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Training Programme On Community Based Water Supply and Sanitation

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CRDA - TRAINING ON COMMUNITY BASED WATER SUPPLY AND SANITATION

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CHAPTER ONE

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OVERVIEW OF WATSAN IN ETHIOPIA

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TITLE - WATER SUPPLY AND SANITATION CONDITION IN ETHIOPIA

1. Introduction

Development and provision of improved water supply systems in an organized and modern manner started in Ethiopia in the 1950's when the Water Resources Department was established. The achievements gained and lessons learnt cannot be considered insignificant though the need is overwhelming.

The present level of water supply and sanitation services in Ethiopia in terms of quality, quantity, coverage and reliability is poor. The provision of adequate and safe water supply to the country's population is hampered by many factors some of which are lack of physical infrastructures, inadequate management capacity in the sub-sector institutions, insufficient investments in the sector, etc. In general the water supply coverage and the population having access to potable water supply services is low and an even much lower percentage have access to sanitation services.

Information is not collected, analyzed and documented properly which will help for the assessment of the water supply coverage, population served, per capita water demand, level of service, etc., which will be used for evaluation and planning. There is also no information regarding the actual existing number of improved water supply schemes constructed by the government institutions and other organizations like NGOs in the country. The information presented in this paper are therefore, collected from UNICEF publications of 1995, Statistical Reports published by Central Statistical Authority in 1995 and data collected by the Ministry of Water Resources in 1996.

The data collected by the Ministry of Water Resources has covered 696 settlement areas. Out of these 145 settlement areas in 182 weredas are used for water supply coverage analysis and 208 towns are used for urban water consumption analysis. The data was analyzed by Ernst & Young in association with tropics consulting Engineers, January 1997.

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2. WATER SUPPLY COVERAGE

2.1 General

According to UNICEF's publication of 1995, the water supply coverage in the country is estimated to be 22% at national level. On the other hand according to the Letter of Sector Policy of the Ministry of Water Resources, (January 1996), the national coverage is given as 26%.

The coverage figures given in the Letter of Sector Policy are based on different assumptions such as physical plans of the regions, agreements made with different NGOs, etc. Moreover since there is no structural linkage between the ministry and the regions, it is not easy to compile the recent coverage at national level due to lack of communication with the ministry. However, there is now improvement on communication between the regions and the Ministry which is expected to enhance the flow of basic data and information.

The Ministry of Water Resources (MOWR) however, has collected extensive field data relevant to water supply and sanitation services, irrigation development and organizational set up of the sectors. The survey was conducted in 1996 over a time period of 8 months. The data collected by the Ministry was then analyzed and compiled by Ernst & Young in association with Tropics Consulting Engineers in 1997. Accordingly the water supply coverage of the country is estimated to be as explained below.

- Estimated average urban and rural coverage with reliability and displacement factors is 5.33%.
- Estimated average urban and rural coverage without reliability and displacement factors is 26.72%.
- Estimated average urban (including the city of Addis Ababa)* and rural without reliability & displacement factor is 28.84%.

Note: With reliability factor means the scheme is operating without or with minimum interruption

With displacement factor means the people use the scheme only when living in the area.

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2.2 Urban Water Supply Coverage

Full water supply coverage (100%) is defined as the availability of water at any time and place. This would mean that a 24 hour supply is guaranteed at source, conveyance system and all other ancillaries such as pumps, accessories and power supplies. Even though this term and definition can be taken as a goal to be ultimately achieved, it is hard to secure such a system in practice in a developing country due to the status of economic development, level of technology and popular awareness by the community to use potable water.

Accordingly the figures given for the urban water supply coverage includes those with low levels of services such as low production levels, inadequate distribution systems, high water leakage in most of the urban centers, etc.

According to UNICEF's publication of 1995, the water supply coverage in the urban areas is 77%. The Letter of Sector Policy of the Ministry of Water Resources, issued January 1996, gives the urban coverage as 76%. In terms of population, the urban population using improved water supply is estimated to be about 4 million.

According to the data collected by the Ministry and analyzed and compiled by Ernst & Young in association with Tropics Consulting Engineers in 1997, the urban water supply coverage of the country is estimated to be 23.70% and 28.51% with and without reliability factor respectively. The analysis result showing the coverage at regional level, including the average per capita water consumption is shown below in Table 1.

The analysis of urban water consumption is based on data from 208 towns, 16 settlements with population of above 30,000 and 192 settlements with population of below 30,000, which had the required data for analysis. The average per capita water consumption is therefore found to be 10.64 l/c/d. Seventy Five percent of the towns have a per capita water consumption less than 15.89 l/c/d.

For towns with a population of 30,000 or more the per capita consumption is 16.84 l/c/d, whereas for towns with a population of between 1,000 and 30,000 it is only 5.33 l/c/d.

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Table 1. Urban Water Supply Coverage and Per Capita Water Consumption by Region (With and Without Reliability Factors)

Region	Water Consumption	Coverage in %	
	(l/c/d)	With Reliability Factor	Without Reliability Factor
Afar	9.14	24.18	28.27
Amhara	8.54	19.20	23.28
Benishangul	2.06	4.05	6.56
Dire Dawa	29.42	62.70	63.67
Gambela	7.61	-	22.38
Oromia	10.71	25.11	30.65
Somali	7.90	1.94	31.64
SNNPR	10.99	22.70	26.53
Tigray	7.61	14.61	21.17
All Region	**10.64**	**23.70**	**28.51**

N.B Due to lack of required variables in the data sheets the coverage for. Harar has not been included in Table 1 above. However for comparative purpose a reasonable estimate has been made.

2.3 Rural water Supply Coverage

According to UNICEF's publication of 1995, the water supply coverage in the rural areas is estimated to be 18%. The Letter of Sector Policy of the Ministry of Water Resources, (January 1996), also gives the rural water supply coverage as 18.8%. It is estimated to be bout 9 million people in terms of population using improved water supply in rural areas. The rural water supply coverage is based on the estimated number of schemes by its capacity to serve a certain population size.

Similar to the urban centers Ernst & Young has made the data analysis collected by the Ministry for the rural water supply. In this analysis rural water supply coverage is defined as the ratio of the estimated volume of water from all existing sources of a particular wereda divided by the theoretical water demand factored for reliability and displacement expressed in percentages.

The survey conducted by Ministry of Water Resources covered only 271 weredas of these only 182 with an estimated population of 19,712,307 (excluding Gambella) had complete data and were, therefore, used for analysis. It should be noted that the survey for weredas does not include data for urban centres within the wereda. The number of weredas according to CSA is 419.

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The analysis indicates an average coverage of 3.32% and 26.46% with and without displacement factors, respectively. These are shown in Tables 2 and 3 Respectively below.

Table 2 Rural Water Supply Coverage with Displacement Factor

Region	No of Weredas		Coverage in %			Estimated Population
	CSA	Data Sheet	Minimum	Average	Maximum	
Amhara	106	27	0.23	0.71	1.49	4,108,766
Benishangul	12	5	.04	0.16	0.38	138,977
Oromia	186	88	0.94	2.94	6.19	8,769,455
SNNPR	74	31	2.32	7.00	13.95	4,772,448
Tigray	41	25	0.53	1.68	3.60	1,922,661
All Regions	419	182	1.08	3.32	6.81	19,712,307

Table 3 Rural Water Supply Coverage without Displacement Factor

Region	No of Weredas		Coverage			Estimated Population
	CSA	Data Sheet	Minimum	Average	Maximum	
Amhara	106	27	5.23	7.19	8.37	4,108,766
Benishangul	12	5	3.66	5.36	6.77	138,977
Oromia	186	88	11.65	15.9	18.33	8,769,455
SNNPR	74	31	11.23	15.17	17.21	4,772,448
Tigray	41	25	9.22	12.53	14.32	1,922,661
All Regions	419	182	19.53	26.46	30.11	19,712,307

2.4 Other Conditions

The following information are also obtained from the data during the analysis which are also relevant in the water supply coverage and level of service. Since the quality of the data is questionable, any summary or conclusion reached should be taken with caution and be used as indicative data only.

- Ground water sources constitute 87% of the 561 urban sources as compared to only 5.52% being from surface sources.
- Of the 561 urban settlement use bore holes as ground water sources followed by springs at 30.48%.

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- Out of a total of 182 rural settlements, bore holes comprise 29%, hand pumps & hand dug wells 33% with a remaining of 38% as spring sources.

- Taking into consideration 888,279 households in the urban settlements, the proportion of households with yard or house connections is estimated to be 10.57%.

- For all regions and taking 278 urban settlements the average private tariff is estimated as Birr 1.56 per cubic meter. Among 295 urban settlement 50% pay more than Birr 10 per cubic meter. Average public tap tariff for urban centers is estimated as Birr 1.58 per cubic meter.

2.5 Operation and Maintenance

Both urban and rural water supply operation and maintenance activities are carried out by Government institutions at regional and zone levels. There are also NGOs involved in the operation and maintenance for the schemes they themselves constructed.

Even though the operation activities are given to identified bodies as stated above still there are problems hampering proper and efficient operation activities. The major problems are lack of proper operation and maintenance, lack of community feeling of ownership, inefficient management and institutional arrangements, water supply schemes are not constructed based on the felt need of the community but from the top down principle and selection of inappropriate technology. Currently about 35-40% of the rural water supply schemes are inoperative.

2.6 Water Quality

Drinking water quality refers to the suitability of water for human consumption and for all usual domestic purposes including personal hygiene. Generally not all water is fit for human consumption and therefore requires certain quality limits for bacteriological, physical and chemical parameters to be controlled with respect to guidelines or standards like WHO drinking water quality guidelines. Accordingly there is no water quality standard or guideline developed for the country for use in water supply development.

The country follows to a certain extent the WHO water quality guidelines. However reports on water quality in various parts of the country indicate that the existing situation is far from satisfactory (UNICEF).

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According to the situation report by UNICEF on Children and Women in Ethiopia, 1993, over 50% of the sampled water schemes in 4 areas did not comply with internationally recommended standards for drinking water. It was also reported that hazardous chemicals in the samples exceed standards in all 4 surveyed regions (Hararge, Shewa, Wello and Bale).

The other chemical water quality related problems are high fluoride contents in the rift valley areas, high sulfates, nitrates and chlorides in the eastern and North western parts and high salinity in the ground water of the Afar triangle.

Water quality surveillance and control is hardly done in the country due to lack of equipment, logistic supports and shortage of trained man power. The urban water supply service which has relatively better capacity than the rural schemes do not even check the quality of the water they produce at regular periods. Even though there is no information on the current situation, water quality checking was done to some extent by the previous WSSA Water Quality Service Unit.

Most of the regions, if not all, have some form of water quality laboratories which are used to carry out water quality tests when samples are collected from the field and brought to the laboratories. However, again the shortage of logistic support, lack of trained manpower and field kits for on site checking are the major constraints hampering surveillance. In addition water quality surveillance and control is not done continuously and systematically. Also there are no regulatory standards and legislation supporting the surveillance.

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3. SANITATION COVERAGE

3.1 General

Sanitation in the country is poor. Limited access to sanitation facilities coupled with low level awareness of environmental sanitation in many areas makes the control of water related diseases difficult. As per the letter of sector policy of January 1996, sanitation is defined only by access to a latrine without consideration of the status of such facilities as well as the determination of its use. In the same document it is stated that the estimated national coverage for sanitation is 7%.

According to the statistical report published by CSA in 1995 the sanitation coverage in some regions is calculated as follows.

Oromiya	13%
Tigray	7%
Addis Ababa	74%
Dire Dawa	55%
Harari	42%
Benishangul-Gumuz	19%
Gambella	14%
Amhara	6%
SNNPR	10% (from health bureau).

3.2 Urban Sanitation

Except the city of Addis Ababa, which has partial sewer system the other urban centers do not have any sewerage system. Pit latrines and septic tanks are used in the urban centers for excreta collection and some people use open field defecation. Vacuum tankers are used to collect the sludge from the septic tanks and disposal is done into open field or in some areas spread over farm lands as fertilizer.

The urban sanitation coverage in some regions as reported by CSA in the 1995 statistical report is:-

Oromiya	60%
Tigray	29%
Addis Ababa	74%
Dire Dawa	55%
Harari	42%
Benishangul-Gumuz	63%
Gambella	31%
Amhara	37%
SNNPR	65% (from health bureau).

Most of the vacuum trucks serving the urban centers are old and not sufficient to cover the demand. In addition responsibilities for removal of sludge are fragmented between the municipalities and the town water supply service offices. In most of the towns the municipalities are providing the service and there are also towns which do not get any service.

Pre-feasibility studies for sanitation have been started to be carried out together with the water supply study and design in some towns. However no further action is taken to upgrade the study to the next level of action. The other issues which have affected the improvement of sanitation are lack of hygiene education and awareness, low level of income and shortage of water supply etc.

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3.3 Rural Sanitation

Sanitation in rural areas is not given due attention by the people themselves and the institutions concerned. According to the information given in the statistical report of CSA, 1995 the following are rural sanitation coverage in some regions.

Oromiya	7.3%
Tigray	2.7%
Benishangul-Gumuz	14.4%
Gambella	11.4%
Amhara	2.5%
SNNPR	5.4% (from health bureau).

Water and sanitation are intimately linked components both being prerequisites for the effective utilization of the other. However the responsibilities for the two components are divided between the Ministry of Water Resources and the Ministry of Health. The Ministry of Health is responsible for rural sanitation promotion by providing hygiene education, awareness creation and construction of demonstration technologies.

The main sanitation technology being promoted currently is the traditional latrine with a sanplat. This shift has been made very recently from VIPs which have been found to be expensive and inappropriate for rural communities.

The fragmentation of responsibilities among two ministries is the major constraints to the development of sanitation activities in the country. In general the sanitation approach in the rural areas has not taken into account the methodology on how to create awareness and selection of appropriate technology that will be acceptable to the community.

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2. INSTITUTIONAL ARRANGEMENT

2.1 Organizational Evolution

2.1.1 Previous Organizations

a. Water Resources Department

Water resources institutions have faced a number of continuous changes and reorganizations through past decades. The nucleus for a water resources organization was created with the beginning of the reconnaissance survey of the Blue Nile River Basin in 1957 by the United States Bureau of Reclamation with U.S. assistance. This organization named "Water Resources Department" was installed as a separate directorate under the Ministry of Public Works. Initially, there were no Ethiopian engineers in the study team. The first graduate engineers started to join the team in 1958. The water Resources Department was jointly financed by the Ethiopian and U.S. governments.

A water well drilling unit which had been drilling boreholes for domestic water supply in the dry low lands with drilling rigs donated by the US was also transferred to the Water Resources Department. This unit was later to form the rural water supply unit. As a matter of fact this well drilling programme which started with US donated drilling rigs as a demonstration programme for borehole drilling, was the first field activity on water resources cooperation between the US and Ethiopia. While a general cooperation agreement in water resources study and development was concluded in 1951, the water well drilling programme started in 1953. This unit was initially placed under the supervision of the Ministry of Industry and Commerce. Initial activities for the Blue Nile Survey did not start until 1957 at which time Geodetic surveys commenced and the US Bureau of Reclamation field staff started their activities in early 1958.

At the completion of the Blue Nile Survey in 1964 the Ethiopian Government continued to support the Water Resources Department mainly to collect hydrological and meteorological data in the Blue Nile Basin. Later the department expanded its activity of data collection to other river basins.

Between 1968 and 1973 an intensive river basin study was conducted for the Wabi Shebelle River Basin with French assistance. Ethiopian staff were seconded to

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the company (actually a consortium of French companies) that was commissioned to carry out the study.

Also an earth moving team with dozers and compactors for the construction of stock ponds in the Borena area for livestock was also attached to the Water Resources Department.

b. Awash Valley Authority

With the construction of Koka Dam in 1960 as a war reparation to Ethiopia by the Italian Government, the regulated flow of the Awash River attracted investors in irrigated agriculture downstream. To control and guide these investors, the creation of a river basin organization became necessary. Thus, the Awash Valley Authority was created by General Notice No.299 of 1962 with the responsibility to control irrigation development and to make further studies of irrigation expansion. The Authority was also responsible to review and approve irrigation plans in the Valley and also to collect hydrological and meteorological data in the Awash River Basin.

c. National Water Resources Commission (1971)

With the growing recognition of the potential importance of the country's water resources for economic development, the Government established a central water resources organization by Order No.75 of 1971 with the responsibility of ensuring the optimum development of the nations water resources, to coordinate all water resources activities, and to ensure maintaining of appropriate standards for the investigation, use, control, protection and management of water resources.

The Commission had a Board of Commissioners composed of representatives of 11 concerned ministries and organizations. The Water Resources Department was the Executive Organ of the Commission.

Though the Board of Commissioners was created to guide the activities of the National Water Resources Commission, the arrangement did not bring with it any structural change which altered the status of the Water Resources Department. The Commission was simply superimposed over the old Water Resources Department whose internal framework remained untouched. This had no impact on the growth and improvement of the Water Resources Department.

d. Ethiopian Water Resources Authority

In 1975 after the 1974 Revolution, the Water Resources

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Department (i.e the Executive Organ of the National Water Resources Commission) was reorganized and given the name of 'Ethiopian Water Resources Authority' (EWRA). EWRA was accountable to the Ministry of Mines, Energy & Water Resources.

