and health education teams should always physically test nearby hand pumps, when they are carrying out their own duties, and report any obvious defects to the pump maintenance team.

TABLE 1 SCHEDULE FOR MAINTENANCE OF SIMPLE HAND PUMPS

daily

1. lock and unlock the pump at hours agreed by the village or community of users.
2. clean the well-head.

weekly

1. thorough clean-up of pump, well-head and surroundings.
2. oil or grease all hinge pins, bearings, and sliding parts, after checking that no rust has developed on them.
3. record any comments from users about irregularities in working (tightness of parts, leaks from stuffing box, fall-off in water raised). Correct these when possible.

bi-weekly

1. if necessary, adjust the stuffing box or gland (this does not apply to the CARE pump). Usually this is done by tightening the packing nut. This should not be too tight - there should be a slight leak when the adjustment is correct.
2. check that all nuts and bolts are tight, and check that there is no evidence of loose connections on the pump rods.
3. check for symptoms of wear at the leathers, noting any comments from users about any falling off in the water raised. If the pump fails to raise water when worked slowly (e.g., at 10 strokes per minute), replace the leathers.
4. carry out all weekly maintenance tasks.

annually

1. paint all exposed parts to prevent development of rust.
2. repair any cracked concrete in the weel-head and surrounds.
3. check wear at handle bearings and replace parts as necessary. On the CARE pump, worn bushes can be replaced by short sections of pipe of suitable diameter.
4. check plunger valve and foot valve; replace if found leaking.
5. check the pump rod and replace any defective lengths or connectors.
6. replace packing at the stuffing box or gland (does not apply to the CARE pump).
7. carry out all monthly maintenance tasks.

Note: Daily and weekly tasks by locals, bi-weekly and annual tasks by maintenance and repair teams.

Common Failures

Both pump design or selection and maintenance should be oriented towards reducing the risk of pump breakdowns and other trouble. Experience in a variety of countries suggests certain hand pump components as the most frequent points of failure. In the operating head these are the hinge pins on which the handle pivots; breakages of the handle, and wear, loss, or breakage of nuts and bolts and other parts. Lack of lubrication and clumsy use (banging the handle against the stops) frequently cause trouble. Pumps with chains between the pump rod and the handle and pumps with fly-wheel handles avoid many of these problems.

Another common cause of pump breakdowns is wear of the leather cup seals in the cylinder, in many countries the most common problem. This problem is reduced by using smoother-lined brass or plastic cylinders instead of cast iron ones, or by using specially impregnated leathers. Some experimentation is under way with synthetic materials such as neoprene rubber or PVC plastic for replacement of leather. Pump maintenance men alwys need a stock of spare leathers. Annex describes how leather cup seals can be manufactured locally.

Another significant cause of pump failures is trouble with valves in the cylinder. Ball valves are normally very simple and trouble-free, but suffer from the defect that pounding of the ball deforms the metal seat. Poppet valves with rubber cushioning have some times been more effective in the long term for this reason. Flap valves are probably the most easily repaired but require more frequent attention.

One other common problem with hand pumps is breakage of pump rods or pump rod couplings and trouble with rod bushings.

Common operating problems with internal causes are summarized in Table 2.

Training

Training programs related to pump maintenance should emphasize installation, operation, and maintenance. The latter is of vital importance. Manufacturers' booklets on installation, operation, and maintenance of the pumps in use should form the "textbooks" of any training course supported by actual on-site training. Figure 1 shows one page from a Laotian booklet on hand pump maintenance. Figure 2 is another example.

Trainees should be instructed in how hand pumps work, the more common causes of failure, and their correction. Training should not be confined to lectures; trainees should be physically involved. On the job training during original pump installation, as practiced by CARE/Tunisia, is an excellent means of training.

Samples of hand pump(s) used locally, with tools to dismantle and reassemble, should be available for training. A collection of broken or worn parts is also useful for demonstration purposes.

TABLE 2

COMMON HAND PUMP TROUBLES AND REMEDIES

TROUBLE	LIKELY CAUSE	REMEDY
1. Pump handle works easily but no water delivered	No water at the source. Well dry	Clean and repair well, or develop a new source or sources of water
	or	
	Level of water has dropped below suction distance of pump	Can be checked with vacuum gauge or with weighted string. Allow well to fill up or lower pump
	or	
	Pump has lost its priming	Prime the pump. If the pump repeatedly loses its priming it may be periodically pumping the well dry; there may be a leak in the suction line; or the foot valve or check valve may be leaking. Repair line or valve
	or	
	The pump leathers may be worn out	Renew the leathers
	or	
	The valves or valve seat may be worn or corroded	Renew valves and repair or renew seats
	or	
	With a deep-well plunger pump the plunger rod may be broken	This trouble would be indicated by the pump running freer and probably quieter. Turn the pump over by hand and note if there is resistance on the upstroke. Broken rods must be renewed and this usually means pulling the drop pipe and cylinder out of the well
	or	
	Shutoff valve may be closed	Open valve
	or	
	Hole in suction pipe	Renew suction pipe

TROUBLE	LIKELY CAUSE	REMEDY
	or	
	The suction pipe may be plugged with scale or iron bacteria growth or sediment	Can be checked with vacuum gauge. Remove suction pipe and clean or renew
	or	
	The pump cylinder may be cracked	Renew the cylinder
	or	
	Leak at base of cylinder	Renew cylinder gasket
	or	
	One or more pump valves held open by trash or scale	Remove valves and inspect for trouble. With deep-well plunger pumps this may mean pulling the pump cylinder or plunger and valves out of the well
2. Pump runs but delivers only a small amount of water	Plunger leathers badly worn (plunger and piston pumps)	Renew leathers
	or	
	Well not yielding enough water	Decrease demands or establish new sources of water
	or	
	Cracked cylinder (plunger or piston pump)	Renew cylinder
	or	
	Pump valves leaking	Repair valves
	or	
	Screen or foot valve may be obstructed	Remove and clean
	or	
	Suction pipes are too small	Can be checked with vacuum gauge. Install larger pipes

TROUBLE	LIKELY CAUSE	REMEDY
	or	
	Foot valve may be out of order	Repair foot valve
3. Handle springs up after down stroke	Suction pipe plugged up below pump cylinder	Remove entire pump and clean out suction pipe. If well has filled with dirt up to suction pipe, it should be cleaned out or the pipe cut off
	or	
	Pump check valve fails to close	Repair check valve
	or	
	Pump check valve fails to open	Repair check valve
	or	
	Water too far from pump	Place cylinder nearer water
4. Leaks at stuffing box	Packing worn out or loose	Renew or tighten packing. Leave packing nut loose enough to allow a slow drip of water. The water serves as a lubricant
	or	
	There is a badly scored plunger rod or pump shaft	Renew plunger rod or pump shaft
5. Pump is noisy	Bearings or other working parts of the pump are loose	Tighten or renew parts
	or	
	Pump is loose on mountings	Tighten mountings

TROUBLE	LIKELY CAUSE	REMEDY
	or With deep-well plunger pumps having a steel plunger rod the rod may be slapping against the drop line	Use a wooden rod or install guides for rod or straighten drop pipe if crooked

FIGURE 1 PAGE FROM LAOTIAN HAND PUMP MAINTENANCE MANUAL FOR FIELD USE

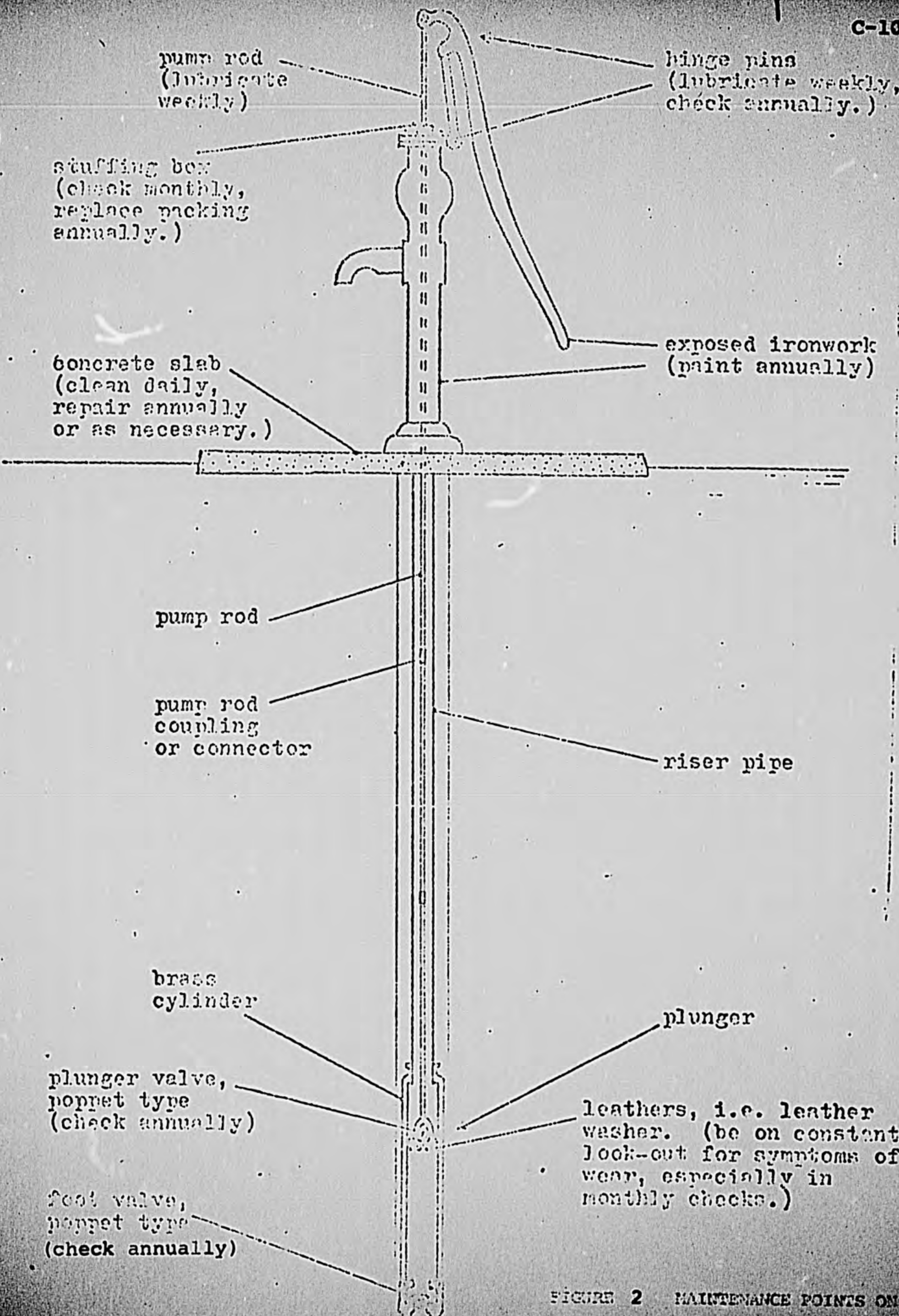


FIGURE 2 MAINTENANCE POINTS ON A SIMPLE HAND PUMP

ANNEX D

LOCAL MANUFACTURE OF LEATHER CUP SEALS

The locally manufactured CARE wooden handled hand pump utilizes a brass cylinder, plunger, and valve assembly of U.S. manufacture (Clayton Mark). The leather cup seals in this assembly require periodic replacement and are the only maintenance part requiring frequent reordering from abroad. CARE has attempted, without success, to obtain information from various manufacturers on how to make leather cups seals in Tunisia. The following notes suggest how these seals might be manufactured by the pump maintenance teams, possibly during inclement weather conditions.

The manufacture of leather cup seals is as much an art as a science but can and is done locally even at the village level. In an emergency, take industrial belting or good harness leather (preferably from the shoulder of the hide - where there are fewer fat wrinkles which may result in "stringiness"), soak it in water, clamp it onto the piston (or object of same diameter) and drive into a pipe of same diameter as the pump cylinder, let dry, remove and trim the wrinkled edge with a sharp knife (including the center hole), soak for 12 hours in an edible oil (Preferably neat's-foot), wax, and lightly apply graphite grease to the wearing surface.

For "mass production", wooden forms can be used. To make the forms, use wooden boards about 3/4-inch (2 cm. $\pm$) in thickness, having holes of the same diameters as the pump cylinders, and nailed to a stiff backboard. Cylindrical blocks, 3/8-inch less in diameter, are bolted concentrically within the circular openings. The bolts should be long enough so that the wet and pliable leather, laid over the holes, can be drawn down by the bolts and blocks, forcing the leathers into position. Then proceed as before.

One of the principal advantages of flap valves is that the leather flapper, generally the part requiring replacement, can also be manufactured locally.

ANNEX E

JAR TYPE WELL CHLORINATORS

(DISINFECTION OF OPEN DUG WELLS)

Abstracted from "Disinfection for Small Community Water Supplies". Central Public Health Engineering Research Institute, Nagpur, India, Undated. Pp. 4-7.

3 Disinfection of Open Dug Wells

It has been observed that fecal contamination is invariably present in all open dug wells. These wells get easily contaminated with poor and unhygienic methods of drawing water and the indiscriminate use of the surroundings.

While well waters can be treated by the addition of bleaching powder or any other disinfectant every day, any method or device that will give effective chlorine concentration for a period of 3 to 4 weeks at a stretch or even for two weeks, would be of immense use. It would be ideal if this device can be cheap, simple and can be fabricated with indigenous materials and skill.