This Authority had under it:

-the Land and Water Studies Agency;
- the Rural Water Supply Agency and,
- the Urban Water Supply Agency, which was transferred from the then Ministry of the Interior. This reorganization was simply carried out by an administrative order without any legislative support through the instrument of a proclamation.

Nonetheless, the period being in the aftermath of the 1973/74 famine when international attention was focused on Ethiopia to provide assistance, it was at this time that rural water supply was given emphasis and the unit for this activity was strengthened in manpower, equipment and finance. It was also the beginning of bringing water activities under one umbrella organization.

e. Valleys Agricultural Development Authority (1977):

In 1977 the Valleys Agricultural Development Authority (VADA), was established by Proclamation No.118 of 1977. The aim of VADA being to be responsible for the agricultural development of the Ethiopian river valleys. This organization superimposed itself over the Awash Valley Authority which was reduced to an agency at the creation of VADA.

The organization which had been entrusted only with the agricultural development of river basins had obviously been handicapped from the beginning by the lack of full responsibility to plan and develop multipurpose projects. This organization did not last long. The few river basin studies conducted by VADA reflected its institutional impediment by treating only the irrigation aspect of multipurpose projects which may otherwise include hydropower as well.

f. National Water Resources Commission (1981)

The first step towards a more comprehensive institutional reorganization of the water sector was undertaken when the National Water Resources Commission (NWRC) was established in 1981 composed of four component authorities. The Commission was

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created by Proclamation No. 217 of 1981 with the objective of providing control, guidance and to ensure optimum utilization of the country's inland water resources.

The Commission was directly accountable to the Council of Ministers. At the same time two Authorities namely: the Water Resources Development Authority and the Water Supply and Sewerage Authority, were created and two others created earlier, that is the Ethiopian Water Works Construction Authority and the National Meteorological Services Agency, were brought under the auspices of the newly constituted Commission. This time the National Water Resources Commission was a strong appropriately empowered central water body with the three operational authorities and one agency.

At the same time of its creation the Commission had a new building which could accommodate the three authorities and the Commission itself. All existing water agencies were brought under one central body.

The organizations under the commission were:

1) Water Resources Development Authority
2) Water Supply and Sewerage Authority
3) Ethiopian Water Works Construction Authority and,
4) National Meteorological Services Agency

The Water Resources Development Authority had the responsibility for studies, design and supervision of the implementation of water resources projects. The Valleys Agricultural Development Authority was merged with the WRDA in this proclamation.

The Water Supply and Sewerage Authority was responsible to provide water supply and sewerage services in the country.

The Ethiopian Water Works Construction Authority which was established earlier has its responsibility limited to construction of water related works.

The National Meteorological Services Agency was responsible for providing meteorological services.

The institutional structure of the NWRC indicates a shift from previous institutional frameworks in that it encompassed the main activities within the water sector of the country in one umbrella body-from the study and planning phase up to the construction and operation phase.

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From a policy perspective, the establishment of the Water Resources Commission may have been triggered by the need to manage and develop the water resources of the country in a comprehensive and integrated manner.

The establishment of the centralized National Water Resources Commission heralded a new era for the water sector in the country. All scattered water organizations were brought under the umbrella of the National Water Resources Commission including the Valleys Agricultural Development Authority and Awash Valley Development Agency.

This offered an opportunity for the water sector to consolidate itself and to build up its capacity in terms of manpower, design and construction competence.

g. Ethiopian Valleys Development Study Authority (EVDSA).

There was a further restructuring of the water sector when, in 1987, the Ethiopian Valleys Development Studies Authority, (EVDSA) was established under Proclamation 317/1987.

The Project Studies and Hydrology Department of the Water Resources Development Authority of the National water Resources Commission was taken away to form the Ethiopian Valleys Development Studies Authority.

The establishment of EVDSA again created a separate body which had, among others, the main responsibility for preparing master plans for the management and development of the country's river basins and also conducting studies of irrigation projects up to the feasibility stage.

All on-going project studies were transferred to it along with staff, buildings, logistics etc. The projects transferred to it were: the Awash Master Plan Study, the Gelana Project Feasibility study and the Baro-Akobo Basin Project.

The Proclamation of EVDSA vested on it the responsibility of the Study of all natural resources in the Ethiopian river basins with special emphasis on water resources. EVDSA was made directly accountable to the Council of Ministers. This was seen as undermining of the central consolidated Water Resources Commission which had under its umbrella all activities of water resources management from data collection to construction and water rights administration. Taking away the study part of WRDA handicapped its activities by making it dependent on

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another organization to select projects for design and eventual implementation.

It might be considered that the creation of EVDSA had resulted again in unnecessarily fragmenting the water sector because some of the major tasks of the Water Resources Commission carried out at the time by the WRDA especially that of studying and planning for the development of the country's water resources was given to the EVDSA. It also had other resource implications in that the manpower and other technical and financial resources were dispersed between these two institutions, there-by weakening the capacity of the water sector as a whole.

On the other hand, at the time of the creation of EVDSA there was the felt need that there should be greater focus on the study and planning aspect of the country's water resources, especially shared water resources, for rapid development of major water resources projects.

Before its demise in 1993, the Water Resources Commission had grown immensely compared to its predecessors in terms of planning, study, design, and construction capacity.

By mid 1991, the Water Resources Commission, had about 900 degreed professionals of whom about 60% were engineers and hydrologist.

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h. Ministry of Natural Resources Development & Environmental Protection

In 1993 the Water Resources Commission was dissolved and made part of the newly created Ministry of Natural Resources Development and Environmental Protection (MNRDEP) by Proclamation No. 41/1993. The National Water Resources Commission was dissolved and its rights and obligations were transferred to MNRDEP. The Commission was reduced to a Water Development Department in the new Ministry. The three authorities and one agency were left as before initially. But later the Ethiopian Water Works Construction Authority was taken away from the water sector along with the Water Well Drilling Agency which were both converted to enterprises. At the same time regionalization of all water supply activities was implemented. Thus the water sector at the central level was only responsible for master plans of inter-regional and international rivers and to provide guidance to regional governments regarding water resources planning, and development.

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One can realize from the above discussion that in the

past two or three decades there was constant reorganization of the water resources sector in Ethiopia.

This period of "institutional instability, reflected in the constant reorganization of the water sector has had dire implications on the managemenent and development of the water resources of the country.

Some of the major negative consequences of the constant reorganization of the water sector in the past are:

- Misuse of technical manpower and financial resources. For example, many technical studies of water resources within the country are found dispersed in different offices without any follow up. Senior and experienced professional staff within the sector are currently very few due to either insecurity of their previous position or dismissal from their jobs. The present market economy has also opened up higher paid jobs and contributed to senior staff leaving the public sector to better paid jobs in the private sector.

- difficulty in establishing a clear and stable system of water resources planning and management because of discontinuity of water resources institutions.

- Fragmented management of water resources due to different sectors having responsibilities for certain aspects of water resources (e.g. hydropower, irrigation etc.) without any coordination .

2.1.2 Present Organizations

a. Federal Institutions

The federal institution which is directly responsible for water is now the Ministry of Water Resources.

1) Ministry of Water Resources

After about two and half years of the water sector under the Ministry of Natural Resources Development and Environment Protection, with clearly reduced activities and uncertainty, the Ministry of Water Resources was established with the Minister a member of the Council of Ministers.

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During the intervening years preceding the creation of the Ministry of Water Resources, the sector had lost most of its senior manpower to the private sector, international agencies and NGOs.

The two authorities of WRDA and WSSA were converted to departments in the new Ministry. The EWWCA is administered under a board with the Minister of Water Resources as the board chairman. EWWCA now known as Water Works Construction Enterprise (WWCE) restricted its activity to major irrigation and water supply projects. Most other regional water supply construction activity had been transferred to regional bureaus.

The powers and duties of the Ministry as promulgated in Proclamation No. 4 of 1995 which defined the powers and duties of the Executive Organs of FDRE were very brief.

The powers and duties of the Ministry as stated in the proclamation are:

1) determine conditions and methods required for the optimum allocation and utilization of water that flows across or lies between more than one regional self-governments, among various uses and regions, including transboundary waters.

2) Initiate the preparation of master plans for undertaking studies of valleys, including the undertaking of studies pertaining to water tariff and collection of bulk charges for large scale water supply schemes, dams and the like.

3) In co-operation with the appropriate organs, prescribe the quality standards for water to be used for various purposes.

4) Ensure the enforcement of laws, regulations and directives of the Federal Government. Give assistance and advice, as necessary, to the regional executive organs.

In the ministry's organizational structure there are seven technical departments and the National Meteorological Services Agency (NMSA). Out of the seven technical departments, the Water Supply and Sewerage Department is fully involved in the water supply sub sector.

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The other departments also contribute to the sub sector.

In the powers and duties of the Ministry discussed above there is no direct reference made to water supply and sanitation.

On the other hand water supply and sanitation activities are being carried out in the Water Supply and Sewerage Department.

Some of the responsibilities of the departments require linkage with the regional government offices. However there is no direct structural linkage between the ministry and the corresponding regional government bureaus. In fact some regions do all their correspondence with the Federal Government ministries through their regional council.

The water resources sector in the regional governments was included in the Water Resources, Mines & Energy Bureau". The Bureaus as far as water is concerned have been entrusted with the responsibility of studying and developing the water resources within their region. As waters/rivers shared by two or more regions as well as international rivers are the responsibility of the central Water Ministry, most rivers being shared by two or more regions, not many rivers or other water bodies became the sole responsibility of one region. This situation brings most of the water resources under the responsibility of the MOWR. However, the question of land (in this case irrigation land) brought up some controversial issues. The regional governments where an irrigation project lies, claimed responsibility on the land in their region as stipulated in the Proclamation which defined the powers and duties of the Regional Executive Organs. This obviously created obstacles on MOWR's ability to give permits to potential developers of irrigated agriculture. It turned out that MOWR would give permits only for water and the developer has to negotiate with regional governments (bureaus) for the land.

Organization Structure of MOWR

The MOWR has a Minister, a vice Minister and nine departments. The following are the Main Departments and units of the Ministry:

Departments of MOWR

The Water Supply & Sewerage Department-

The Water Supply and Sewerage Department has very few

degreed professionals with much reduced number of engineers than the previous WSSA. Of these professionals most are young and inexperienced. The senior and most experienced professionals have departed looking for better opportunities, mainly to the Private Sector. It is questionable if this department can deliver the expected control and guidance to the regional bureaus and other water developers in the country. To improve the situation by attracting more experience engineers and support staff a structural change which has an enhanced remuneration and administration system has to be instituted.

Water Resources Departments

The other eight departments represent the former WRDA and EVDSA and cover their activities. Here is where the main responsibilities of the MOWR are discharged. Such important technical activities cannot be entrusted to a regular department under a ministry's structure.

It was a good decision for the Government to have created a Ministry of Water Resources which represented the water sector at the same level that all other sectors are represented in the government structure.

However, the unfortunate part of this restructuring is that the two authorities of Water Resources Development and Water Supply and Sewerage have been reduced to mere departments. They have lost their autonomy and their capability to attract competent professionals with enhanced management systems including better pay scales. A regular department in a government Ministry cannot have the flexibility that can respond to the demands of project management in terms of financial, personnel and property management. This situation should be rectified, to strengthen the operational departments.

The Water Resources Studies, design, implementation, supervision and water rights administration would work more efficiently and with better accountability if these activities are placed outside the conventional structure of MOWR. It is proposed to establish a sort of Board of Water Development or Water Development Directorate or Water Development Authority as it is this nomenclature that is still used in the country, eg. Ethiopian Roads Authority (ERA), Ethiopian Electric and Power Authority/Ethiopian Electric Power Corporation (EELPA/EEPCO) and the Ethiopian Telecommunication Authority (ETA). With the situation of the country in terms of shortage of skilled manpower, one cannot expect accelerated development in water resources unless a strong central water organization responsible for the proper study, design, supervision of implementation and water rights administration is established. The Federal Government has to take full responsibility for all major water resources development such as the design and

implementation of dams, major water conveyance systems, hydropower stations and major reclamation activities. This could only be possible by strengthening a central water body with autonomous administrative and financial powers.

Departments:
- Hydrology
- Basin Development Studies
- Transboundary Rivers Study
- Design
- Contract Administration
- Water Right Administration & Water Utilization Management
- Water Supply & Sewerage
- Planning & Project
- Women's Affairs

Services:
- Audit
- Legal
- Management & Training
- Public Relations & Information
- Administration & Finance
- Supply & Equipment

Six services units and two departments report directly to the Minister while the remaining departments, services and the one agency are accountable to the Vice Minister.

Comment

In the present organization chart it is not necessary to show so many services above the Vice Minister reporting directly to the Minister. The Minister is a political appointee who should be responsible for policy matters. He should not be bogged down with day to day activities of the Ministry. In as much as he is a member of the Council of Ministers he should not be burdened with internal routine administrative matters.

Only the 'Audit Services' should be reporting to the Minister directly. All other services should report to the Vice Minister. The two departments of Women Affairs and Planning & Projects' should come in parallel with the other nine departments. Operational departments should not come in between the Minister and the V/Minister. Now this brings in the question of whether the nine Technical Departments now shown reporting to the V/Minister should continue to do so in the future.

These departments need close supervision by a purely technical person, not of course by a Vice Minister who also is a political appointee.

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Water Supply and Sewerage Services Department: It has three teams under it namely:

1. Water Supply and Sewerage Technical Services Team
2. Water Supply Design Team and
3. Water Supply and Sanitation Quality & Standards Control Team.

The Water Resources part is composed of six departments mainly consisting of the previous departments in the WRDA and EVDSA with an additional Department of Transboundary Rivers Study Department.

MOWR has little contact with the regional water activities in most cases, the regional bureaus are directly accountable to the regional Council and communication to the central ministries is through the regional councils.

Quick and effective communication between the ministries and regional sector bureaus does not exist. Effective guidance, coordination and collaboration are therefore encumbered with lengthy routing of communication.

NGO activities in the various regions lack coordinating mechanisms for standardization of designs and water supply equipment.

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a. Regional Institutions

At regional level, the Water, Mines and Energy Development Bureaus are established to carry out the water development activities including water supply and sanitation. Afar, Benishangul-Gumuz, Gambella and Somali Regional Bureaus are organized as Water Resources Development Bureaus and do not include Mines and Energy activities. Most of the regional bureaus, except the four regions mentioned above, are established by taking the branch offices of the former WSSA and EWWCA. Most of the bureaus have branch offices at zonal level which carry out the maintenance of water supply facilities and in some regions construction of urban water supply, rehabilitation works and new rural water supply schemes. The bigger urban water supply schemes are managed and operated by the water supply service office of each town.

The offices in very few bigger towns provide service of vacuum trucks to desludge and dispose of domestic sewage.

The rural water supply schemes are managed by water committees elected by the community.

In general the duties and responsibilities of the bureaus, as stated in the proclamation among others include:

- ensure that Federal Government laws, regulations and directives in relation to the conservation and utilization of water resources are respected in the regions,
- control the implementations of the country's water resources development policies,
- Grant permits to persons engaged in water works Construction activities in view of utilizing the water resources of the regions.
- Supervise the balanced distribution and utilization of the water resources of the regions for various types of services or uses,
- Plan, study and design rural water supply schemes,
- Supervise and inspect the activities of urban Water Service units,
- Provide technical and maintenance services for the urban water service units and rural water points,
- Promote community participation.

The regional governments have the authority to decide on water and sewerage tariffs. From the duties and responsibilities of the bureaus described above there is practically no mention of sanitation.

Even though not mentioned in their duties and responsibilities, some bureaus are carrying out drilling of boreholes, construction of rural water supply schemes. In addition as the name implies, some regional bureaus are also responsible for mines and energy development sub-sector. Such an arrangement may deny water and sanitation activities the proper significance they deserve.

c. Addis Ababa Water and Sewerage Authority.

The Authority is responsible for the city of Addis Ababa for the

- Supply of adequate and safe water for different uses:
- Provide waste water and sludge disposal services,

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- Operation and maintenance of water supply facilities, safe guard surface and underground water from undue exploitation and prevents its contamination.

The organization is administered and supervised by a Board of Directors under Region 14 Administration. The Authority has four main departments and six service units. It has also five branch and one sub-branch offices to support its field operations in the city.

d. Other Institutions in the Sector.

The other institutions which are involved directly or indirectly in the water supply and sanitation are the following.

- Ministry of Public Works and Urban Development through municipalities is responsible for the collection of urban solid waste and desludging of domestic sewage and disposal of the same.

- Water Works Construction Enterprise (WWCE) is established very recently by restructuring the former Ethiopian Water Works Construction Authority (EWWCA). The enterprise is an independent government owned organization which carries out construction of major water supply and irrigation works. The enterprise obtains its works by competing with other private contractors.

- Water Well Drilling Enterprise (WWDE) is a small autonomous government owned contractor for drilling water wells for different private and government organizations in urban and rural areas.

- Ministry of Health Provides health education, promotes rural sanitation and supervises the construction of some small scale rural water supply schemes.

- Many other local institutions like private contractors and consultants are involved directly or indirectly in the sub sector development.

- Local NGOs Like ERO, ODA, ADA, TDA, etc. are also nowadays involved in water supply development, particularly in the rural water supply and sanitation development.

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CHAPTER TWO

BASIC HYDROLOGY

SURFACE WATER SOURCE SELECTION AND INTAKES

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INTRODUCTION TO BASIC HYDROLOGY

1. THE HYDROLOGIC CYCLE

To understand the complicated relationship between precipitation and runoff, it is imperative to get a complete insight into the hydrologic cycle. The hydrologic cycle is a continuous process by which water is transported from the oceans and land surface to the atmosphere to the land and back to the sea. A simplified representation of the hydrologic cycle is shown in Fig.1.

Hydrology is mainly concerned with the water in its course from the time it precipitated upon the land until it is discharged into the sea or returned to the atmosphere. The precipitated water may be intercepted or transpired by plants, run over the ground surface and enter streams, or infiltrate into the ground. Much of the intercepted and transpired water and the surface runoff returns to the atmosphere through evaporation. The infiltrated water may percolate to the deeper zones to be stored as ground water, which may later flow out as springs or seep into streams as discharge and run to the sea and finally evaporate into the atmosphere to complete the hydrologic cycle. Thus the hydrologic cycle undergoes various complicated process of evaporation, precipitation, interception, infiltration, percolation, storage and runoff.

The principal source of energy for operating this great natural system of waterworks is the sun.

The hydrologic cycle continuously keeps a balance between the water of the earth and the moisture in the atmosphere. precipitation is the fall of moisture from the atmosphere to the earth surface in any form. For land areas:

$$\text{Precipitation} = \text{Runoff} + \text{Losses}$$

Thus the importance of an in depth study of the hydrologic cycle lies in making use of long-term available precipitation and runoff data for planning engineering projects.

2. HYDROLOGIC DATA

Adequate basic data are essential for hydrological study. Complex features of the natural processes involved in

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hydrologic phenomenon make it difficult to treat hydrologic processes by rigorous deductive reasoning. Moreover, most of the factors governing hydrologic phenomena are not controllable and capable of experimentation. One cannot always start with a basic physical law and determine the expected hydrologic result because of the random nature of the factors controlling the hydrologic phenomena. Rather, it is necessary to start with the mass of observed data, analyze these facts statistically to establish the systematic results needed in decision making processes. The solution to all hydrologic problems is based on: (1) the collection and systematic compilation of data, and (2) the intelligent analysis and correct interpretation of data.

Type of Data

To investigate properties of hydrologic variables relating to distribution of water quantity and water quality in time and space, four types of data are available.

(1) The first type is historic data or observation of processes in time. If no observed initially, this information is lost. A majority of present day hydrologic data belong to this type. For example, river discharges, rainfall depths, evaporation depths, temperature, etc.

(2) The second type is field data observations along lines or surveys of hydrologic phenomena across areas or in space like the determination of depths of groundwater, determination of sediment characteristics along river bed and similar surveys. This data can be surveyed when necessary: the economic factor is usually the limiting condition. A substantial part of hydrologic data can be this type.

(3) The third type is laboratory and field experimental data related to hydrology acquired by methods similar to data obtained in hydraulic experiments. This type of data is mainly used in basic and applied research.

(4) The fourth type is the simultaneous measurement of two or more hydrologic variables in order to establish a relationship among these variables mainly for the purposes of transferring statistical information among variables.

Measurement of Hydrological Variables

It is not physically possible to catch all the rainfall,

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runoff, evaporation, etc. over a drainage basin; the hydrological variables of an area are sampled by measuring instruments such as rain gauges, evaporation pans, etc.The measurements are made at several selected representative points.

Flow Measurement

For springs and very small streams, accurate volumetric quantities over time intervals can be measured. For a large stream, a continuous measure of one variable, river level, is related to the discharge calculated from sampled values of other variables, velocity and depth, so that the final result is strictly an 'estimated measurement'.

The discharge of a river is obtained from the product of mean velocity and cross-sectional area of a flow section.

The simplest method of determining a velocity of flow is by timing the movement of a float over a known distance. Surface floats comprising any available floating object are often used in rough preliminary surveys; these measurements give only the surface velocity and a correction factor must be applied to give the average velocity over a depth. A factor of 0.7 is recommended for a river of 1 meter depth with a factor of 0.8 for 6 meters or more.

3. SCOPE OF HYDROLOGY

There are three broad problems in hydrology: (1)the measurement, recording and publication of data, (2) the analysis of these data to develop and expand the fundamental principles, and (3) the application of these principles to tackle practical problems

4. WATER RESOURCES

The development of water resources require the conception, planning, design, construction, and operation of facilities to control and utilize water.

Water is controlled and regulated to serve a wide variety of purposes. Flood control, land drainage, sewerage, and highway culvert design are applications of water resources engineering to the **control of water** so that it will not cause excessive damage damage to property, inconvenience to the public, or loss of life. Water supply, irrigation, hydro-

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electric power development, and navigation improvements are examples of **utilization of water** for beneficial purposes. Pollution of natural water threatens the utility of these waters for domestic/municipal and irrigation uses hence pollution control or **water-quality management** has become an important phase of water resources engineering.

Quantity of water

Water resources project is for the control of or use of water, the first questions naturally deal with the quantities of water. Where utilization is proposed, the first question is usually: **How much water is needed?** This is probably the most difficult of all design problems to answer accurately because it involves social and economic aspects as well as engineering. Basically the answer depends on future demands for domestic water, irrigated crops, and hydroelectric power. On the basis of economic analysis, a decision must also be made concerning the span of years for which the proposed works should be adequate.

Almost all project designs depend on the answer to the question: **How much water can be expected?** Peak rates of flow are the basis of design of projects to control excess water, while volume of flow during longer periods of time is of interest in designing projects for use of water. The answers to this question are found through the application of **hydrology**, the study of the occurrence and distribution of the natural waters of the earth.

The water flowing in a natural stream is not necessary available for use by any person or group desiring it. The right to use water has considerable value, especially in regions where water is scarce. Like other things of value, water rights should be protected by low, and the legal answer to the question **Who may use the water?** may be required before the quantities of available water can be evaluated.

Water quality

In addition to being adequate in quantity, water must often withstand certain tests of quality. Polluted water bodies create problems for fish and wild life, are unsuited for recreation, and are often unsightly and sometimes odorous. Chemical and bacteriological tests are employed to determine the amount and character of impurities in water. Human and plant physiologists must evaluate the effect of these impurities on human consumers or crops and set standards of acceptable quality. The engineer must then provide the necessary facilities for removing impurities from the water

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by mechanical, chemical, or bacteriological methods.

5 RAINFALL IN ETHIOPIA

Ethiopia is a country of great geographical diversity, with high and rugged mountains, flat topped plateaus, deep gorges, etc. The varied topography of the country shows extreme changes in altitude with its lowest point at about 120 meters below mean sea level and its highest point about 4600 meters above mean sea level. The differences in altitude and relief create a large variation in climate and rainfall in various regions of the country. Annual rainfall ranges from less than 200 mm along the eastern lowlands to more than 2000 mm in the western part of the country. Different climates are found in Ethiopia, varying from very hot lowlands to cold highland mountain zones. Altitude is the most important factor for these climatic contrast.

All available water supplies in Ethiopia, surface and ground waters, are derived from rainfall.

It can be concluded that the amount of rainfall that prevails at any point in Ethiopia is influenced by the location of the point relative to the source of moisture, the direction of winds and the topographical relief.

In Kiremt (or summer) air stream brings moisture from the Gulf of Guinea and results in 'big rains' season. Generally this season occurs from June to September. The Indian Ocean is also another moisture source specially for the southeastern part of the country in March and April.

Many studies have shown that altitude is strongly related with rainfall quantity. However, it should be known that altitude is only one element. For example, in Ilubabor area an elevation of about 2000 m amsl receives an annual rainfall of more than 2000 mm while in the Tigray area, the same elevation receives less than 600 mm.

It was possible to recognize up to five basically distinct rainfall profiles, that can be described as follows:

A Strongly peaked unimodal profile with peak in July and August and dry from October to May. This covers northern part of the country.

B Skewed bimodal profile with absolute peak in August and relative peak in April, and covers eastern part of the country.

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C Symmetric bimodal profile with peaks in May and August. This covers south-eastern part of the country.

D Skewed bimodal profile with absolute peak in April and relative peak in October, and covers southern part of the country.

E Strongly flattened unimodal profile with maximum from May to September. This covers south-western part of the country.

Some typical rainfall profiles are shown in Fig. 2.

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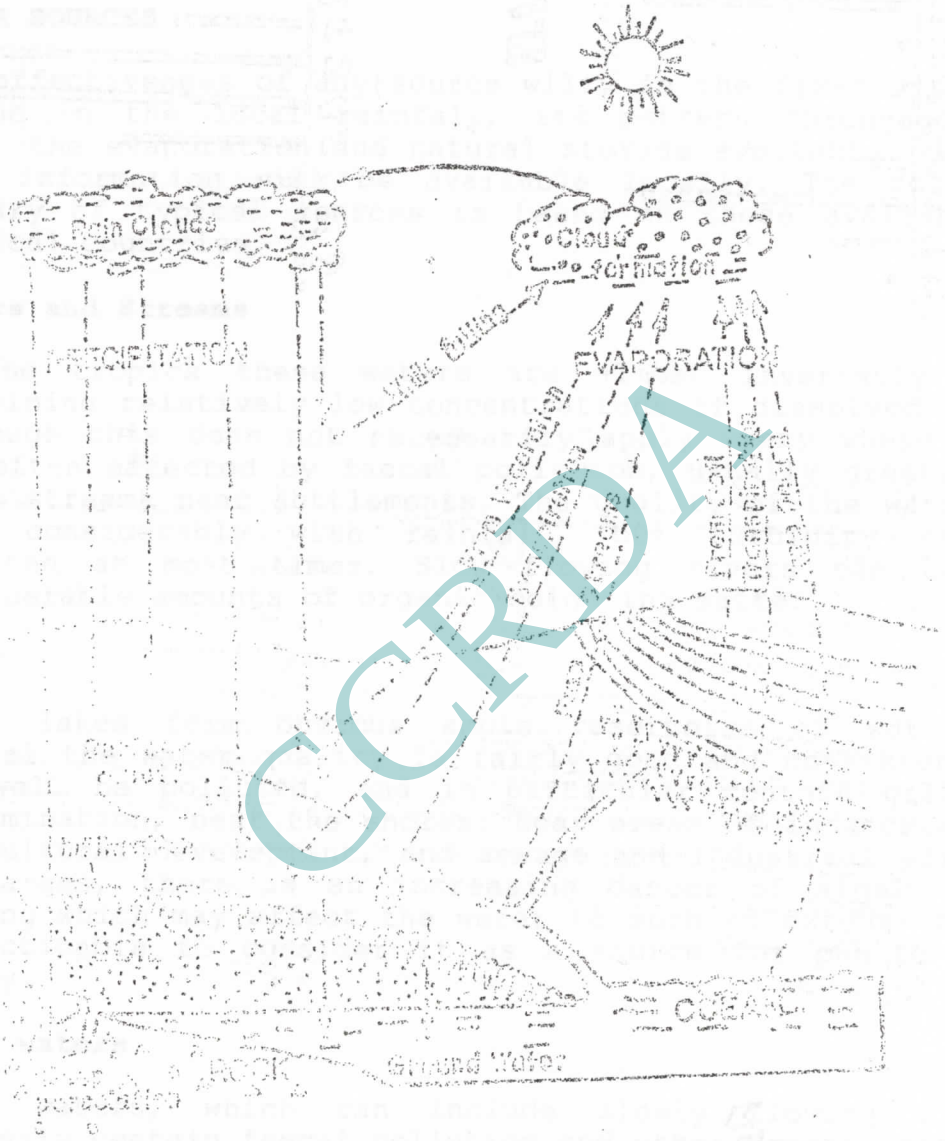
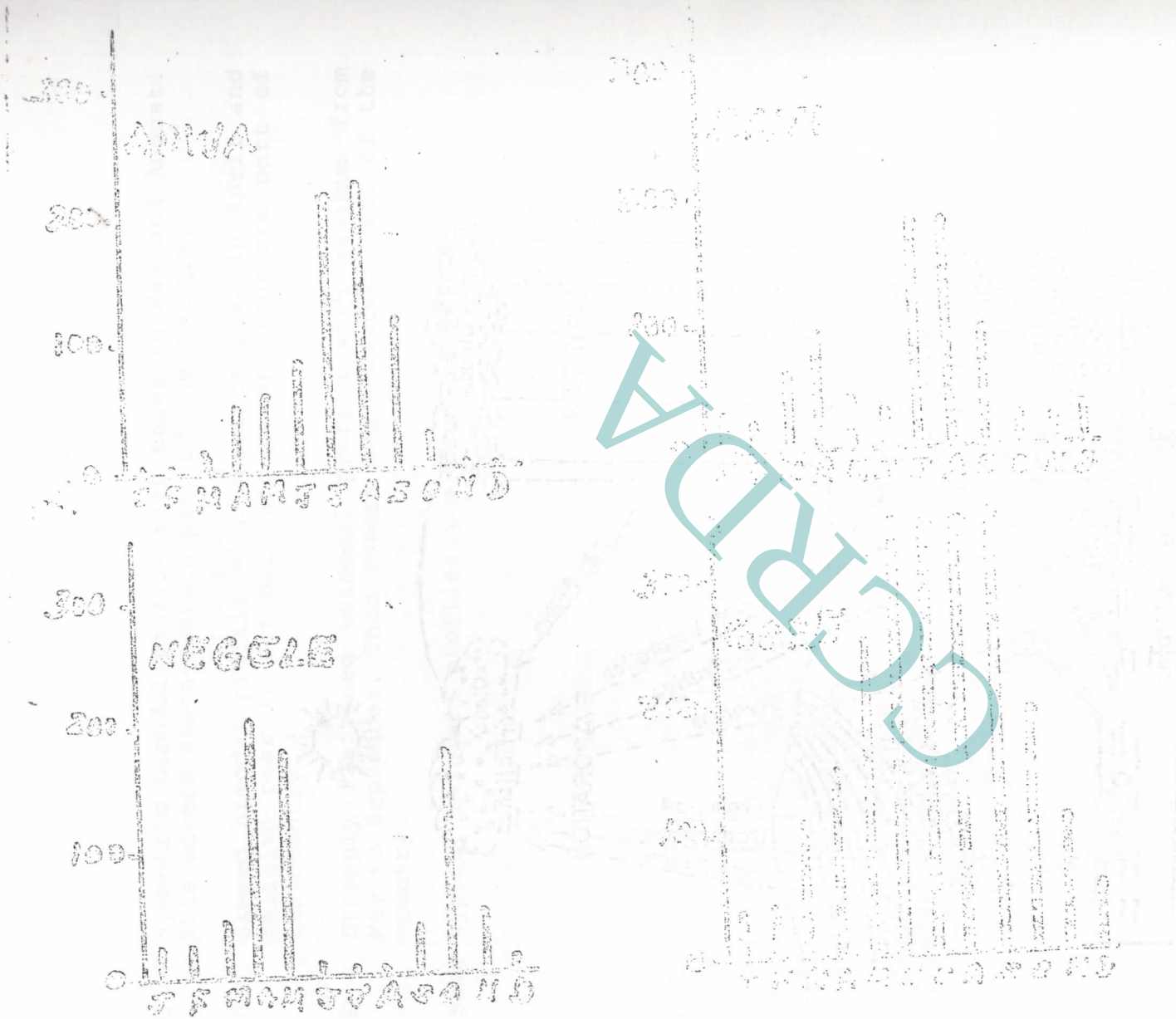


Fig. 1. Schematic representation of hydrologic cycle

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Fig·2· Mean Monthly Rainfall

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SELECTION OF A WATER SOURCE

1. WATER SOURCES

The effectiveness of any source will, in the first instance, depend on the local rainfall, its pattern throughout the year, the evaporation and natural storage available. Most of this information will be available locally. The following summary of typical sources is based on those available in tropical countries.

Rivers and Streams

In the tropics these waters are almost invariably soft, containing relatively low concentrations of dissolved salts, although this does not necessarily apply every where. They are often affected by faecal pollution, usually greatest in small streams near settlements. The quality of the water can vary considerably with rainfall, but turbidity can be expected at most times. Slow flowing rivers can contain considerable amounts of organic colouring matter.

Lakes

Large lakes form obvious ample reservoirs of water. In general the water quality is fairly good and consistent but may well be polluted, and in particular contain bilharzia contamination, near the shores. Near areas of industrial and agricultural development, and sewage and industrial effluent discharges, there is an increasing danger of algal growth forming which may affect the water to such an extent that is impracticable to consider it as a source for public water supply.

Swamp waters

Swamp waters, which can include slowly flowing rivers, generally contain faecal pollution and other organic material in comparatively high concentration, giving rise to an unacceptable colour. These waters are usually acidic.

Springs

In areas of impervious substrate, springs can give a reliable supply and if properly maintained, and sufficiently distant from pollutants.

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Springs derive their water from underground. Water is naturally discharged from where its flow is impeded by less permeable strata. It is essential that careful control is maintained of the land near the seat of the spring in order to prevent pollution. Quite often a source like this can be utilized to provide a supply to a community, without pumping, at minimum cost and maintenance (Fig. 1).

Wells

A well must be dug or sunk into the permeable strata and the water lifted manually or by pumps. It is essential that careful control is kept on the land adjacent to the well head. It is usually advisable to prevent surface water entering the well by sealing the top section with brick or concrete.

Alongside major rivers there are often large gravel deposits which retain water even when the river may seasonally dry up. The water drawn from wells in such river gravel will usually be of a considerably better bacteriological quality than the river water itself. Wells in river gravel need to be lined with perforated structure to hold back the gravel.