A "dosing cartridge" developed in Bulgaria for the disinfection of waters was reported to be cheap and simple. It was merely a porous earthen or concrete pot filled with bleaching powder and immersed in water and was reported to be working efficiently for long periods when used for disinfecting wells.

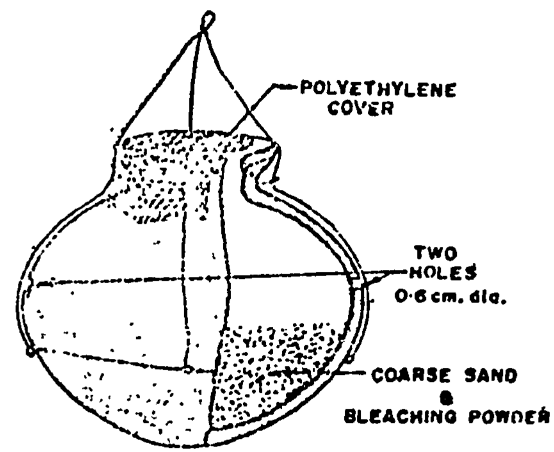
"Dosing cartridges" as described by Zdravkov* were tried but found unsatisfactory. Several experiments with pots of a variety of porosities failed to give adequate residual chlorine for longer than 2 or 3 days. This was due to the blockage of the pores of these pots with calcium carbonate deposits. Bleaching powder was also found to form a hard mass inside the pot locking up a large quantity of chlorine. It was, therefore, not possible to use porous earthen pots for disinfecting well waters.

* M. Zdravkov, "New Methods of Chlorinating Drinking Water", WHO/Env. San/124, 25th November, 1959.

Since the fine pores on the entire surface of the pots get choked with calcium carbonate, it is necessary to make holes in these pots for the diffusion of chlorine. To keep the bleaching powder in a bulky condition and to facilitate the diffusion of chlorine from the mass, it is also necessary to mix coarse sand with bleaching powder before charging these pots. After several trials with holes of different diameters at different positions, and with different proportions of sand and bleaching powder in the mixtures, the following units are recommended for the disinfection of wells.

3.1 Single pot with holes in the middle

An earthenware pot of 12-15 liters capacity, with two 0.6 cm diameter holes in the middle periphery of the pot, is filled with a moistened mixture of 1½ kg of bleaching powder and 3 kg of coarse sand (in the range of 1.4 to 1.6 mm). This normally occupies the volume of the pot below the level of the holes. Its mouth is covered with a polyethylene or any other foil and the unit is lowered into the well one meter below the water level.

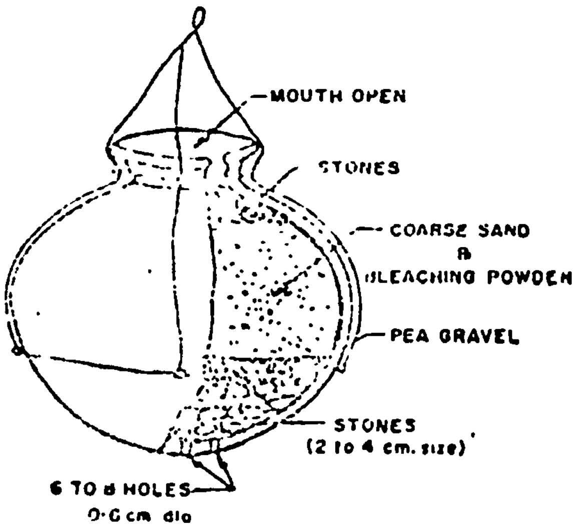


This unit can chlorinate wells of 9000-13000 liters water content having a withdrawal rate of 900-1300 liters/day (40-60 people/day) for a period of at least one week giving chlorine residuals in the range of 0.2 to 0.8 ppm.

3.2 Pot with holes at bottom

The device consists of an earthen pot of 7 to 10 liters capacity. Six to eight holes of 0.6 cm diameter are made in the bottom of the pot. The holes are then covered with stones or pebbles of 2 to 4 cm size. This is then covered with pea gravel of smaller size.

A dry mixture of 1.5 kg of bleaching powder and 3 kg of sand is placed over the gravel. The pot is then filled with pebbles or stones upto the neck to weight it and facilitate its lowering in the water. The pot is lowered with its mouth open unlike the previous case. Addition of sodium hexametaphosphate (75 gms or 5 per cent of bleaching powder) helps in prolonging the chlorination period by keeping the mixture soft.

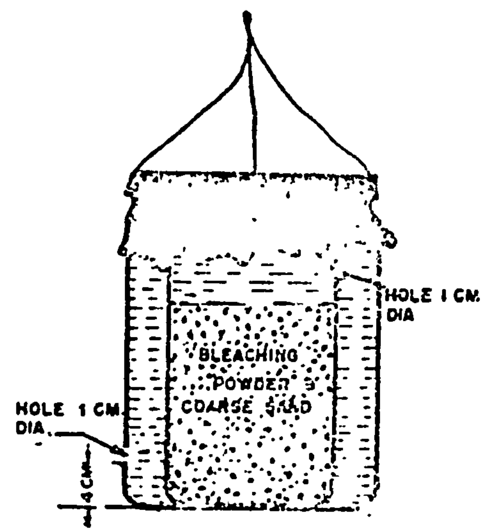


With community wells of 9000 to 13000 liters content and daily draw off rates of 900 to 1300 liters (40-60 people/day), one pot is enough to give required chlorination (0.2 to 1.0 ppm) for two weeks. With larger wells and higher draw-off rates, 2 pots are necessary per well, although the chlorine residuals on some days are on the high side. Generally the wells require 1 to 2 days to build up enough residuals after the initial introduction of the pots unless sufficient bleaching powder has been added to the well manually to satisfy the initial chlorine demand.

3.3 Double pot system

When a single pot, with holes either in the middle periphery or at the bottom, is used in small household wells containing about 4000 liters or less and having a withdrawal rate of 360 to 450 liters of water per day, it will be found to over-chlorinate such wells. For this purpose a unit consisting of two cylindrical pots, one inside the other, will be found to work well.

In this case the inner pot is filled with a moistened mixture of one kg of bleaching powder and two kg of coarse sand to a little below the level of the hole, and is lowered into the outer pot. The mouth of the outer pot is tied with a polyethylene or any other foil. The unit is then lowered into the well with the help of a rope, 1 meter below the level of the water. This depth is chosen to avoid breakage of the pot due to collision with buckets used to draw water. The rope is tied either to the support of the pulley used for drawing water or to a nail hammered in the inside wall of the well.