Rainwater

Rainfall can be collected as runoff, from impervious areas such as corrugated iron roofs (Fig.2), rock catchment (Fig.3) or artificially formed catchments of concrete or other watertight material. The size of storage tank or pond required depends entirely on the rainfall and its distribution throughout the year. The storage tank or pond must be of sufficient size to give the daily demand over the maximum expected drought period. The catchment areas must then be of sufficient size to guarantee that the tank or pond will fill again before the next dry spell.

2 SELECTION OF A SOURCE

Adequate supply of good quality safe water is essential to the promotion of public health. Where more than one possible source of water can be available for a community, the choice should be made in the order of priorities: firstly, the reliability of the source, secondly, its purity and lastly, the ease with which it can be supplied to the consumers.

Since water is essential to life, the first priority is that it must be made available to consumers even if the quality is not entirely satisfactory. The second priority is to protect the water supply from contamination by faeces. Failure to

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provide adequate protection will expose the community at risk to outbreaks of intestinal diseases. In the community, those at greatest risk of water-borne diseases are infants, young children and the elderly.

Most water related diseases are spread by wastes from an infected or ill person being transmitted to water supply in some way. Therefore, any water supply system should be protected from contamination. If people and the livestock are permitted to approach the water source, disease spreading contamination can pollute the water. A properly designed water supply system can exclude most of these hazards.

As already stated above, water can be available on the surface (such as streams) or in the ground (such as springs and wells). Compared to surface water without sufficient treatment facilities, it is well known that groundwater is usually much more safer for drinking purposes.

Spring water usually has the best water quality. Whenever a water-point or water supply is planned the first alternative to be investigated is the possibility of using a spring. For rural water supplies, springs which are protected and developed are widely recommended. The quantity and quality of springs are well known by their users and this data makes convenient to construct a successful project. The only problem that might have to be solved is its distance from the beneficiaries.

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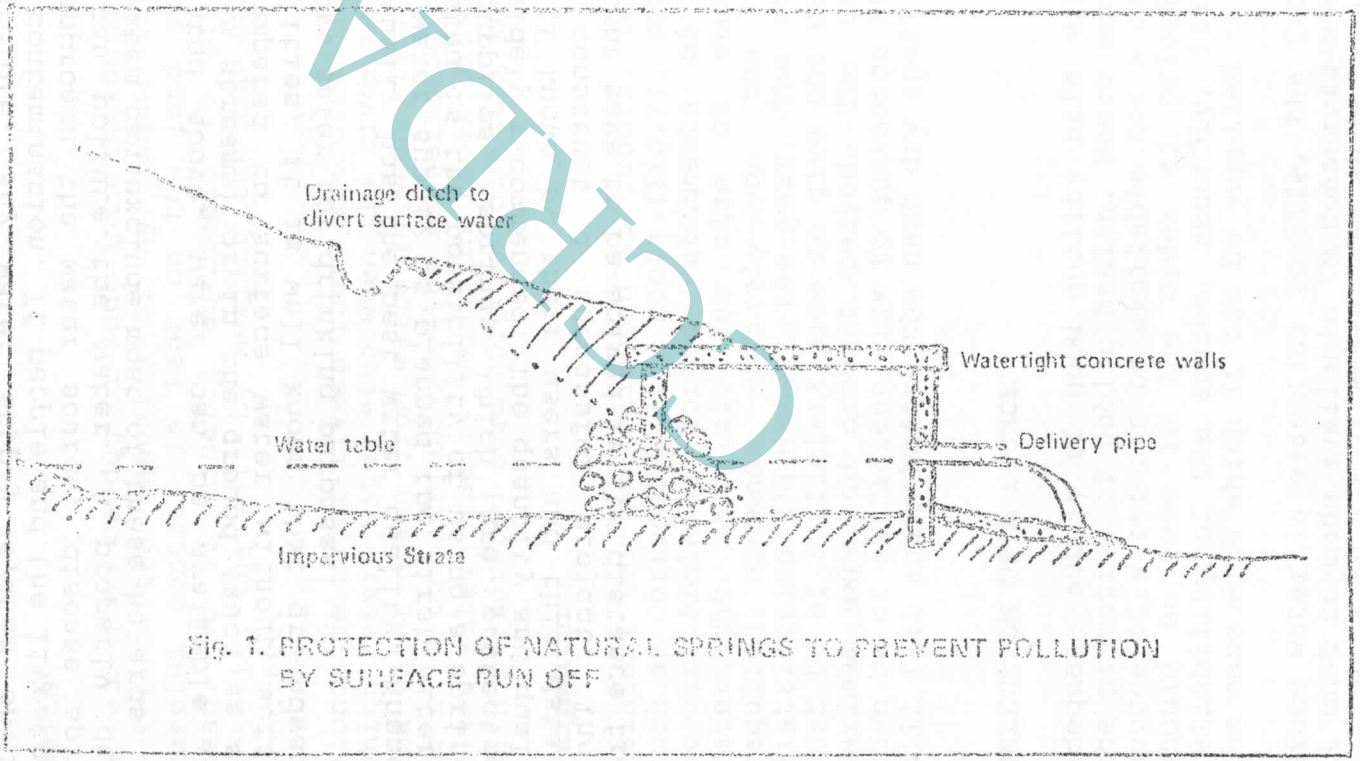


Fig. 1. PROTECTION OF NATURAL SPRINGS TO PREVENT POLLUTION BY SURFACE RUN OFF

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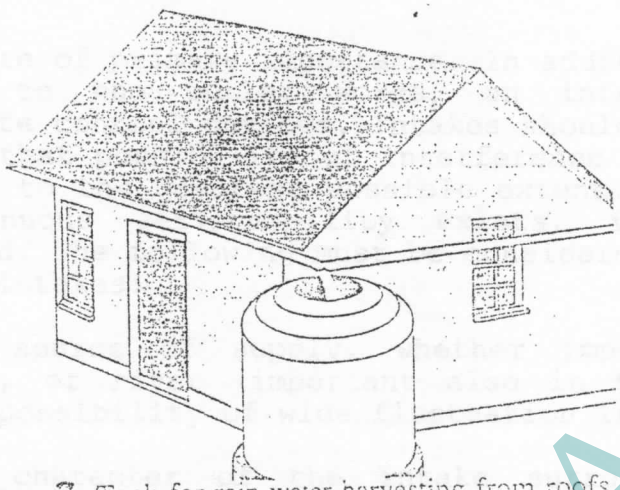


Figure 2. Tank for rain water harvesting from roofs

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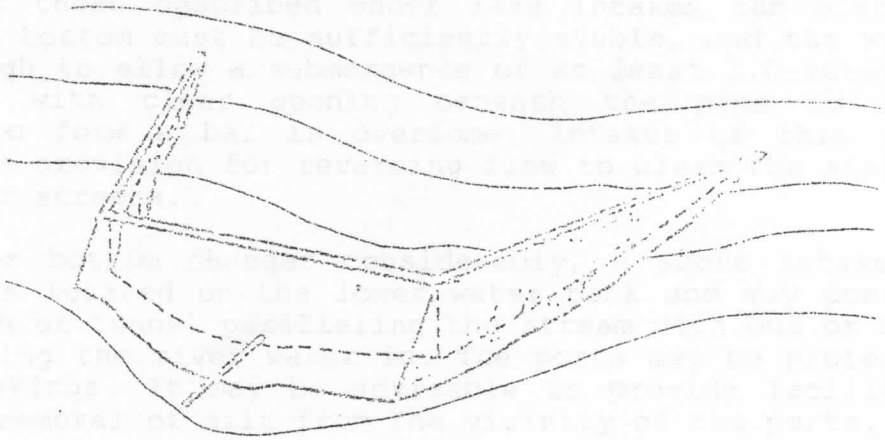


Fig. 3. Rock catchment

INTAKES

Intakes are of primary importance. In addition to forming the entrance to the outlet works, an intake structure may accommodate control devices. Intakes should be so located and designed that possibility of interference with the supply is minimized to the greatest possible extent. Where uncertainty of continuous serviceability exists, intakes should be duplicated. The following must be considered in designing and locating intakes:

(a) the source of supply, whether impounding reservoir, lake, or river (important also in this connection is the possibility of wide fluctuation in water level);

(b) the character of the intake surroundings, depth of water, character of bottom, the effects of currents, floods, and storms upon the structure and in scouring the bottom;

(c) location with respect to the sources of pollution;

(d) provision for excluding floating material as logs and vegetation.

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1. River or Stream Intakes

Where rock foundations are available elaborate river intakes resembling bridge piers with ports at various depths, to allow for fluctuations in rivers can be built. Pipe intakes similar to those described under lake intakes can also be build. The bottom must be sufficiently stable, and the water depth enough to allow a submergence of at least 1.0 meter at all times with clear opening beneath the pipe so that tendency to form a bar is overcome. Intakes of this type should have provision for reversing flow to clear the stainer openings or screens.

Where river bottom changes considerably, a shore intake is used. It is located on the lower water bank and may consist of a trench or tunnel paralleling the stream with one or more ports leading the river water in. The ports may be protected by bar gratings. It may be advisable to provide facilities for quick removal of silt from the vicinity of the ports. To

prevent such silting, low diversion dams have been built to deflect the main current past the intake during low river stages.

River intakes are especially likely to need screens to exclude large floating matter which will injure pumps. Submerged crib intakes may use wood for this purpose; other intakes [lace vertical gratings of steel bars. Fine screens, if installed, are usually placed in the more accessible pump well at the entrance to the suction pipes.

2. Intakes from Impounding Reservoirs

The water of impounding reservoirs is likely to vary in quality at different levels, making it advisable usually to take water from a few meters below the surface. This, with the fluctuation of water level which may be expected in reservoirs, makes it advisable to have ports at various heights. Where the dam is of earth, the intake is usually a concrete tower located in deep water near the upstream toe of the dam. Access to the tower so that the gates of the various openings may be manipulated is obtained by means off foot-bridge. The ports may be closed by sluice gates or by gate valves on short lengths of pipe. Where the dam is masonry, the intake may be a well in the dam structure itself, also with openings at various heights.

3. Lake Intakes

If the lake shore is inhabited, the intake should be so located that danger of pollution will be minimized. It is also advisable to have the intake opening about 2 meters or more above the bottom so that large amounts of silt will not be carried in with the water.Entering velocities must be low, otherwise excessive amounts of floating matter, sediment and fish will be carried in.

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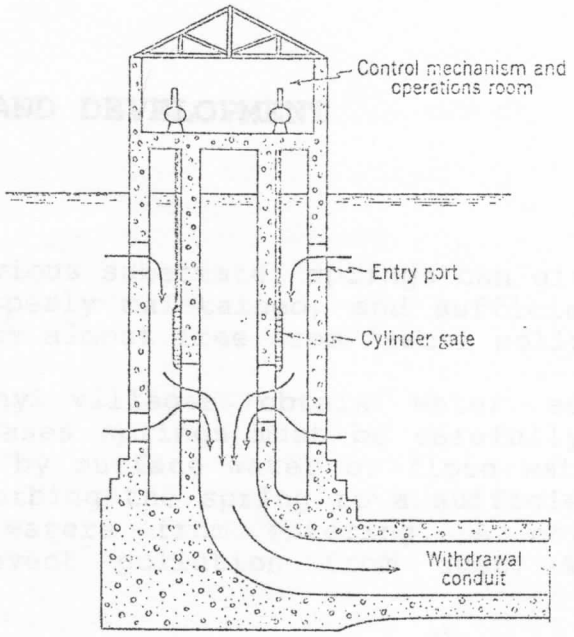


Fig.1. Section through an Intake Tower

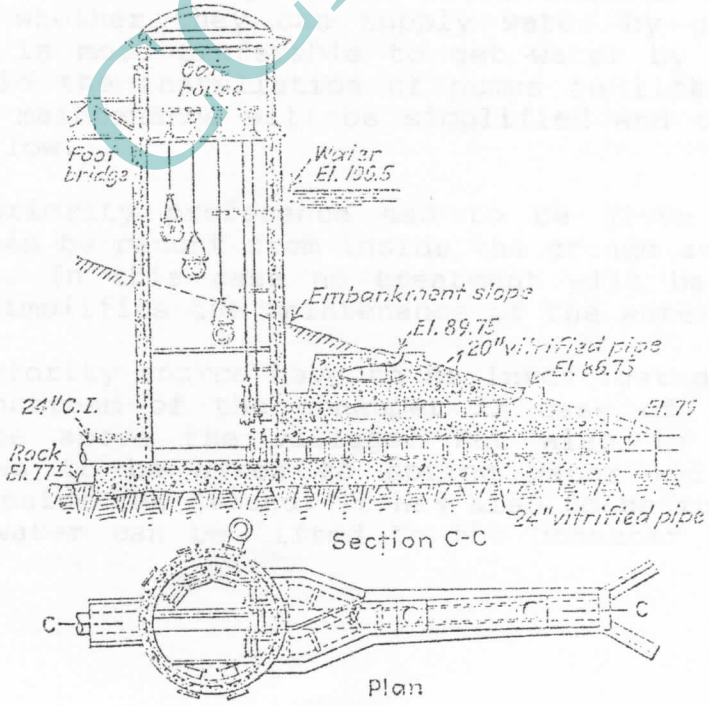


Fig.2. Intake in Impounding Reservoirs

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SPRING PROTECTION AND DEVELOPMENT

1. Springs

In areas of impervious substrate, springs can give a reliable supply and if properly maintained, and sufficiently distant from pollutants, or almost free from faecal pollution.

In Ethiopia, many villages obtain water supplies from springs. In all cases springs must be carefully safeguarded against pollution by surface water or flood waters. This is accomplished by curbing the spring to a sufficient height to prevent surface waters from entering. A cover is also necessary to prevent pollution from dust, animals, and insects.

This will necessitate a tight collecting basin, preferably covered. Shallow ground water or seepage insufficiently filtered may enter the spring-water stream just after rains is receiving such water. This condition may require a special underground gallery or pipe to intercept deeper water.

2. Location of Water Source

With first priority all possible water sources have to be investigated whether they can supply water by gravity the consumer. It is most preferable to get water by gravity in order to avoid the installation of pumps to lift water. In this way the maintenance will be simplified and the running cost be kept low.

The second priority preference has to be given to spring water which can be caught from inside the ground avoiding any contamination. In this case no treatment will be required, which again simplifies the maintenance of the water supply.

With third priority source have to be investigated which are situated downstream of the consumer is case of failing to find a source above the village. But also in this case preference has to be given to spring water which can be caught from inside the ground. It has also to be investigated whether the water can be lifted to the consumer by natural resources.

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3 Spring Catchment

A spring catchment has to be constructed in a simple and practical way. It depends on the topographical situation, the structure of the ground and the type of source. No attempt should be made to change the springs natural flow rate. If there is any obstruction the spring can get dirty or the water will try to find another route. The installation has to be carefully built to avoid the possibility of water pollution by accident or negligence or even on purpose.

The depth and the construction of the catchment depend on geological and hygienic considerations as well as on material covering the water bearing soil. The spring catchment should be covered at least by 3 m. If it is not possible to cover it properly, it is necessary to make special protective arrangements. If possible the catchment should be built with depth up to the impermeable strata.

Blasting near springs should be avoided. The free flow of the water must be guaranteed during the construction.

There are three main parts in a spring catchment: the actual catchment (perforated pipes or a channel built with dry walls), the supply pipe to the inspection chamber, and the inspection chamber.

The inspection chamber has two parts an entrance basin for the water and an operation chamber for the appropriate installation. The purpose of the inspection chamber is to control water quantity and quality (sometimes by sedimentation).

It is important to construct the catchment very carefully because it is the heart of the water supply. In case of failure to do so, it may cause a total break down of this entire water supply. More over the catchment will not be accessible after back filling.

Normally the digging on the source is started on the point where the water comes out of the ground. While following the flow of the source in to the ground a drain has always to be kept open to ensure a free flow off. This is required to avoid any increase of pressure of the source inside the ground and hereby forcing it so find another way out which may not be controlled any more. Moreover, this provision will enable the technician to have a clear picture of the direction of the flow of the source.

Once the excavation is completed the building work can be started. There are two parts. A permeable construction into

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which the water enters and a cut-off wall which has to avoid the by passing of water.

The permeable construction consists usually of a drain in dry stone masonry perforated pipes. The cross-sections of this catchment drain should be sufficiently large to ensure the maximum out flow with out any obstruction to the natural spring flow. The drain has to be sloped 1 to 2%. In case of firm ground no flooring is done. But in case of sandy ground a dry pavement has to be foreseen. The speed of the water should be limited by providing additional catchment drains, because the speed increases the drag force of the water.

Around the drains a filter will be built with gravel, the minimum diameter of the gravel has to be in relation to the holes of the perforated pipes or the spaces in the dry wall. To avoid any contamination never walk on this gravel.

The water tight cover of 5 to 10 cm concrete has to be placed on the top of the drains and the gravel. This cover needs to be extended on all sides 10 cm in to the walls. Surface water reaching this cover needs to be drained off.

The barrage is construction on the opposite side of the point where the water is entering in to the catchment. It guider the water to enter the supply pipe leading to the inspection chamber. The barrage has to be built in to the impermeable stratum a well is in to both side walls to prevent the water from by passing the foundation of the cut-off wall is cast in to the excavation directly against the ground in order to get tight connection to the ground. The barrage is constructed on top of the foundation, either in concrete or stone masonry.

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Supply pipe to the inspection chamber

The piping material has to be resistant to aggressive water. The pipe should be slope at least 2%. The diameter of the pipe has to be according to the maximum yield of the source, but at least 80 mm. It is advisable to install one additional pipe in reserve. The extra pipe should be installed a bit higher than the first one, so that the case taker knows when the first pipe is not working that a failure has occurred which be has to follow up. The installation of an extra pipe is necessary because once the catchment is blocked, the source will build up pressure behind the catchment and force another outlet. This may cause an un-repairable failure because the source may disappear completely.

Inspection Chamber

Every catchment should be equipped with on inspection chamber to allow easy access to the spring. The chamber should not be too small to ensure sufficient room for all the installation works.

The building has to be water-tight inside and outside corners and edges have to be rounded. Each chamber should be ventilated, if possible in combination with a drain-pipe or an entrance. Ventilators and man holes should not be directly above the water, they should rather be placed in the operation room. Entrance or manholes should be 50 cm above ground level with door-steps at 25 cm. Man-hole covers should be locked to prevent un authorized persons from opening them. It is advisable to cover the chamber (including overflow and doors) so as to prevent any possibility of pollution and the entering of small animals in to the chamber.

Each spring catchment needs its own entrance basin, from where the water flows in to a collection basin. If necessary it should be possible to cut off a single spring from a supply. The inlet must be 20 cm above the high out possible water level. It is important that each basin can be drained. There should be no obstruction to the water flow caused by placing the inspection chamber too high in relation to the spring.

The dimension of the overflows and drains have to be capable of draining off the maximum spring capacity without restricting spring flow.

For hygienic reasons, it is important that timber is not used as a building material and that no timber is left in the catchment or inspection chamber (the timber gets rotter and will be come a breeding place for insects).

If one masonry and concrete seem to be the most suitable and long-lasting building materials for spring catchments. Buildings in store masonry may require an outside plastering coat in a swampy area. The chemical behaviour of the water and the ground influences the building material.

The major components of the inspection chamber are: pipe from the spring chamber, baffle plate, overflow pipe, overflow edge, cleaning pipe, supply pipe to consumer, drain pipe, ventilation with wire-net, aeration pipe, climbing iron, stainer, main valve and entrance (minimum 60x70 cm).

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4 Water Point

The construction of the water point gives two main advantages. These are improvement of the quality of the water and storage of water during the night.

A water point normally consists of a storage chamber and a wash basin. Attention has to be given to provide good foundation, especially in swampy areas and on hill sides.

A proper drainage for all over flowing and used wash water has to be installed. The design should be such that all water runs to a certain point, from where a drainage trench with a good slope will lead it quickly to a nearby natural gutter.

A storage tank (or reservoir) should be built if the direct supply of a is not sufficient for the consumers particularly in the dry season. The storage reservoir should be designed as crack free structure to eliminate any leakage. Usually a wash basin is connected to the storage tank. If the spring flow is small, the water should be limited for drinking purposes only.

For distribution points and other locations where pipes are required galvanized steel pipes or PVC pipes can be used. Galvanized steel pipe with screwed joints is widely available, in size from 12 to 75 mm (1/2 to 3 inches) diameter. Galvanized pipe resists to some extent internal and external corrosion.

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DESIGN AND CONSTRUCTION OF POND SYSTEMS

A. TRADITIONAL PONDS

Ponds are the most popular means of rain water harvesting used by the people in many parts of Ethiopia. They are filled and replenished by the yearly runoff which flows from the surrounding slopes.

In order to minimize the hardship of fetching water for domestic use and watering animals from the far away locations, the range lands and villages have small ponds. According to accounts given by the people and observations made during some surveys, most of the ponds cannot serve for the whole year. Apart from the natural self purification, the water from the ponds is not subjected to any form of treatment. It is generally turbid and highly colloidal due to high load of sediment delivered from the catchments.

In areas where traditional ponds are widely used, the best alternative source of water supply seems to be the construction of improved pond. It has been observed that the main problems with the traditional ponds are their insufficient capacity and the water quality specially during dry seasons.

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B. IMPROVED PONDS

1. Components

An improved pond should be able to solve both the quantity and quality problems to an acceptable level. An improved pond system should have the following components (see Fig.1):

a. Collection drain
b. Siltation pond
c. Transition from siltation pond to storage pond
d. Storage pond
e. Transition from storage pond to supply well
f. Supply well
g. Spillways at collection drain, siltation pond and storage pond

2. Site Selection

Having decided that there is a good possibility harvesting water by ponds the most important consideration is that the source should not be in any danger of pollution. This means contamination by human and animal waste, which may find its way into the water directly or indirectly through the soil. This problem can be overcomed by sitting and placing the pond uphill and safe distance away from a source of pollution.

There are also other points to be considered in sitting a pond. The ground surrounding the pond should have a surface declining away from it so that it will be properly drained.

Generally, sanitary zones should be defined for all ponds. A sanitary zone is an area provided around the pond to protect the pond against pollution. The sanitary zones should be for the first defined area 100 m in diameter and the second defined area 200 m in diameter. The first defined area should be fenced and forested or planted with grass. Construction of non-water works structures and habitation of the area, swimming, washing, pasturing and watering of cattle should be prohibited in the first defined area. The first and the second area defined areas should be leveled and provided with ditches or drains for surface waste discharge. To locate grazing of cattle within 200 m from the water source ought not be allowed in the second defined zone.

Ponds can be developed by enlarging an already existing depression or simply by excavating a pit in flat areas or sloppy areas. The shape can be made to fit any location. The side slopes should not be steeper than the angle of response of the soil or should have ratio of 1:1. The excavated materials can be stacked, spread, or removed. Ponds can also be constructed on sloping land by excavating uphill pond area and placing cut materials on the down hill side to form a an embankment.

Soils should have the desirable bearing strength for construction and minimum infiltration rate to minimize losses through seepage.

3. Size of the Storage Pond

Pond is a storage reservoir which is filled by diverting water into it from the surface-runoff.

The cost of the water is mainly influenced by the ratio of volume of storage capacity to the volume of excavated earth, known as the storage/excavation ratio or S/E ratio. Just

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digging a hole and storing water in it would give an S/E ratio of 1.0, but this can usually be increased by using the excavated soil to form a surrounding bank to contain water above original ground level. A naturally occurring depression may also lead to a good S/E ratio. Several shapes have been worked out which give the best S/E ratio for different conditions. When choosing the best size and shape it is necessary to consider the slope of the ground and the kind of water supply. Gently sloping ground from 1 percent to 4 percent will give better S/E ratios than flat ground.

The catchment area of ponds can be increased by the use of catch drains. Catch drains pick up surface run-off, and when the reservoir is full any surplus is spilled safely through overflows in the catch drains.

It is also an important design consideration to minimize evaporation by having more depth and less surface area.

Seepage losses are likely to be more important than in the case of on-stream storage, and the higher value of the stored water makes it more important to consider how seepage may be reduced. The cheapest possible way of reducing seepage is puddling the soil. If there is sufficient clay in the soil, just working it when saturated may seal it.

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4. Construction of Storage Pond

Pond construction activity includes excavation and embankment construction. The excavation work is the major part and does not need much care and attention except that the side walls should be reasonably inclined so as to avoid sliding. However, construction of embankment above the natural ground level should be done as follows.

- at least 1.0 m width free space should be kept between the base of the embankment and the edge of the excavated pond;
- the excavated soil from the storage pond and siltation pond can be used as a filling material;
- fine grained materials such as clay should be used for the core in order to minimize seepage;
- appropriate compaction should be applied by spreading soil layers with depths 5 to 10 cm;
- the slope of the fill should be at least 1:2 (1 vertical to 2 horizontal.

5. Siltation Pond

Sediment deposition in a pond reduces the capacity of its storage. Any measure taken to reduce the sediment deposition improves the life of the pond.

Silts can be trapped by providing long, wide and flat basin (or canal) prior to the entrance of the water into the storage pond.

The transition from the sedimentation basin to the storage pond should be provided with filter. A primary filter can be constructed from 75 mm diameter perforated and solid galvanized steel pipe. The recommended size and space of perforations and 5 mm and 4 cm, respectively. The perforated part of the pipe is placed on the floor of the siltation pond while the solid part is placed across the partition wall between the siltation pond and the storage pond.

In order to minimize siltation in the storage pond, there should never be overflow from siltation pond to storage pond. The siltation pond should be provided with natural spillway and once the storage pond is filled to the required level the runoff should be diverted from the siltation pond.

6. Supply Well

It is proposed to extract water from ponds through a connected hand dug well in order to improve the water quality. It also provide safe way of fetching water from ponds.

The well cover should be designed in such a way that it be removable to facilitate well cleaning particularly in the removal of silted material.

The well cover should be constructed with a slope into a cattle trough or soak away pit such that water will not accumulate in the area and invite pollution of the groundwater and mosquitos. There are a number of literatures proposing methods and details of well construction.

Fencing of the well, the pond and the immediate surroundings will also assist in keeping the area clean and to prevent abuse of the pump and the water system by animals, children etc.

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7. Sedimentation

This is the process of the removal of silt from water by gravity in a basin or wide canal.

Silt can be trapped by providing long, wide and flat basin (or canal) prior to the entrance of the water into the storage pond. The transition from the sedimentation basin (siltation pond) to the storage pond should be provided with filter.

Construction of siltation ponds should fulfil the following:

- The storage pond should be designed such that overflow do not occur. This can be fulfilled by allowing the water level in it to be equal to the water level in the siltation pond at its designed maximum water level. This would help to minimize the silt getting into the storage pond.

- There should not be over flow from siltation pond to storage pond. Flow from siltation pond to storage pond should only take place through the pipe system designed for this purpose.

- If the siltation pond is filled flow should get back through the inlet and be discharged through the spillway.

8. Storage Reservoir

When water is stored in a reservoir for a period of between one to several months, there is usually a very great decrease in the number of bacteria of intestinal origins and other water borne diseases also disappear. To some extent this effect may be due to sedimentation, but the bacterial action of ultra violet radiation and light is of major importance near the surface; there are numerous biotic agencies which probably play a major role in the reduction of the enteric micro-organism.

Soil Filter

Soil filtration is an excellent method of water treatment for rural water supplies. It can give good results and requires minimum operation and maintenance. Soil filters have the advantages of being extremely effective in the removal of pathogens.

Soil filters are not actually build artificially rather they are natural. Once a storage pond and supply well systems are

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made available, the earth mass between any two wells can act as a filter media, while one of the wells is connected with the storage pond directly through a pipe line. This is called earth filter. Thus the storage pond is acting as recharging source for the supply well system.

9. Protection of Catchments

The capacity of the storage ponds and the frequency of silt removal from sedimentation ponds is totally dependant on the quantity of sediment transported from the pond catchments. Therefore, besides the protection of catchments from pollutants there is also a need of reducing the erosion from them.

The amount of soil erosion caused when rain falls on farm land depends on three things: the nature of the rain, the kind of soil, and the way the land is being farmed. Nothing can be done about the nature of rain and much can be done about the kind of soil.

The third factor affecting erosion is the way the land is managed, and only here one can influence and control it. However, the difference in soil loss resulting from different management is tremendous. The same land can suffer catastrophic erosion under one form and land-use, and none at all under another.

The most fundamental principle of soil conservation is that it can only be effective when the land-use is ecologically sound. Good soil conservation does not conflict with profitable proper land use.

Whenever possible vegetation should be used for gully control. The effect of vegetation is to slow down the speed of flow, reducing scour and causing deposition of silt. The deposited soil gives better growth, which traps more silt, and so on.

In order to maintain better water quality, it is advisable to exclude the catchment from grazing and avoid the pollution that may be produced by livestock.In such a situation the most important method of catchment treatment is cut and carry (or zero grazing).

Cut and carry is a conservation-based management technique to preserve soil and vegetation. It also provides fodder for livestock and firewood from area closures. Cut and carry allows an excellent recovery of vegetation and a maximum soil protection. Livestock trampling and extreme grazing down to the roots is excluded and higher productivity will arise.

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Fig 1. Components of a Pond System

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Fig. 2. Typical Sand Filter for Ponds

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CHAPTER THREE

COMMUNITY PARTICIPATION CONCEPT & OBJECTIVES

COMMUNITY PARTICIPATION SCOPE & BENEFITS

COMMUNITY SENSITIZATION & MOBILIZATION

COMMUNITY MANAGEMENT

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COMMUNITY PARTICIPATION AND MANAGEMENT IN WATER SUPPLY AND SANITATION

1. INTRODUCTION

The problems of poor water supply and sanitation services continue to be more and more critical than before, despite considerable effort to improve the situation and expand access. Evidence and field observation explicitly indicates that centrally managed schemes, among others constraints, are difficult to implement and operate when communities served are dispersed, remote and relatively small and lack financial, skilled manpower, materials and social infrastructure needed to enhance development.

In contrast, locally managed systems appear to function reasonably well and be sustainable, effectively used, and replaceable once. Such schemes are difficult to standardize for all communities, but water and sanitation experts agree that they have numerous advantages over other approaches. Efforts have been made to identify programs that work and determine which types can be adopted to specific sites by applying practical community management (C.Mgm't). Field experience suggests that C.Mgm't of water supply and sanitation (WSS) entails far more than a mere redefinition of responsibilities, that it must be anchored in local socio-economic, administrative and political realities. Community needs and strategies for meeting them must be refined in concept with community participants and local leaders, who were already experienced in managing existing resources. It is widely believed that community managed schemes can succeed where top-down methodological approach have failed, not merely because of greater community participation (CP), but because of greater community control over decision making. This is what makes C.Mgm't a dynamic system. Communities obtain WSS system they want and will support. At the same time, C.Mgm't shouldn't be thought as a simple choice between a top-down or bottom-up approach. Rather, it is the out-come of a collaborative partnership between the community, Government, Non-Government Organizations (NGOs) or external agents, in which neither is dominant and each understands and accept its role. This relationship places both parties, communities and governments as the local point of decision making and help create or support conditions, respectively, in which community based actions can occur, here, external support agencies can also play a large

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role in bringing about such partnerships. The end effort is to create a community managed services that foster a sense of ownership and promote and encourage willingness to pay, which in turn contribute to better overall performance.

On the other hand, expanding and sustaining WSS is becoming a serious problem. The size of the task itself constitutes an enormous obstacle. Since, 58% of rural residents of the world have no access to improved water supplies and 84% have inadequate sanitation according to WHO, 1987 report. Raising costs pose another problem. For example, WHO 1987 publication indicated, "Between 1980 and 1985, the unit costs of improving rural water supply and rural sanitation rose 24% and 39%, respectively". These have tripled by today. Meanwhile, funding has been declining and many completed schemes are in disrepair and others have been abandoned. whereas the number of population and their demand is geometrically increasing 1, 2, 4, 16, 32 ... This state of affairs has led many researcher experts to question whether the emphasis on centrally managed systems needs to be re-evaluated and a new approach taken to the provision of rural water supply and sanitation (RWSS) as a public service. That is why CP and Mgm't have been proposed as one possible alternative strategy in view of the increasing evidence that systems are more sustainable when designed, established, operated and maintained by the users community. With perception of the above introductory note, we shall explore the basic concept of CP and Mgm't here below:

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2. THE BASIC CONCEPT OF CP AND C. MGM'T

2.1 Community Participation (CP)

2.1.1 Definition

Community: can be defined in many ways:

- it may refer to a group of people living in a geographically defined areas, or
- to a group that interacts because of a common social, economic, or political interest.

Participation: is a strategy for sustainable development. Achieving full and effective CP in development activities is a difficult job and much depends on the way members of the community are approached by field staff, extension workers or technical consultants. The experience of development projects has proved that didn't succeed, because the intended beneficiaries failed to change behavior or attitudes that were critical to the project's success.

There are also other reasons why costly facilities may fall into disrepair, such as the failure to mobilize the will of people, pressure from prestigious leaders, people talks to motivate community trying to induce behavioral change, large community meetings to explain roles and obligations and setting up local committees to enforce CP.

Women the once who are carrying out most of the relevant tasks of WSS may be reluctant to take part or to speak at the meetings.

As the carriers of WSS for domestic needs and as the principal molders of the family's hygienic habits, women's involvement in decision making is of critical importance. Women with modest training, encouragement and technical support can make a highly significant contribution to WSS. They have shown their capabilities in fulfilling intelligent and responsible roles in community level planning, management, needs assessment, site selection, pump maintenance and fund-raising. Women also exercised intelligence and initiative to increase WSS project effectiveness and to widen support at the local level. Thus the concept of CP in WSS programme is not complete unless women along with their families, play a responsible role in both its planning and over all management.

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2.1.2 Real Community Participation

When? How? Why? What? Who? Where?

Many efforts have been done at CP. Some work with enthusiasm to the extent of sweating, while others relax and fill reluctant. The following cases of WSS project could illustrate that CP may be more complex than we think.

a) The "Cheap Labour" Concept of Participation

In some WSS projects, the community is considered to have participated when it provides free, unskilled labour for construction and donate raw materials in the spirit of self-help. The role assigned to villagers is to carry pipes, dig trenches and perform other unskilled construction tasks. The thinking parts like surveying, planning, designing is done entirely by engineers and other technically trained personnel.

Some believe that free labour contributions, which is obviously lowering the costs of project, increase the people's identification with the system being built. The assumption is that if they have built a system with their own unpaid labour, they will take pride in it and want to maintain it in good order.