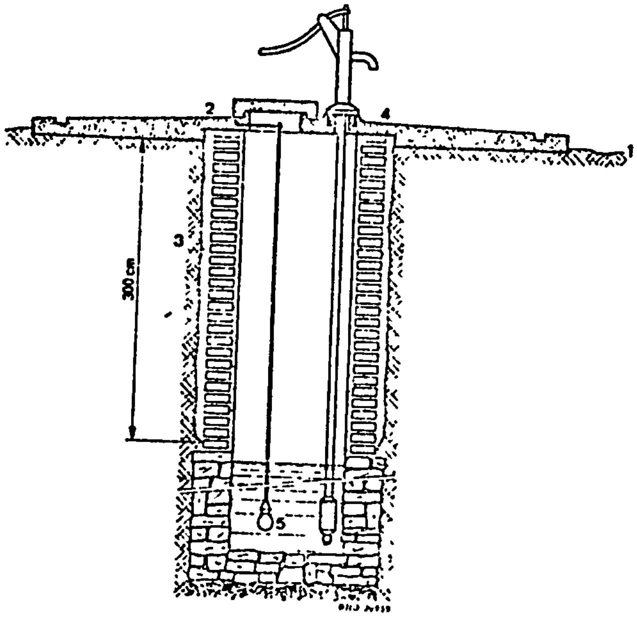


Such a unit will work satisfactorily giving a chlorine residual in the range of 0.15 to 0.5 ppm for 2 to 3 weeks in the small household wells containing nearly 4500 liters of water and having a draw-off rate of 360 to 450 liters per day.

ANNEX F

SANITARY SURVEY CHECKLIST

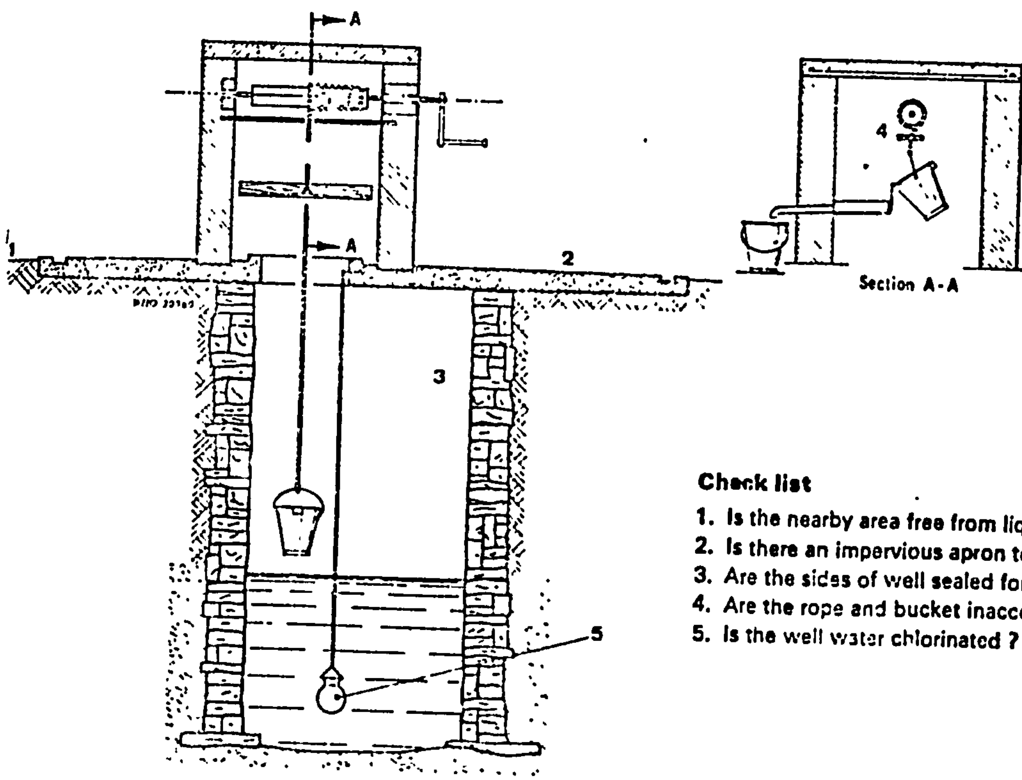
DUG WELL WITH PUMP



Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there an impervious apron to exclude surface water ?
3. Are the sides of well sealed watertight for 3 m below ground level ?
4. Is the eduction pipe to pump sealed in apron at exit ?
5. Is the well water chlorinated ?

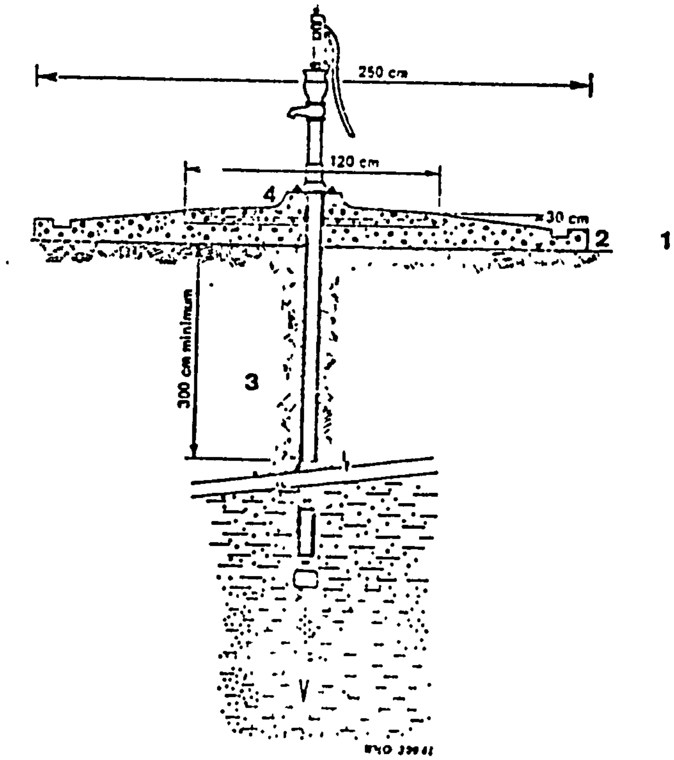
DUG WELL WITH WINDLASS



Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there an impervious apron to exclude surface water ?
3. Are the sides of well sealed for 3 m below ground level ?
4. Are the rope and bucket inaccessible to the users ?
5. Is the well water chlorinated ?