Whereas, others contest this assumption. they point out that pride of ownership depends also on what the people's priorities might be. That is, if the construction project is not a priority for the majority or average community member, labour may be contributed under duress, not voluntarily. If so, then interest in using and sustaining the facility may die after a while.

b) The "Cost-Sharing" Concept of Participation

In WSS project, the key issue is not just cost reduction, but the most important one is cost recovery. They advocate cash contributions by community members in cash or in kind towards maintenance. People's willingness to invest apart of their meager resources in maintaining the system. E.g. to pay the local mechanic is an indication that they value the service and are therefore committed to keeping it in good working order.

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Others believe that agreements to maintain a system may not in themselves be a reliable indicator of local commitment. For example, if the average community members, and in particular, women have not been involved in decisions concerning the system, they may revert to their old water sources when the pump breaks down rather than contribute towards the cost of repair.

c) The "Contractual Obligation" Concept of Participation

The above mentioned concepts of CP is considered to be adequate to prevent WSS project misuse. However, WSS project designers concentrated on local leadership, committees and locally recruited volunteers technicians for operation and maintenance in order to sustain and generate support, due to the following assumptions:

- Winning over local leaders will help to legitimize the project
- Water committees will be able to promote, manage and monitor local contributions and water usage.
- Through training of volunteer mechanics, pump miners and other local technicians, aides, technology can be transferred to the community.

Contract is often drawn up, to make it formal and binding. This contract spells out in detail what roles and responsibilities apply to each partner in the project. e.g. Government and/or NGO and the community. The community has the option to either accept or reject the terms of the contract or it may even negotiate some changes through the formal power structure of the village. Sufficient time may be given for people to review the terms of the contract among themselves. It is assumed that by assigning management roles to local water committees and by training local mechanics there is greater chance for the contract to be fulfilled.

On other hand, it is questioned whether this approach sufficiently involves the average villager. People feel that contracts that have been negotiated primarily with village leadership and presented at the large meeting may not fully understood by the mass community. Therefore after a while contributions in cash and/or kind may decline.

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Setting up local committees immediately following the first village meeting also runs the risk that the best representative people may not be nominated. Similarly, pump care-takers who have been hastily selected may drop out for lack of commitment and accountability to the community at large.

d) The "Community Decision-Making" Concept of Participation

It is believed that a substantially different approach than the above is needed to create a strong sense of local responsibility for sustaining, effectively using and properly replicating WSS.

Cost-cutting, cost recovery measures as with local institutional mechanism approaches are becoming important for WSS development. However, genuine commitment and widespread support by the community as a whole will only come about by a process of participatory community education and by involving a broad base of the community in decision-making right from the Hence, the decision making requirements should incorporate not only male, but women. Women lack of schooling or literacy skills should not be prevented from making valuable contributions to community decision making. There are others who feel that a broad mass community is to difficult, since field staff are not equipped and training would take too long and also cost too much. But experiences and experiments proved that participatory training is not either excessively difficult or costly, and has long term benefits.

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2.1.3 Developing a Common Concept of CP

It is important to capture individual's concept on what is CP? there are, in fact, many definitions, but it is all those close to the project have at least a common understanding of the These are some questions to explore, which might help us to develop a common CP.

- What d by CP?
- What ticipation? By whom? Men or Women or both? In what form? vels? In which roles? For what purpose/s?
- Who and in what way?

- What needs to be done in order to get that kind of participatory process going?
- What indicators, including people's behavior, will tell us that the process has been effective?

People may have different answers to those questions. For example, in the WSS sector, the exceptions of the engineer may be very different from that of the health educator or community development officer. The extension agent's perception of which type of CP is feasible may differ significantly from that of a central office manager who is concerned with costs of installation and maintenance of WSS systems.

Even if everyone can not agree on common answers, there is great value in people hearing one anther's ideas. The ideal is to clarify and refine concepts, reconcile divergent views and differences and combine ideas into coherent policy and understanding in order to arrive at a common concept of CP.

These will lead us to the common understanding on CP as that:

- it involves people in decision making process and planning of action programming to solve problems.
- it engages people in an assessment of situation, defining of problems and setting up the priority
- involves target people in the acceptance of responsibilities for implementing WSS programme
- manifestoes the willingness of beneficiary communities in contributions of free labour, locally available materials and cash in kind in money term.

In nut shell CP implies to people's involvement in development efforts to be achieved with and by the users community, but not just for the people as a gift. That is why the concept of CP is taken to mean that user community plays an active role in its own affairs by sharing and exercising social, economical and political power. With this perception, the concept of CP is also defined as "an active process where by beneficiaries influence the direction and execution of development projects rather than merely receive a share of project benefits"

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2.1.4 Community Management (C. Mgm't)

Community management as applied to WSS systems has generally been concerned with questions of O&M, women's involvement, in cash and kind contributions, all of which engage CP and were said to promote sustainability, effective use and replicability. Yet field experience has shown that sustainability depends not on CP alone, although CP does appear to provide the environment required for successful management, which has come to be known as the enabling environment. Therefore, general CP in significant decision making may be seen as one precondition for C.Mgm't. Furthermore, if CP occurs at different levels of intensity, then the potential for C.Mgm't will depend on the level of CP that has been achieved.

As noted earlier, the concept of CP implies that the beneficiaries involved in development activities, whereas C.Mgm't refers to the capabilities and willingness of users to take charge and determine the nature of the development affecting them. Thus in WSS systems, C.Mgm't means that the community exercises responsibility for decision making and control over the subsequent execution of these decisions during project development. Thus, C.Mgn't refers to the capability of a community to control and strongly influence the development of its WSS schemes, which has three basic components, listed below:

- ◊ Responsibility, the community takes on the ownership of WSS system and attendant obligations to the system.
- ◊ Authority, the community has the legitimate right to make decisions regarding the system on behalf of the users.
- ◊ Control, the community is able to carry out and determine the outcome of its decisions.

C. Mgm't is concerned with all issues pertaining to responsibility i.e. ownership, decision-making authority; control over project development and systems operations. It may imply a variety of management systems, from extensive contributions of self-help labour at lower levels of service to specialized managers at higher levels of service.

Participation and management can be distinguished on the basis of fee-collecting activities. Participation implies that the community performs routine operational duties such as record keeping, accounting and payment collecting under a system predefined by an external

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agency, whereas management implies that in addition the community establishes tariff schedules and institutionalizes its own form of fee collection. The following are distinction hinges on the important preconditions for C.Mgm't:

- There must be community demand driven for an improved WSS system.
- The information required to make informed decisions must be available to the community.
- Technologies and level of service must be commensurate with the community's needs and capacity to finance, manage and maintain them.
- The community must understand its options and be willing to take responsibility for the system.
- The community must be willing to invest in capital and recurrent costs.
- The community must be empowered to make decisions to control the system.
- The community should have the institutional capacity to manage the development and operation of the system.
- The community should have the human resources to run these institutions.
- There should be a policy framework to permit and support C.Mgm't.
- Effective external and internal support and service must be available from Gov't, NGOs and other donors as well as private sector (like training, technical advice, credit service ... etc.)

Most of these preconditions will be obtained if an active and effectively appropriate approach is taken to enhance CP. It is a such approach which lays the groundwork for C.Mgm't.

The relationship between CP and C.Mgm't can be seen as a building process in which participation (being the lowest stage) leads to management through progressive levels of local responsibility, authority and control as management passes from the external agency to the community. These levels of C.Mgm't is depicted on Table 1 here below:

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TABLE 1

LEVELS OF C. MGM'T

Level	Responsibility	Authority	Control	C. Mgm't
I	External agency little community responsibility	External agency informal community consultations	Eternal agency limited community participation	Insufficient
II	External agency community responsible for operation	External agency limited formal role for community institutions	External agency modern CP	Limited
III	Joint; community responsible for O & M	Joint; collaborative role for community and agency	Joint, strong & limited C.Mgm't	Moderate
IV	Community; external support	Community; external support	Community; external support	Sufficient
V	Fuel community responsibility	Full community responsibility	Full community responsibility	High

Level I: is the lowest/baseline for C. Mgm't. At this stage, the community plays only a marginal role in system development and operation. This level of activity was typical of earlier approaches to the provision of improved supplies, many of which were only providing solutions to technical problems. The external agency is almost entirely in charge and responsible for development, of schemes O & M. The community may accept responsibility for unskilled labour, locally available materials and to some extent may pay for O & M. This level of participation is seldom sufficient for the community to develop a sense of ownership and responsibility. Community or its leaders may be consulted when the system is built. Consequently, people may refuse to use or maintain this WSS.

Level II: refers to a situation in which a community has somewhat greater than level I, but still very limited capacity for management. Most WSS projects that have some social or promotional components probably fall in this category. The external agency retains responsibility, authority and control over most aspects of system development, while the community acts in a subordinate and supportive manner. The external agency promotes CP with a view to increase project efficiency, effectiveness and reduce project costs. The intensity of CP is sufficient to grant the following to the community:-

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1. enough authority to play a limited role in project decision making and
2. enough control over project development to become capable of operating the completed scheme

Despite some degree of participation, communities at this level are seldom prepare to take full responsibility for system maintenance. Therefore, WSS system will remain the on going responsibility of the external agencies or will fall into disrepair.

At Level III: a collaborative relationship develops between the community and agency. Most projects cited as good examples of CP are probably at this level of management capacity. Although implementing agencies, and/or non-governmental organizations (NGOs) seldom relinquish their command over project development at this level, they delegate sufficient authority and turn over enough control to enable and encourage the communities to take on joint responsibility for the development and O & M of their completed systems. CP is promoted intensively at this level with a view to achieving capacity-building and empowerment objectives. At this stage, community committees are organized and committee members are trained to take on management responsibilities. Authority for sharing in decisions concerning project preparation and implementation is delegated to community organizations that are expected to make system operationally sustainable and effective.

Level IV: represents reasonably effective community control of all the main elements of the system. The community, (not the external agency) is in charge of its system. The agency, here, merely provides technical and financial assistance to support C. Mgm't. The transition from level III to level IV can not take place unless enough of the preconditions for C.Mgm't have been met to enable the external agency to turn over management responsibility to the community. There may be a lag, between the community's demand for improved services and its ability to cover all, or even most of the capital costs, or between its authority to make decisions and human resources it needs to made them well.

The capacity for C.Mgn't develops through a dynamic process in which change and growth occur at every level as well as between levels. The external agency must still play a supporting role at level IV to ensure that development will continue to take place.

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Level V: is where the community becomes fully responsible, has full authority and is in full control of all system activities. The external agency now acts as an enable to ensure that the necessary technical and financial resources needed to support community-managed systems are in place.

Management capacity can be assessed by the level of CP in contributions to WSS development and operations. The willingness of a community to finance its WSS is a measure of C.Mgm't potential. Because decisions are made in the context of CP. In community-managed systems, users identify and mobilize resources. The correlation between a community's willingness to pay and its management role is based on the assumption that those who play an activist role will select, support, and sustain systems most appropriate to their needs. At all levels, the willingness to pay instills a sense of ownership that engenders more effective cost-recovery schemes. In sharing capital and recurrent costs, the community takes responsibility for setting tariffs, organizing fee collection, and establishing effective O & M.

Community contributions can be cash payments and in kind donations of time, labour, skills, land and local materials. In some cases, these contributions are made through one time fee collection at the start of the project or cover the community share of capital and recurrent costs through water fees and other charges.

WSS project support can be local contributions in kind or cash payments (cost recovery) from the community and support from external agency which may include technical assistance and/or loans.

Table 2 illustrates how the relative degree of support from the community and agency can be used as a measure of C.Mgm't, here below:

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TABLE 2

LEVELS OF PROJECT SUPPORT

Level	Contributions in kind from Community	Cash payments from Community	External Support from Agency
I	None to limited	None to limited	Full external support
II	Some self-help labor, local material; weak	Some O & M	All capital & most O & M costs
III	Self-help labor, local materials, active committee support	All O & M and minimal capital costs	Most capital costs
IV	Most non cash needs, strong committee support & Mgm't	All O & m and some capital costs	Some capital costs
V	All non-cash needs	All O & M and most capital costs	Access to loans and grants

In the classic CP model, communities may chose to make all of their required contributions in the form of cash payment rather than in a mix of cash, local materials and voluntary labor. Particularly, high income communities may substitute cash instead of in-kind contribution to hire labor or purchase materials that might otherwise be donated. As Mgm't capacity increases and more users opt to pay for system support rather than volunteer their own time and effort, Mgm't roles become more and more specialized. Therefore, in kind contributions are not essential characteristic of C.Mgm't, although they may be crucial for effective CP. The decision to make contributions marks the activity as a Mgm't function. However a community has a high Mgm't capacity does not always mean it will be able to recover costs quickly, since cost recovery is a process, made up of progressive targets that vary with each community's ability to meet them. Cost recovery may also have little to do with Mgm't capacity in communities that receive grants-in-aid or donations of services and materials as the case of poor villages.

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2.2 Benefits of Community Participation & Community Management

The concept of CP & Mgm't has received increasingly favorable attention, because the systems based on this principle appear to be more sustainable than those managed externally. Such WSS systems generate various benefits such as better health, an increase time available for other activities, and many socio-economical advantages. These benefits appear to accrue in three stages list here below:-

I. Immediate behavioral changes: short-term improvements in system performance such as greater use of WSS facilities, adoption of improved hygienic practices and greater community support for O & M.

II. Change in support conditions: long-term improvements in available resources and complementary investments.

III. Long-term impacts: anticipated health, social well-being, economic and environmental quality changes.

In the past CP and Mgm't in the activity of WSS project was conceptualized as effort of individual to implement plans already made and imposed by the gov't or other development agencies as the "Top-Down" approach i.e. deductive and authoritative traditional type. This approach prescribes passive acceptance which results in the failure of the project. However, the new and present approach is participatory which involves the target beneficiaries at the initial discussions, prioritization, planning, implementing, (construction) O & M as well as monitoring and evaluation of the WSS project at all stages without demarcation. The most commonly accepted advantages and benefits of this CP & Mgm't are enumerated below:-

1) More people can be served with CP and services can be provided at low costs to each community.

2) Genuinely motivated and participated community in decision making of WSS activities will help to accomplish more task at relatively low cost.

3) Participation encourages adoption to local knowledge, needs and circumstances. Community has an intrinsic value for participants and involvement's are more of instrumental advantage as a means to achieve the ends which enable community to participate actively in the process of development which affects them.

4) CP is a catalyst for further development efforts, since popular participation will lead to a more united community. The organizations created i.e. committees arrangements for voluntary labour and enthusiasm generated by success will provide the means and stimulus for further efforts to tackle other needs by strengthening their sense of ownership and responsibility towards the projects, particularly WSS programmes.

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5) CP guarantees that a felt need is involved. Communities have demonstrated their needs and willingness to support the project. They have shown collective efforts to organize and participate in the projects.

6) CP ensures that things are done in the right way. If communities take an active role in planning, design and site selection of WSS projects, they will use it confidently and presumably be better adopt to their needs.

7) CP encourages the development of sense of ownership and responsibility.

8) CP & Mgm't enables the use of indigenous people possess local practices and valuable experiences that might help their WSS project activities. CP will facilitate the usage of their skill.

9) CP & Mgm't leads to freedom of rural people from the dependence on professionals. A radical approach to CP envisages the prospect of freeing communities from dependence on mechanical experts, technicians and other professional through locality capacity building (training and material provisions).

10) CP & Mgm't gradually develops consciousness among users, enabling them to know the structural cause of their situations, rights and obligations under the existing law. Through CP & Mgm't the target people will better understand the nature of the constraints, hindering their escape from poverty. They learn how to make more effective demands on Gov't, NGOs and other agencies, acquire a method of resolving their problems by collective efforts through the genuine CP and efficient Mgm't.

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3. Community Sensitization & Mobilization

The over riding goal and objective of CP & Mgm't in WSS is not simply to ensure sustainability of a system by teaching people how to function in a committee or how to fix a pump and conduct O & M activities. Rather, it is to help people develop the outlook, competence, self confidence and commitment which will sustain a responsible community effort in WAT.SAN sector and beyond. In doing so, community sensitization and mobilization should be concentrated on over all human development aspects.

Community mobilization:

Is important to facilitate the aggregation of demand. Demand theory assumes that individuals will express their preferences if the incentive are correctly created. Since water system is a good to be shared and considered as a priority, being demand - responsive at the community level.

Project should employ staff to facilitate the process and ensure that the community demand is representative of all member of user community. Such community mobilization may take form meeting and include gender sensitive techniques to ensure that women's voices are heard.

The aim of community mobilization is to ensure that there is a demand for service among all potential users to:

- identify the preferences and priorities of the community
- ensure that users are committed to operating and maintaining the system before a decision is reached to build a new system.

When community mobilization is weak or absent, project risk will arise, having their benefits appropriated by community leaders or dominant ethnic groups, excluding women and other user groups from decision making processes and project benefits, jeopardizing a community's commitment to sustain the water system.

A vital difference between participatory approach and didactic method is the emphasis that is placed on establishing horizontal relationships and maintaining a cordial atmosphere. The introduced activities must be such that:

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* consider all equally,
* resourceful respectful to each other,
* develop mutual understanding and good team work
* create a climate of trust and mutual respect
* respect for experience, ideas and potential
* encourage to participate actively in generating fresh ideas

Activities that can be used as tension breakers or as means to strengthen group interaction, that will enable to:

* express expectations
* build peer relationships
* develop skill in team work and
* appreciate their abilities and other group members

Integrate participants from different backgrounds such as village people, trainers, technical experts to break down hierarchies among the members including everyone in discussion and assess different perspectives and capabilities, through participatory approaches.