. TUBE WELL*

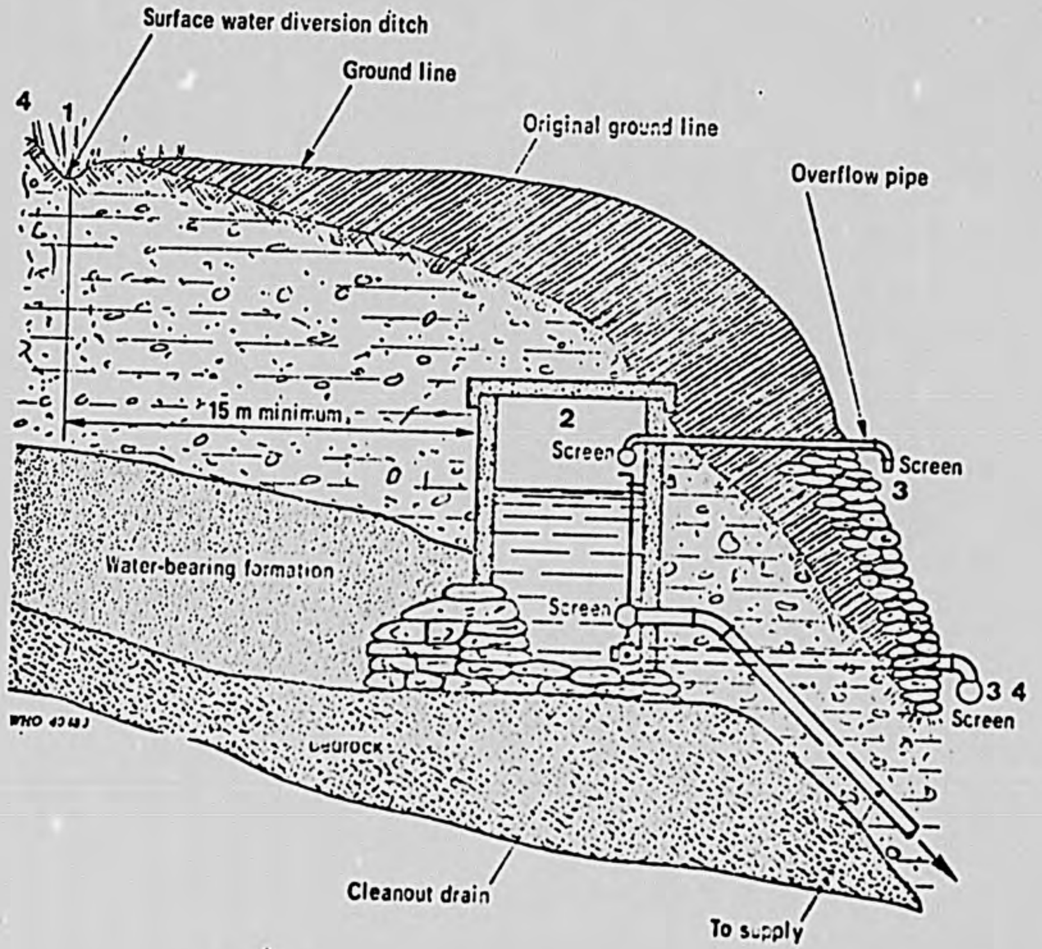


* Reproduced from Wagner & Lanoix (1959)

Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there a watertight concrete apron and is drainage provided?
3. Is there watertight tubing for 3 m below ground level ?
4. Is the eduction pipe to pump sealed in apron at exit ?

PROTECTED SPRING SOURCE



Check list

1. Is there a diversion ditch around the spring to divert surface water ?
2. Is the collection structure inaccessible to users ?
3. Is drainage provided below the outlet pipes ?
4. Are animals excluded by fencing of spring area ?

ANNEX G

PNEUMATIC MEASUREMENT OF WATER LEVELS IN DEEP WELLS

Source: Ground Water and Wells, Edward E. Johnson, Inc., St. Paul, Minnesota, 1966. Pp. 90-91.

however, exceeds that of other means for measuring depth to water.

Air Line Method

Figure 58 shows the installation of an air line in a well for the purpose of determining the depth to water. The air line consists of a small diameter pipe or tube of a length sufficient to extend from the top of the well to a point several feet below the lowest anticipated water level to be reached during the test. The exact length of the air line must be measured as it is placed in the well. If flexible tubing is used, steps must be taken to be sure that the tubing hangs vertically in the well and does not spiral inside the well casing. The air line must be completely air tight throughout its entire length and connections to it at the ground surface must be air tight.

Quarter-inch copper or brass tubing is commonly used for the air line. The upper end of the air line is fitted with suitable connections and valve so that an ordinary tire pump can be used to pump air into the tube. A tee is provided in the line to which a pressure gauge may be connected to measure the air pressure in the tube. A gauge calibrated to indicate pressure in feet of water serves better than one with a scale reading in pounds per square inch (psi).

The device works on the principle that the air pressure required to push all the water out of the submerged portion of the tube equals the water pressure of a column of water of that height. If this pressure is expressed in feet of water, the depth to water can be calculated.

A necessary first step is to determine accurately the depth from the top of the well casing or from some other reference point to the lower end of the air line. Once installed with the pressure gauge connected, air is then pumped into the air line. The pressure shown by the gauge increases until it reaches a maximum value which means that all the water has been forced out of the air line. At this point, the air pressure in the tube just balances the water pressure and the gauge reading shows the pressure necessary to support a column of water of a height equal to the distance from the water level in the well to the bottom of the tube. If the gauge indicates feet of water head, then it shows directly the submerged length of the air line in feet.

Subtracting the submerged length from the total length of the air line gives the depth to water below the measuring point chosen. A measure-

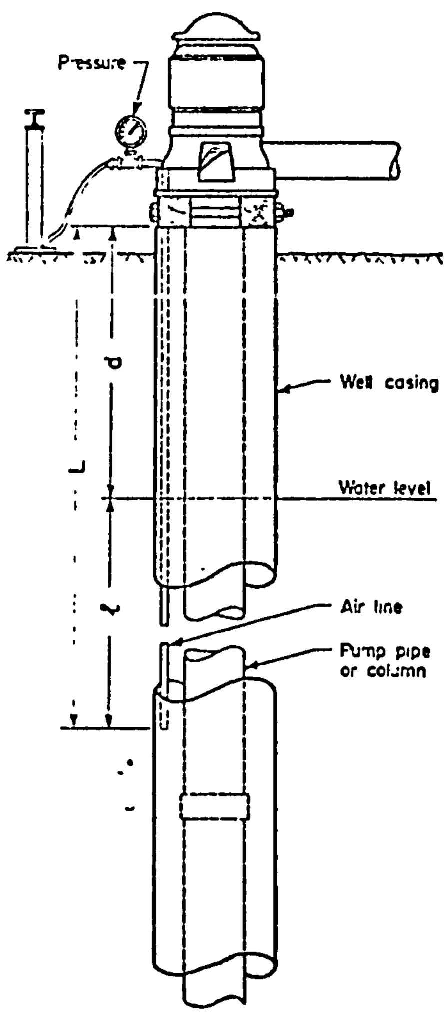


Figure 58. Typical installation for measuring water levels by air-line method.

ment made before starting to pump the well indicates the static water level.

Any change in water level is represented directly by a difference in pressure shown by the gauge in subsequent measurements. Drawdown during pumping and during recovery after pumping is stopped can be readily recorded from the pressure readings.

Referring to Figure 58, the depth to water is always calculated from the following formula:

$$d = L - l$$

where

- d is depth to water, in ft
- L is depth to bottom of air line, in ft
- l is pressure head, in ft, represented by a column of water of height equal to the submerged length of the air line.