The participatory approach, often known as learner - centered, has been used as a means of helping learners take greater control of their lives and their environment by developing their skills in problem-solving and resource management. Unlike traditional teaching method which is didactic style, some times also referred to as the "top-down" or "banking" approach, since its primary purpose is the transfer of knowledge, message or contents pre-selected by outside specialists, participatory techniques such as SARAR focuses more on the development of human capacities to:

- assess
- choose
- Plan
- create
- organize and
- take initiative

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These skills can be developed through participatory training then spill over many other aspects of life increasing community ability to take initiative, responsibilities, articulate ideas, generate solutions and solve problems.

These aims are synthesized in the following five characteristic of the SARAR approach as follows:-

SELF - ESTEEM - groups and individuals are acknowledged and enhanced by recognizing that they have the creative, and analytic and solve their own problem.

ASSOCIATIVE - STRENGTHS - the methodology recognizes that when people form groups, they become stronger and develop the capacity to act together.

RESOURCEFULNESS - Each individual is a potential resource to the community. The method seeks to develop resources generating solutions to solve problem.

ACTION - PLANNING - to solve problems is the central to the method change can be achieved only if groups plan and carry out appropriate acting.

RESPONSIBILITY - actions that are planned must be carried out. Only through such responsible participation do results become meaningful.

It is with these conceptual approach that one should:

* "Go to the people .....
  Live among them .....
  Love them .....
  Learn from them .....
  Start with what they know .....
  Build with what they have .....
  But of the best leaders .....
  When the task is over and accomplished .....
  The people all remark .....
  We have done it ourselves ....."

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The important things to be accomplished in order to sanitize and mobilize CP in the activities of WATSAN project are depicted here below:-

A. Human Development Activities :

i. Baseline attitudinal assessment which is communities openness to take initiative, creativity, being involved in group work and problem - solving

ii. Expressions of hopes & fears, sharing expectations

iii. Group self Selection giving possible choose in which groups in community would like to work with .....

iv. Personal adjectives introducing to each other in an enjoyable way with respectful manner.

v. Group dynamics short activities to relax or recharge the group after intensive activity or at the start of activity.

B. Methods :

it is a core of SARAR approach that helps to create effective learning experiences enabling villagers to conceptualize and carry out Water Sanitation Projects.

Methods are organized in five clusters and are sequenced to have a cumulative effect,

1st community are involved in using their creativity looking at the situation in a new ways, then

2nd gain tools for investigating, then

3rd analyzing the reality, and

4th develop skill in planning and finally

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5th accessing information for Water Sanitation and also for other community development initiatives. In short methods are subdivided into five i.e. creative, investigative, analytic, planning and informative.

C. Field - Reality :

looking and focusing on a practical real life problem. There are four areas which need attention and to be highlighted at the field, i.e.:

1. CP from various perspectives
2. The situation of rural women like:
   - Psychological barriers to CP, - feeling of dependency, - low self - esteem, - fear of disapproval of husbands or elders, - lack of common purposes and resources,
   - inability to take risks
   - Fear of talks that require unfamiliar skills or that may increase women work load
3. The roles and responsibilities of extension agents and technical experts
4. Your own key field reality issues

i.e. when you may come across field reality issues that are important in your own situation, use the activities as proto types for creating your own exercises on your own key issues. Example developing a mural on CP and women's involvement, i.e. stimulating individual and group ideas on the meaning and concept of CP and sensitizing people to women's roles /involvement's in WSS sector, respectively.

3.1 Characteristics of CP

- CP has become a favored development strategy, because it involves people in decisions and actions affecting their welfare. The concept was originated in the process of community development during colonial era in Africa and Asia, as a means of improving local welfare, training people in administration, and extending government control through local self-help activities. However, CP fell in the late 1960s and early 1970s, because of the top-down bureaucratic approach to development and its failure to redistribute benefits, since CP of that era come to be associated with forced labour,

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although it was called voluntary. Gradually the governments of developing countries and external support agencies begun to place new emphasis on participatory efforts. As a result of greater democratization in CP private, religious and NGOs actively involved, which saw a need to integrate rural development, provide basic services and alleviate poverty.

- CP come to imply any number of concepts from self help, animation and user choice to local participation and participatory democracy. At present, the concept of CP is taken to means that the community plays an active role in its own affairs by sharing and exercising political economic power. That is why World Bank experts, --------- ------ defined it as "an active process where by beneficiaries influence the direction and execution of development projects rather than merely receive a share of project benefits.

3.1.1 Historical Development of CP in Ethiopia

- Ethiopia has been described as, "The Water Tower of Africa" because of her vast potential water resources. But, not developed, exploited and effectively utilized due to the shortage of skill man-power, material and Financial resources.
- In reference to the historical development of rural water supply projects (RWSPs), the activities started in the early 1950s with the introduction of boreholes drilling for some towns and farm plots of top government authorities and also the construction of ponds for the semi-nomadic people and their livestock.
- The 1st and 2nd five year Ethiopian National Plan, which were during 1957-1961 and 1963-1967 respectively neglected RWSPs due to the lack of fund, poor organizational structure, shortage of qualified staff and absence of clear cut policy directives. Even the 3rd. Five year National Plan which was in 1968-1972 did not attach considerable priority to RWSPs, where:

  - 150 wells were planned with equipped facilities, but 70 wells were drilled and out of which only 35 were equipped with the required facilities and additionally,
  - 23 wells were constructed and
  - 220 schemes were maintained and also some ponds were developed.

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It was the historical incident of 1973/74 drought, which pulled the attention of Ethiopia government and external assisting agencies to consider the importance of water supply development. Since then significant amount of financial, materials and technical assistance were donates by government agencies, to mitigate the critical problems of Water shortage in drought affected regions.

Ethiopian government assigned top priority to RWSPs during the Ten Year Perspective Plan of 1974-1984 and achieved the construction of 1174 boreholes.

1260 hand dug wells
150 springs

Population explosion, human development and various activities both in economic and social fields pressed and highly raised the demand for water. This reality prompted the UN to convince International Water Conference, held in Mar-Del-Plate, in Argentina in August 1976 and the resolution of the conference crystallize primary of water resource development, and management.

Following Argentina water conference, the International Drinking Water Supply and Sanitation Decade (IDWSSD) was declared in 1980, with the objectives of beneficiaries involvement in the planning, construction, operation and maintenance of Water and Sanitation Project. The need for IDWSSD strategy was discussed in reference to the issues of how to implement CP in Water Sanitation Project activities.

These conducive atmosphere paved the way for CP to be established in Ethiopia, introducing in water sector in early 1977, right after African Water Conference, held in Addis Ababa. The conference adopted a resolution of promoting a local communities involvement to alleviate water problems of rural communities.

On the basis of the resolution and ad-hoc committee was set up by then EWRA and which was later named Water Resources Commission (WRC) to prepare organizational structure of CPPS. Accordingly the draft guidelines was submitted in 1980 and approved in 1981.

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3.1.2 The Objectives of CP

The aims of CP in context of development programs may include the following objectives:

a) Sharing Project Costs, Contribution money, labor and local available material to gain effective resources mobilization of user community is construction, operation and maintenance as well as organization and management (O&M)

b) Increasing project efficiency to encourage and organize beneficiaries to carryout self-help water sanitation projects in planning and implementation.

c) Increasing project effectiveness to ensure beneficiaries share in project design and implementation as to give a due consideration to Water Sanitation Project and is appropriate to the needs and decisions of the user villagers.

d) Building beneficiary capacity to promote users share in management tasks and O & M responsibilities, increasing community contribution, so as to enable government and NGOs funds to be used for increasing Water and Sanitation facilities in other areas or for any required improvement and expansion tasks in the same community.

e) Increasing community empowerment to develop and increase users community awareness and sense of responsibilities to ensure sustainability, effective use and replicability of the schemes reducing number of systems failing into disrepair, misuse and vandalism: This objective will enable beneficiaries to share power and increase their political awareness and influence over development outcomes.

3.1.3 Community Participation & Management Activities

It is well understood that local communities, particularly the water needy people are eager and accept anyone positively to achieve their and goal of getting safe drinking water through working with them. The major activities of CP associated with most successful WSS are the following:-

1. Community mobilization and organization : CP means involving as many community members as possible by providing an institutional vehicle through which they act, motivating project use to participate genuinely.

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2. Project negotiations: Communities need to communicate their preferences and have a say in the type of project to be considered. Project users input may be given in consultations between community leaders and agency officials or in public discussions within committee meetings. It may consist formal bargaining on issues such as WSS project design, community contributions and external assistance.

3. Committee operations: Community organizations e.g. water and sanitation committees are usually elected or appointed by beneficiaries. Their potential operating effectiveness depends on the degree to which they allowed to function in WSS project activities.

4. Training : is necessary for system managers committee members, and all others involved in project implementation. Community members should be trained and pass on their skills to others.

5. Hygiene & User education : help to develop responsibility for the system and feelings of control over the environment in the minds of participants. Such training should be participatory and practical type, rather than didactic and theoretical and it should encourage a behavioral change to maximize health benefits.

6. Community contributions : Communities must contribute to WSS projects development and operations, if they are to feel that they own the system. Contribution should include monetary investments, materials, equipment, labour, committee membership and general participation in project.

7. Cost recovery : the community should interpret cost recovery as an obligation to meet its share of the cost of WSS project. In particular, the community must meet obligations to external agency to get the genuine assistance from them.

8. Operations and Maintenance (O & M) as well as Organization and Management (O & M) : Communities should accept and exercise responsibility for O & M. Care takers and repair crews should be well trained and responsible to the community based WSS projects.

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9. There are also expanded function of external agencies. WSS Project field staff play an important role as they form a link between the project and the community in organizing, training and facilitating. They work with the community to accomplish the development tasks that the community themselves have chosen to undertake.

3.1.4 Areas & Scopes of CP & Management

Successful WSS project involves beneficiary community in the whole phases of project cycle i.e. from project inception up to completion and over all management aspects. In principle, limiting the areas and scopes of CP is undesirable. The beneficiary communities should be encouraged to activity participate and take the full flag management of WSS project ensuring sustainability and responsible community effort for further water sector development. With these concept, the ideal and major areas and scope of CP in WSS project are briefed as follows:

3.1.4.1 Users Participation in planning an preparation Phases of WSS Project:

- Areas and scopes of CP varies from country to country at this stage. In countries where users communities pursue. Participatory development approach, local people are involved in the initial discussions and decision making concerning their project.
- Although there is no model of CP suitable for all situation, community involvement scope and integration with other development sectors, setting facilities, decision on types and design of technology, selection of water sources are given a due consideration during this phase of project.

3.1.4.2 Implementation and Construction Stage of WSS

At this stage CP may be expressed in two areas i.e.:

a) Preparation for construction like:

- Site selection
- land preparation
- cleaning
- fencing project site
- collecting and stocking materials for construction

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- provision of houses for project technicians living
- construction of stores .....

b) - Provision of free labour, money in cash and kind
- Locally available materials
- Supervision through the local Water Sanitation committees

3.1.4.3 Operation & Maintenance as well as Organization and Management (O & M) Phases

Areas and scope of CP in O & M phase include the following responsibilities:

- selection and paying pump operators salary
- cover lubricant and fuel costs
- cover minor repair and maintenance costs
- contribute fund for maintenance costs
- establish village water committees and supervise the system
- ensure site are clean, fenced and protect from vandalism....

3.1.4.4 Monitoring and Evaluation (M & E) stages of WSS

M & E is carried out in order not to repeat mistakes and adjust the corrected and appropriate approach where possible. Consequently, it is recommended that M & E should be included in WSS project and be designed at the very beginning of the project till the last so that the necessary baseline data are collected involving as much local participation as possible. Therefore, M & E of WSS program, areas and scopes concentrate on the following main information and/or data ....

+ Users satisfaction or dis-satisfaction on project
+ How far improved water supplies have reached the most disadvantage groups i.e. poor, women and the remote communities ....
+ Cost effectiveness of CP in construction, management, O & M and other expenses
+ Impact of the improved WSS project on health, knowledge, adoption of improved facilities and communities attitude changes
+ Socio-economic impact of the project i.e. redistribution of income, reduction of burden benefits achieved and increased productivity

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+ Users complaints on project i.e.:

  - Number of breakdown
  - duration of breakdown
  - type of breakdown
  - amount of water lost through leakage,

+ Conditions of hygiene around water supply points,

+ Benefits of self-development experience, cooperativeness and community spirit.

+ Appropriateness and transfer of technology, e.g. VLOM types of pumps,

+ Project influence and adoption of self-reliance,

+ Reduction of water borne and water related disease and vector breading places

M & E activities and their application have to be accomplished according to the prevailing practical realities.

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4. Gender Approaches/ Issues in Water Sanitation Sector

4.1 General Remarks

Gender sensitivity is a consideration of existing culturally and traditionally influenced roles tasks and responsibilities of men and women in communities and consequently increased involvement of women in:

- Planning
- Designing
- O & M
- Management of Scheme

Will lead to reduce losses of investment because systems will be culturally accepted, supported and used.

Active involvement of women has proved:

- to have a positive impact of O & M functioning of Water Sanitation facilities and
- to lead to better hygiene

As consequence improved Water and Sanitation facilities contribute to:

- improved the health of women and their families
- reduce time spend by women and children on Water collection

This, in fact, might have the advantage for women:

- to save energy and
- to participate more in social community activities

The traditional role of women and their knowledge are the basis of their active involvement in Water and Sanitation Projects:

- involve women in project preparation, ask their views, use their traditional knowledge and skills
- provide they are informed, involved and empowered, as main interest group, they will give support to the projects and secure their sustainability.

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4.2 Gender Approach /Issues

Involvement of women in WATSAN project can not be undertaken in isolation, but water supply, sanitation and environmental and domestic hygiene improvement are community issues, which require the involvement of all women, men and children. This means:-

- Women should not be treated as positive passive beneficiaries of WATSAN
- WATSAN activities should not only focus exclusively on women

WATSAN projects should take into account that men and women have different:

- Needs
- Expectations
- Roles and responsibilities with in community
- Decision-making and problem solving power
- Access to resources ..... in order to arrive at a more equitable

Sharing of project benefits among men & women. This gender approach is required to prevent:

- Women from getting a dominant managerial role
- Women from getting a dependent role

Therefore, men should be made aware of the advantages of improved Water & Sanitation for the Whole Family in general and the important roles and tasks of women in particular, since women are the main traditional carriers of water for domestic needs and the principal molders of the family's hygienic habits. Therefore, women's involvement in decision making in Water & Sanitation sector is of critical importance.

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5. Community Sensitization & Mobilization

The over riding goal and objective of CP & Management in WSS is not simply to ensure sustainability of a system by teaching people how to function in a committee or how to f a pump and conduct O & M activities. Rather, it is to help people develop the outlook. competence, self confidence and commitment which will sustain a responsible communi effort in Water Sanitation sector and beyond. In doing so, community sensitization and mobilization should be concentrated on over all human development aspects.

A vital difference between participatory approach and didactic method is the emphasis th is placed on establishing horizontal relationships and maintaining a cordial atmosphere. The introduced activities must be such that:

* consider all equally,
* resourceful respectful to each other,
* develop mutual understanding and good team work
* create a climate of trust and mutual respect
* respect for experience, ideas and potential
* encourage to participate actively in generating fresh ideas

Activities that can be used as tension breakers or as means to strengthen group interactio that will enable to:

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* build peer relationships
* develop skill in team work and
* appreciate their abilities and other group members

Integrate participants from different backgrounds such as village people, trainers, technical experts to break down hierarchies among the members including everyone in discussion an assess different perspectives and capabilities, through participatory approaches.

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6.4 Gender and Health

Improved Health, productivity and achieving a better living environment are the major objectives of Water Sanitation projects. The reduction of Water Sanitation related diseases can only be achieved and better health conditions can be reached at through:

- the use of more water of better quality
- adequate personal hygiene and food hygiene
- adequate environmental and household hygiene
- use of safe methods of excreta disposal by all members of the community

These measures can also contribute to:

- reduce the direct and indirect cost of such Water Sanitation related disease and
- Wave the human suffering from suffering with these diseases

Changes in hygiene practice are required to achieve substantial health impacts. The role of women in this respect is crucial at:

- Household Level where women as mother and household managers, initiate and bring about changes in sanitation and hyginer practices like :
  - domestic hygiene
  - food handling
  - first - aid
- Community level, women can have influence on planning and implementing local hygiene education programms.....

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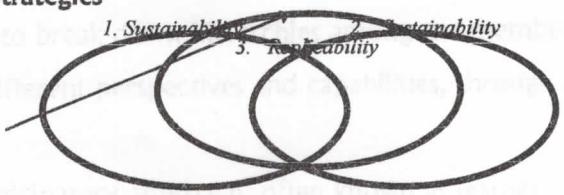
7. 5. Organizing Community for Sustainable Projects

7.1 *WATSAN Projects Objectives, Elements and Indicators at the Community Level*

The major goals and objectives of WATSAN projects are:-

- to achieve sustainability
- effectively used WATSAN system
- replicability of WATSAN projects
- achieve capacity building....