Suppose we have an installation where the distance from the top of the well casing to the lower end of the air line is 95 ft. As air is pumped slowly into the line, assume that a maximum reading of 46 ft on the gauge is reached. The depth to water is then the difference between 95 and 46, or 49 ft. Let's say that this is the static water level.

Assume now that the pump is started. As the water level in the well drops, the submerged length of the air line decreases and the pressure indication on the gauge drops accordingly. A gauge reading of 34 ft, for example, would mean that the submerged length of the air line has decreased by 12 ft and the depth to water has changed to 95 minus 34, or 61 ft. This indicates a drawdown in the well of 12 ft below the static water level. If the gauge reads in psi, each reading must be multiplied by 2.31 to convert it to feet of water. A reading of 15 psi, for example, corresponds to a pressure head of 15 times 2.31, or 34.6 ft of water.

The dependability of the measurements made by the air line device varies with the accuracy of the pressure gauge and the care used each time in operating the tire pump to get the pressure reading. Depth to water can be determined usually within 0.2 ft of the exact value. The air line is not accurate enough for use in observation wells during an aquifer test, but it is the most practical means for measuring water levels in a pumped well. To avoid disturbances from turbulence near the intake of the pump, the lower end of the air line should be at least 5 ft above or below the point where water enters the pump.

Aquifer Test Data

The arrangements for an aquifer test must permit the following controls and measurements:

1. Constant pumping rate, even though the pumping level may vary during the pumping period.
2. Accurate measurement of drawdown in the pumped well and in one or more observation wells some distance away.
3. Accurate record of time each measurement is taken as pumping proceeds.

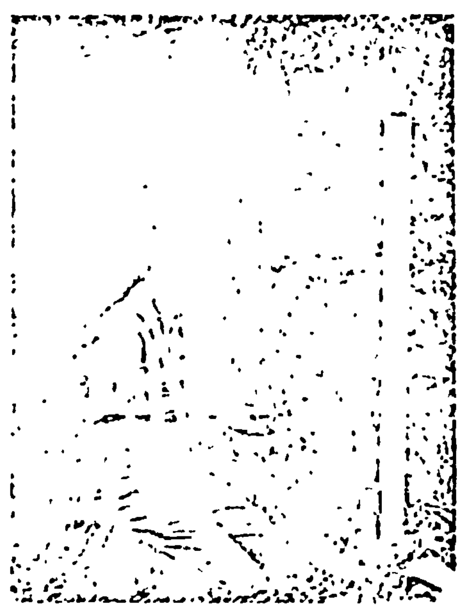


Figure 59. Measuring water levels in observation wells using the wetted-tape method.

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INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

INTERNATIONAL DEVELOPMENT ASSOCIATION

PUBLIC UTILITIES DEPARTMENT

NOTES SERIES

MEASUREMENT OF THE HEALTH BENEFITS OF INVESTMENTS IN WATER SUPPLY

Report of an Expert Panel

to the

International Bank for Reconstruction and Development

May 5 - 7, 1975

January 1976

Central Projects Staff
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SUMMARY AND CONCLUSIONS

The general conclusions of the panel are as follows:

(i) Other things being equal, a safe and adequate water supply is generally associated with a healthier population. This has been unequivocally demonstrated for urban areas and in varying degrees for rural situations. The difficulty lies in measurement rather than in qualitative trends. The problem with collecting field observations on the health effects of water supply is that on a cross-section basis other things are never equal and on a through-time basis other things usually cannot be held constant or accurately controlled. Consequently it is extremely difficult to identify and measure exactly the health effects of improved water supply, and there is a limit to the precision attainable. Furthermore, even if a case were found where governmental, physical, environmental, economic, cultural and educational factors which affect health could be reasonably controlled, the detailed findings of a health and water supply study are unlikely to be transferable from that particular setting to situations elsewhere.

(ii) While long-term longitudinal studies of large size and expense are probably the only means through which there is any chance of isolating a specific quantitative relationship between water supply and health, separate from the multitude of other interrelated factors, the very high cost, limited possibility of success and restricted application of results lead the panel to recommend that the Bank does not undertake such studies. Furthermore, given the current state of knowledge, attempts at a rigorous quantification of the health benefits of Bank water supply projects are likely to be futile. It should be sufficient to accept the universally recognized fact that the provision of an adequate quantity of safe water is a basic necessity for the maintenance of good health and productivity.

(iii) Although the scope for an exact quantification of health benefits for purposes of cost/benefit analysis is very limited, the need of the Bank and governments for greater insight into the extent to which disease may be reduced by various measures still exists. The panel therefore believes that the Bank might undertake a few modest impact studies in which perhaps only one or two specific diseases might be closely followed. In this way it may be possible to gradually build up knowledge of how water supply and other governmental, economic, social, educational and environmental changes have been associated with changes in health. Then at a future time when investment is to be made and where it is to be directed at public health improvement, the availability of more accurate information would assist decision makers in determining where and in what way the investment could be best allocated. Any health impact studies which are undertaken, however, should be carefully chosen, and because of their questionable payoff, should be modest in scope, manpower and money expenditures.

(iv) The possibility of acquiring and making use of knowledge relating to the effect of water supply, and other environmental and sanitation variables on health depends partly upon the availability within the Bank of experienced individuals, familiar with the details of international medical-epidemiological investigations. If the Bank decides to pursue project-impact studies to any extent, it is essential that it have one or more such highly qualified individuals on its staff.

I. INTRODUCTION

1. The major problem impeding the accurate forecasting of the health impact of changes in water supply is the difficulty of designing field studies which adequately control the large number of social, political, economic, environmental and educational variables which affect health. While access to an adequate quality and quantity of water is necessary for the maintenance of good health, water supply is but one of many factors which can have a significant impact on the health of a population through time.

2. Given the interrelationships which exist among the numerous factors which affect health, for a field study to have a chance of successfully isolating and measuring any one causal association, considerable effort must be made to ensure that all data which are monitored and collected reflect actual conditions as accurately as possible. In retrospect, most past field studies have been based on data which proved to be too inexact for the task of separating highly interrelated factors. In the report which follows the panel has attempted to highlight some of the problems and the approaches which should be considered by those who wish to engage in further efforts to quantify the health benefits of water supply.

II. METHODOLOGY OF MEASUREMENT AND INDICES

3. In practice, in deciding which aspects of health and diseases are to be measured before and after the introduction of improved water supplies, a balance has to be struck between precision and comprehensiveness, on the one hand, and cost and quality and quantity on the other. If there is the possibility of carrying out several studies simultaneously, and if the results of these studies are to be comparable, it is necessary (1) that methods of measuring the same variable at different places and times should be standardized as far as possible, and (2) that the methods of data collection should be as simple as possible, while retaining as high a degree of reliability as possible.

4. In any study, out of the large number of possible variables which can be monitored, a limited few would have to be selected on which to concentrate. Those of particular concern would include water use, health, and health-related environmental variables. The more important of these are discussed below.

Water-Use Variables

5. All studies directed at assessing the health impact of water must include the measurement of water consumption in terms of both quantity and quality.

(i) Quantity of water used in liters per capita per day, and the purposes for which the water is used. There may be complications due to particular water use (e.g., large non-consumptive use for gardens or laundry) which need recording.

(ii) Quality of water used. For most circumstances relevant to Bank projects this is equivalent to the amount of fecal pollution present, as assessed in a standard manner. The fecal coliform count is probably as good as any such measure, but other well-standardized techniques might be acceptable. In special circumstances actual pathogens may be determined.

Measurement of Health Variables

6. A large group of relatively universal water-related diseases and conditions can be assessed by the following limited number of procedures:

(i) Diarrheal history of infants by questionnaire or survey.

(ii) Fecal inspection and examination for bacteria and parasites.

(iii) Clinical examination, especially of skin and eyes.

(iv) Observation of physical development and the nutritional status of children.

(v) Observation of the state of personal hygiene and the sanitary condition of dwellings.

These are discussed in paragraphs 14 - 21 below.

7. The timing of studies may be important -- some conditions have an annual incidence cycle, so that repeat observations must be at a similar time each year, whereas others are irregularly fluctuant, so that cumulative data over a long period of time are needed even as a baseline.

8. The age group 1 to 14 is considered to be the one most sensitive to the waterborne and water-related diseases which lend themselves to examination. In general, the collection of information related to health would best be concentrated on this group.

9. <u>Questionnaires and surveys</u>. Answers to questionnaires are usually unreliable. However, with present uncertainty over the etiology of much diarrhea there may be need for this group of diseases to rely on history, covering a short period (one week or so) prior to taking the history. The operational definition of diarrhea in children needs further refinement, but it should be realized that the mother's views on what is and what is not diarrhea will prevail in the usual follow-up, in which recording of past events has to be based on the mother's description. Where health services are adequate, and records are reliable, valuable supplementary data may be obtained from hospitals and clinics.

10. <u>Fecal inspection</u>, when practicable, will give an independent estimate of diarrheal prevalence at the time of the visit. Bacteriological examination for shigellae (which are very common in developing countries) provides a relatively precise index, provided facilities are adequate for prompt culture. More refined bacteriological and virological examination may prove informative where resources permit. Cholera and typhoid, which often are less frequent than shigelloses, pose serious difficulties as indices under most circumstances. Protozoal and helminth parasites should be estimated quantitatively by a well-standardized technique; for example, using one gram of feces and quantitatively examining for egg and cyst content of the total sediment.

11. <u>Clinical examination</u> of skin and the conjunctiva enables the frequency of surface infections to be determined. Standardized recording has not yet been attempted, but appears feasible. Clinical examination will also detect any really ill people with severe infections: typhoid, leptospirosis, hepatitis, etc., but these will not normally attain a prevalence where they can be measured in population surveys. Clinical and hospital records may be of some value where they exist.

12. The status of <u>physical development</u> of children can be determined by field measurements of height, weight, and skinfold thickness; these tests are well standardized and of general applicability, provided ages are known and attention is given to establishment of norms. Examination of nutritional status and screening for deficiency diseases would be an asset.

13. More general field observations of the level of <u>personal hygiene</u> should be established by presence or absence of ectoparasites; by consumption of soap; assessment of body and clothing cleanliness; etc. Investigations of sanitary conditions of dwellings should concentrate on those facilities where water plays an important role, e.g., water faucets, toilets, laundry and washing facilities, etc. A method of proper scoring for hygiene level must be developed and maintained to ensure comparability.

14. <u>Other locality-related tests</u>. Several special methods are available for specific infections. Usually only one or two methods will be relevant to a particular location, for example, mid-day urine tests for urinary schistosomiasis, night blood tests for filariasis, skin snips for onchocerciasis, and blood tests for serological detection of anthropod-borne virus infections and of other infective diseases. Diseases in this group will not usually be significant in studies to measure the impact of drinking water systems.

15. Health problems which may be monitored by the general procedures discussed above include the following:

(i - ii) Those due to bacteria (shigella, salmonella, vibrio cholerae); viruses (rotaviruses and other enteroviruses) and parasites (amoebae, schistosomes, ascaris, trichusis, hookworms, giardiasis, other gastrointestinal trematodes).

(iii) Skin sepsis, tropical ulcer, scabies, yaws, bejel, pinta, leprosy, tinea, guinea worm, trachoma, onchocerciasis, conjunctivitis.

(iv) Malnutrition from any cause.

(v) Infestation with ectoparasites (lice, fleas).

16. The aim is to ensure a broad coverage of the range of water-related diseases affected by water supply, and that where the same disease (or health attribute) is measured in two places, or at two times, it is done in a comparable manner.

Other Health-Related Variables

17. Evaluation of selected other relevant variables is crucial, firstly to attempt to ensure that extraneous factors do not invalidate ascribing the health difference between project and control area to the water improvements; aspects in which the project and control areas appear to differ significantly need particular attention. Secondly, knowledge of the effect of related environmental, social and cultural variables is also likely to prove of great value in attempting to maximize the benefits from any given water supply installation.

18. These related variables will vary from case to case, but will usually include:

(i) extent of health education and general education;

(ii) water-related facilities (laundry and bathing facilities);

(iii) sanitation facilities;

(iv) other health-related facilities;

(v) dietary differences;

(vi) economic, social and cultural differences; and

(vii) climatic and geographic differences.

Health State Indices

19. For practicable field application, indices which summarize the health state of a population could be of significant value. These indices, however, should be few in number, simple in measurement, reliable, selected to be appropriate to different countries and regions, and related to prevalent diseases. This last point is particularly important in that through time each index must be carefully "calibrated" so that the exact measures for which it is a surrogate are well known. In all instances, uniformity in field and laboratory methods is essential to ensure international comparability of the results of studies and eventually, if possible, to produce valid transferable findings.

20. Indices to be measured should be selected according to the characteristics of each individual project; not all need to be measured in any given situation. Unfortunately, since no two study areas are the same from the standpoint of disease incidence, culture, religion, economic status, etc., it is unlikely that specific results can be transferred to other similar projects with any degree of confidence. If detailed data were accumulated in a number of ongoing field studies, increasing transferability of method and finding might emerge, if not of mathematical precision, at least of working usefulness.

21. Even in so-called developed countries, there is a lack of long-term consistent health data which has already been collected. In developing countries the situation is usually far worse. Age-specific mortality data, by cause and reported morbidity, are available only where organized minimum public health services exist and adequate census figures permit calculation of rates; even then they are likely to be incomplete. Hospital and clinical records are also of highly variable quality. This is generally due to poor access to medical care by large parts of the population, and a lack of knowledge of the size of population served by individual institutions.

22. The lack of health data at the country level hampers the development of health impact studies. Without such data the country itself finds it difficult to allocate resources between the health sector and other sectors on a rational basis, and the Bank finds it difficult to evaluate different investment alternatives which might have an impact on health. Where data do not exist, the establishment of a data base would have to be included as part of the study, an effort which is difficult and usually costly, and which is unlikely to yield data which are useful for statistical analysis in the short term.

23. The difficulty of the exact quantification and measurement of many of the variables discussed in the above sections is immediately evident. Nevertheless, it should again be emphasized that many of the above factors would have to be measured in any study to isolate a water supply-health relationship, since diseases are often the result of a highly interrelated constellation of causes and circumstances. These diseases may be spread by a variety of vehicles, vectors, and modes of dissemination in addition to water. The isolation of the impact of water supply, alone, on the occurrence of these diseases constitutes one of the great epidemiological challenges. The following section attempts to address this challenge through the question, "Can the health impact of water supply be isolated by field studies which have reasonably limited financial budgets?."

III. ALTERNATIVE FORMS OF HEALTH IMPACT STUDIES

24. In the light of past practices and the lessons therefrom, the panel considered several general approaches to field studies and attempted to make judgments on the usefulness of these approaches to the Bank.

Retrospective Studies

25. From a fixed point in time all available health records may be tabulated for a preceding period of at least two years extending over comparable seasons, for one or more towns, cities, or regions. If routine vital statistics are available and have been adequately maintained, such so-called retrospective studies could be a helpful starting point to decide whether or not more intensive investigation is warranted. If hospital and clinic services exist they might provide useful leads to the types of specific diseases that exist in the population and a rough approximation of their incidence. Such data would be valuable in planning further investigations, selecting population groups for study and estimating the sizes of samples which are necessary.

26. Some members of the panel considered such investigations made in the past to have been faulty in precision of measurement, in adequacy of base data, and in accuracy of findings. Others on the panel were of the opinion that a reasonable number of existing retrospective studies more or less meet scientific tests of validity and might be examined, with care and probable profit by Bank staff. Studies which several members of the panel felt were worth reviewing again include references 4 - 14 on bacterial diseases and 15, 16 on parasitic diseases. Evidence of waterborne transmission of typhoid, cholera, shigelloses and hepatitis is available (4-15). Recently other infections, such as giardiasis, have also been shown to be transmitted by water,[16] and other studies have shown the importance of good water supplies in control of cholera,[18] other diarrheal diseases and enteric infections.[19]

27. Where reasonably accurate base data have been recorded for some years, retrospective studies can be pursued at relatively low cost in manpower and dollars. The panel feels that the Bank could invest modest sums of money in such selected investigations. A typical example discussed was a study which could be undertaken in one of the developing regions of Yugoslavia where basic health data and vital statistics are available. An analysis of these data, with particular reference to their association with water supply and other measurable environmental, economic and social factors, might be useful to the Bank, which has a number of water supply investments in Yugoslavia. Other such possibilities for studies may also appear if consciously sought by Bank staff, particularly in areas where projects of both the Bank and WHO exist in parallel.

Long-Term Longitudinal Studies of Total Health Impact

28. The panel devoted considerable time to a discussion of long-term longitudinal studies, which are considered the best way of attempting to measure the total health effects of water supplies. The number of new studies thought to be necessary if significant results were to be expected ranged between 10 and 20, widely distributed geographically. However, it was generally concluded that, given the problems of controlling for the many interrelated factors, the reliability and transferability of conclusions from one study to the other (and, in turn, to global applicability) were doubtful. Among other major drawbacks of long-term longitudinal studies are: unavailability of expert workers; delayed conclusions; inadequate base data; cost; and significant changes in control areas over time.

29. Generally, long-term longitudinal studies of total health impact can not and should not be undertaken without both supervision and recording in the hands of highly experienced investigators. Suitable personnel do not exist in most countries and would have to be trained. This would take time and could also result in withdrawing expert manpower from other important public health activities. Studies, of course, would have to be carried out with the full cooperation of local authorities and under the umbrella of central and local health officials.

30. Few localities exist where specific disease and health data are available for long-term monitoring. The development of more accurate vital statistics would be a major continuing obligation of such studies. Once data start becoming available, the length of time desirable for each investigation would be a further five to ten years, before reliable findings might become available. This interval was considered generally unsatisfactory for Bank use.

31. Given the limited time available to the panel, the question of cost was not closely examined. Preliminary estimates, however, suggest that the cost of long-term longitudinal studies of total health impact could run well over a million dollars per study.

The Scope for More Limited Studies

32. Long-term longitudinal studies have significant cost, time, and transferability disadvantages. Cross-sectional and time-series retrospective studies, in addition to suffering from the transferability problem, generally cannot be expected to provide data which are of sufficient reliability to allow the isolation of any specific causal relationship between water supply and health. As a result, the panel concluded that substantial amounts of scarce resources should not be devoted to attempts to isolate specific causal water supply-health relationships.

33. It was suggested, however, that selected Bank water supply projects could be used as a basis for more limited exploration. A small number of projects could be selected, with reasonable geographical spread, in which base health data, and other economic, social and environmental data, could be

obtained at the beginning of the project and be continuously monitored throughout its construction and operation. For purposes of simplicity, perhaps only the one or two diseases with the highest prevalence would be followed in detail. Arrangements could be made with the borrowers to provide experienced supervision for each study, with a relatively uniform methodology of inquiry and under the aegis of the Bank. Within the boundaries of the projects, areas might be selected for detailed analysis and compared with control sections and with areas in which there existed different levels of service quality. With a series of such projects under way, it would be reasonable to hope that in the course of time a body of information could be accumulated from which water supply, general environment, and health status correlations would emerge and be of some limited use when evaluating and designing other projects to be undertaken by the Bank.

34. One specific example discussed was the Uttar Pradesh water supply and sewerage project. It could offer an opportunity for monitoring exercises of this type. Detailed cooperation, of course, would have to be sought from the local and state health authorities. Portions of the inquiry related to specific measurement techniques might be subcontracted to experienced teams from agencies such as the World Health Organization. Central management of any such monitoring exercises should probably be the responsibility of the Bank.

Manpower Requirements

35. The possibility of acquiring additional useful knowledge relating to health, water supply, and other environmental and sanitation-related variables depends partly upon the availability within the Bank of highly experienced individuals, familiar with the details of medical-epidemiological investigations. If the Bank is to pursue any project-impact studies intensively, it is essential that one or more such professional staff must be highly qualified and with long experience in this difficult field, preferably in international work. This would help ensure an acceptable quality of such studies on the one hand and, on the other, contribute to raising the levels of health benefits of the Bank's current investments in water supply by providing advice on ways and means to maximize the health benefits of water supplies. The Bank may also seek such expertise from the World Health Organization, national agencies, and other appropriate organizations.

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