1. Sustainability
   - ♦ Functioning systems
   - ♦ Management and capacity building
     - Individual
     - Local
     - Institution
   - ♦ Financing and cost sharing
2. Effective Use
   - ♦ Optimal use
   - ♦ Hygienic use
   - ♦ Consistent use
3. Replicability
   - ♦ Community ability to expand service
   - ♦ Transferability of agency methods and
   - ♦ Strategies



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WATSAN Project Objectives	Elements and Indicators
1. Sustainability: ▪ Functioning Systems	▪ Quality of water at source ▪ Number of facilities in working order ▪ Breakdown and repairs
▪ Functioning Systems - Individuals	▪ Management abilities (decision making) ▪ Knowledge and skills ▪ Confidence, self /concept
- Local institutions	⊗ Autonomy ⊗ Supportive leadership ⊗ System for learning and problem solving
▪ Financing and Cost-sharing	→ Community Contribution → Agency contribution → Unit costs
2. Effective use ▪ Optimal use	– Number and characteristics of users – Quantity of water used, all purposes – Time taken to use facilities – Management of water resources
▪ Hygienic Use	⊗ Water quality at home ⊗ Water transportation and storage practices ⊗ Home practices to improve water quality ⊗ Site and home cleanliness ⊗ Personal hygiene practices
▪ Consistent Use	→ Pattern of daily use → Pattern of seasonal use
3. Replicability - Community ability to expand services	– Additional water /latrine facilities – Upgrading of existing facilities – New development activities under-taken
- Transfer-ability of agency methods	→ Proportion and role of specialized

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and strategies	personnel → Established institutional framework → Budget size and sheltering → Documented planning & implementation procedures

7.2 Establishment of Water & Sanitation Committee

A rural village WATSAN project shall have a committee which will be established by democratically election of the target beneficiary community. In organizing and forming a such committee government and/or NGOs field agents should play facilitating role. The number of this committee members should be 5-7 composing at least 2 or more women member as much as possible. It is also advisable to include health officers, sanitary workers and village teachers for the sake of professional contributions.

7.2.1 Collective and Individual members Duties and Responsibilities

There must be working guidelines /manuals which describe collective and individual members duties and responsibilities depicting the following main issues:

- Definition of Guidelines terminology
- Committee Formation, Quorum and Service Year
- Collective & Individual Members Responsibility
- Working Relationship with other
- Governmental, NGOs and other agencies
- Tariff setting their responsibilities
- Employees and
- Amendment and penalty....

GCRDA

8. 6. Enabling Environment for CP & Management

- The availability of conducive government policies and convenient strategies for development endeavors
- Governmentally approved and legally accepted working guidelines and management manuals that facilitate the target beneficiary communities and WATSAN projects implementing agencies
- Training methodological techniques like:
  - Participatory Rural Appraisal (PRA)
  - Demand Responsive Approach (DRA)
  - Participatory approach /Learner - centered
  - Promotion of the Role of Women in Water and Environmental Sanitation Service
    = PROWWESS
  - Participatory Hygiene and Sanitation Transformation (PHAST)
  - Traditional Teaching Vs.

    Participatory Training
    (Didactic/Authoritative method and Social Marketing Vs. Participatory Training i.e. more open and flexible SARAR type /style)

Learner centre = Participatory approach = more open and flexible = PROWWESS experience with SARAR fosters a process of human development which engage learners in creative problem solving, provide new room of self-expression, where learners discover talents and abilities which they never knew they had, increasing their self confidence enormously.

CCRDA

9. The Role of Partner Organizations

Partner organizations play a major role in the project. They serve as intermediaries between the project and communities, providing training and technical guidance during:

- design and construction of WATSAN Project
- implement the health and hygiene component.

The overall strategy assumes that partner organizations are:

* more experienced in community based approached than governmental organizations
* expect to have long-term partnerships with communities thus ensuring the sustainability of the facilities
* aware of important role of women in development and
* adopt an integrated and coordinated approach to development

Many partner organizations involved in the project have demonstrated high levels of professionalism and competency. However some of their projects have encountered considerable difficulties like:

- a shortage of skilled engineers and technical staff,
- losing staff to other private sector or government agencies or other NGOs

Partner organizations include :-

large national NGOs, as well as small NGOs, local and indigenous NGOs and also local government entities.

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9.1 Building Capacity of Partner Organizations

Due to the weak performance of may partner organizations, project staff should focus on capacity building to improve field level performance. In particular there must be:

- established a technical resources pool to provide ongoing support, monitor construction, and resolve day to day implementation problems

- adopted explicit selection criteria based on experience in WATSAN projects, number of technical staff, institutional presence and financial management capabilities.

- developed new monitoring procedures based on community satisfaction,

- increased training for the health, hygiene and community mobilization components

These steps will minimize delays in community mobilization, improve in quality of construction, and promote the health and hygiene education programs.

Innovative measures to create competition among partner organizations may include the following points

Interdicting financial incentives....

How can project introduce greater financial incentive for partner organizations to improve their performance

Reducing the number of partner organizations should WATSAN project limit the number of partner organizations to minimize training and administration costs?

Involving, private sector .... How can WATSAN project get the private sector involved more and more? Does private sector has large roles to play?

Increasing the role of community .....

Are there mechanism that would allow community organizations to gain access to funds directly from WATSAN Project to increase their roles to play ??

CCRDA

9.2 Partner Organization contracts

Initially partner organization contracts were in put based with no incentives for acceleration of WATSAN project implementation. But, today partner organization contracts are based on outputs and payments, based on achievement. Initial project experience suggests that partner organizations do not necessarily have sufficient capacity to do so. The project must analyze what are the most appropriate roles for partner organizations i.e. the government, the private sector and communities.

9.3 Community Based Organization (CBO)

- Community responsibility for O & M is crucial for WATSAN Project sustainability

- The community based organization collect money from each household for overall project expense including O & M and scheme employees salary payments.

- CBO depends on individual and personalities might face risk of collapsing, whereas,

- CBO that have become institutionalized, financially stable and have expanded their role beyoe WATSAN project to include:

- income generating
- credit service and other economic development activities will be the most successful.

- CBOs have also broadened the objectives to include other development activities such as:

- nutrition	- income generation
- agriculture	- vocational training and credit and facility services

9.4 The Role of Government Agencies

Would serve as a policy-making body with responsibility for general oversight and monitoring of the WATSAN project

In early phases, the national government bodies was heavily involved in the overall WATSAN project cycle activities conducting:

- Technical training
- developing the social strategy
- coordinating partner organization
- facilitating further decentralization
- improve performance at all level of development
- allow the national and regional level WATSAN project units to assume the more appropriate role of policy making and
- institutional strengthening of all partner organizations.

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CHAPTER FOUR

NEED IDENTIFICATION AND PRIORITY SETTING

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CRDA - TRAINING ON COMMUNITY BASED WATER SUPPLY AND SANITATION

COURSE TITLE - NEED IDENTIFICATION AND PRIORITY SETTING

1. GENERAL

Need identification and priority setting is very crucial for any community based development interventions to be undertaken. The interventions to be undertaken has to be based on the need of the community and has to be also the top most need in the priority list for the community. Such interventions, when implemented will be sustainable in terms of operation and maintenance and management and administration by the community.

The main reason for the failure of the interventions carried out in a top-down procedure are the implementation of the works are carried out without the identification of the need and priority of the community. The community has to be therefore consulted and be given a chance to identify their own needs and prioritize the needs according to their problems.

The community will obviously have a number of needs due to the social and economic conditions which are now prevailing in the country. In such situation prioritizing their needs might be difficult to the community and may be confusing due to the seriousness of all the needs. In such case the community has to be given advice on how to identify needs and set priorities in relation to the problems of the community, natural and financial resources available and the potential to realize the implementation of the identified need in terms of human resources and equipment capacity.

In identifying and prioritizing the needs different group of the community has to be approached and participate as there are a lot of needs which the community want to address. Different groups of the community may come out with different needs and priorities and this has to be resolved by trying to bring the ideas of the community together as much as possible. The development workers have great role to play in assessing the needs of the community and in assisting the community to identify and prioritize their needs

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2. TYPE OF NEEDS

2.1 Social and Cultural Needs

The social and cultural needs of a community could vary from one community to another. In most cases the social and cultural needs of a community could revolve around construction of churches, mosques, provision of services for instance related to their cattle such as vaccination, pesticides for the insects affecting their crops, etc. There are also, in most of the cases, communities expressing food aid or some type of assistance in kind such as closing or grain as a top priority.

2.2 Development needs

There are some outstanding communities and/or community members who advocate the community in order to have some constructions and services to be located in their proximity in order to improve their living standard. Such constructions and services could be schools, bridge on a difficult river, clinic, water supply scheme, road, veterinary clinic, etc. Such community may identify one of the above mentioned or similar activities as their needs.

2.3 Environmental Needs

In a community the need for improved environment or up keeping the existing situation could be given a priority. This may most of the time relate to the agricultural activities such as soil and water conservation, afforestation, etc. The community may not directly express this need as environmental need but describe it in other ways. The expressions described by the community has to be then carefully understood in order to give response to the community in a proper way.

2.4 Economic Needs

The economic needs which the community may raise when approached could be many among which loan for purchase of different agricultural inputs, cash loans to by food items during deficit seasons, for purchase of pack animals, cattle fattening for profit making, etc. are some of them. The community may also put the availability of credit facilities as one of the needs.

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3. NEED IDENTIFICATION PROCESS

3.1 Procedure In Need Identification

As explained in chapter 2 above there could be a number of needs which the community would like them to be improved and implemented for them. However, the community will not present such needs to the concerned government and non government organizations unless approached by the organizations themselves or unless the issues are hazardous to the community in general.

Community representatives may sometimes explain some of their needs which they want to be implemented for them to the nearest government body such as wereda administration council. The needs which will be presented to the wereda administration council in most of the cases are mostly related to the agricultural activities and in some cases health related particularly when there is some kind of epidemic out break such as cholera, malaria, etc.

There are also very few communities who will present their needs to other government offices and to non government organizations to assist them. Some communities already start to contribute some cash or material to satisfy their needs through the assistance of others on what they have contributed.

In order to identify the real problems of the community and assist them properly to improve the situation depending on their needs, the community has to be approached by the development workers. The development workers who are approaching the community has to be careful not impose development activities in their own field or sector which may not be the priority need of the community.

The development workers together with the community has to discuss the prevailing conditions of the community and encourage the community members to discuss their own problems. He has to give chance to the different group of the community such as women, elders, youth, farmer group, development committee and others as appropriate to speak about their common problems.

The needs of the community could be identified based on discussions with the community as explained earlier. The discussion could be carried out with different members of the community using different techniques of participatory approach method.

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The development worker has to prepare check list and questions to be raised during the participatory approach methods. The check lists and the different questionnaires have to take in to account the aim of the discussions and has to be prepared by taking in to account different indicators which helps to identify the needs of the community in a best way. The participatory approach methods to be used in the need identification process include:

- Semi-structured interview
- Group discussion
- Key informants discussion
- Secondary data from government, community records, etc.
- Participatory/ direct observation
- Transact walk
- Community mapping
- Structured questionnaire for household interview

In addition to the participatory approach methods the government line offices at wereda, zone and bureau levels have to be consulted and information be collected which will be used in the identification of needs.

The findings obtained through the discussions by the different methods and from the line bureau offices have to be organized and analyzed by the development workers prior to the setting of priority of the identified needs. The identified needs have to be verified by the different discussion groups or community representatives as appropriate.

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3.2 Role Of The Community

The community has a great role to play in the identification of their felt needs. In fact identification of needs has to be done by the community themselves but not by other people since they are the ones who exactly know their problems. The needs identified by the community themselves will properly answer their problems when implemented.

The community will also have sense of ownership and look after the functionality of the scheme implemented with his participation and identification. The community will also pay for the operation and maintenance of the schemes and carry out the administration and management of the schemes. The community based approach towards the development activities will be greatly encouraged for the sustainability of the schemes.

In order to satisfy the conditions mentioned above the community should be given the first chance to identify their own needs with the assistance and advice given to the members of the community by the development workers. In such a way the community will have a great role to play in the need identification process. Some of the roles which the community could play in the need identification process are:

- With the advises given to them will discuss on the problems of the community.
- List all the problems prevailing in their locality.
- Give information regarding the resources available in their locality.
- Describe difficult situations in their locality.
- Give information to the development workers about their capacity and participation in the implementation.
- Explain their willingness and affordability to run the scheme during operational service.
- Will identify the major potentials available in their locality that can be used to solve the identified problems.
- Discuss among the community members about the listed problems and agree only on the needs which are very serious.
- Will validate the identified needs that they are their real problems and are identified by themselves.

Some of the community needs are time related. For instance if the community is approached during the planting time the need of the community could be provision of fertilizer or if during dry time the top need could be water supply. Therefore, in order to have realistic information and to identify the real problem of the community, the development worker has to choose the appropriate time to approach the community.

Given the chance to identify their problems the community will feel much convenient to participate in the next stages of development activities. The participation of the community will rise as a result of given chances and recognition in the need identification decision making process.

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4. PRIORITY SETTING

4.1 General

Priority setting in general may not be an easy task for the community as well as the development workers. The community has a lot of problems which they want them to be solved and the different group of the community may also have different priority needs which could be conflicting with the needs of the other community group. This could happen from the poor economical status of the community and sometimes from the social and cultural differences within the community or difficulties in relation to the environmental conditions .

All of the prioritized needs or the top one may not be implemented always due to some reasons such as lack of resources, problems related with policy issues, in adequate capacity in terms of equipment and human resources, etc. The community should have such understanding in setting priorities of the felt needs.

Priority setting sometimes could be also distorted because of the sector bias of the development workers who are supposed to assist the community. The development workers during the discussions with the community may try to impose directly or indirectly on the community about the benefits and supports given by his sector. Some of the community members may realize the situation and divert the others to focus only on the sector in which the development worker is involved so that they can get the sector assistance to satisfy their needs although it may not be their top priority.

The community may not prioritize their needs logically except from the severity of the problem in their view. In such case the community has to be assisted in setting their priorities by taking in to consideration the available resources, capacity to implement in terms of man power and equipment as well as the capacity of the community to manage and administer if it has to be sustainable.

4.2 Prioritizing Among The Needs

Ones the problems are identified the development workers have to ask the community themselves to list their identified needs in priority orders with the serious problem on top which the community would think has to be implemented at first and so on. All the problems have to be prioritized according to their importance although all of them may not be implemented at once or by the same development program.

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The felt needs of the community could be many and may not be possible to implement all of them with a limited resources available from the financier and the community themselves. As a result of this the community has to prioritize their needs based on the resources available. This has to be properly explained to the community in advance and the community consensus has to be obtained on this issue prior to starting the prioritization of the identified problems.

The community may have a series of felt needs which they want them to be solved immediately. But the top priority felt need of the community may not be solved by a development program which is mainly focusing on water supply activities. In such situation one has to be very careful not to disappoint the community by saying that the need is not in his sector and will not be implemented after having spent so long process in discussing the need and setting priorities with the community.

On the other hand the community has to be informed to be realistic in identifying and prioritizing their needs. If the needs are identified and prioritized wrongly because of the reason that the development program is focusing on the water sector this will result in poor sustainability of the schemes after implementation and the community will not also fully participate during the physical implementation and in the management and administration during the operation of the scheme.

The development workers might be only from the water sector and if water is not listed as a top priority, he should not try to impose water to be as a top priority. On the other hand the development workers have to be also careful again not to give falls promises to the community saying that the top priority need identified in any sector by the community will be implemented or should not say that it will not be implemented unless the priority is in the water sector. In fact the best way to solve the problem is the integrated approach to the rural development and enhancing the awareness level of the community through education at different levels.

4.3 Priority Among The Community

Implementation of water supply schemes identified as top priority needs by different communities may have to be again prioritized by the implementing or financing organization due to limited implementation capacity, shortage of budget, etc. In this case the needs of the different community has to be prioritized. The following factors could be applied as criteria for prioritization of needs among the communities.

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Size of population

The community with higher number of population could be given the top priority in the development of water supply and sanitation program. This could be because of so many reasons among which some are:

- The number of people lacking water supply and sanitation service could be high.
- The chance of being exposed to different diseases could be high.
- The potential to pay for the operation and maintenance cost could be high so that the scheme will be sustainable.
- More people could benefit with a lesser per capita investment cost and this would allow to cover more communities with the limited resources.

Present water supply coverage

If the present improved water supply and sanitation coverage is not adequate or does not exist, then the community has to get priority. Some times the existing improved water supply system might not be adequate to cover the water demand of the community and needs expansion and improvement. In such case one has to be careful not to send back the community to the old traditional sources which may result in a hazardous condition than when they were using the traditional sources completely.

Distance to the existing water sources

In some areas there is shortage of water sources weather improved or traditional due to poor water resources potential, quality problems or insufficient capacity of the community in terms of technology to dig a traditional well. In such cases the community has to travel long distances to fetch water from where it is available and can be collected easily. The burden of fetching water mainly rests on the shoulder of the mothers and the young girls who are supposed to look after the other family affairs and go to school respectively.

A lot of time is spent by walking to fetch water which is of poor quality and not good for health. The use of the water, which is obtained in such hard way, in sufficient quantity for some purpose will be also limited there by affecting the hygienic condition of the family. Such community has to be given priority among the community.

The walking distance which may have to be seen critically could be relative to the distances which the other communities under consideration are also walking.

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Prevalence of water and sanitation related diseases

The prevalence of the water supply and sanitation related diseases are one of the factors which has to be used for the prioritization of the needs among the communities. This can be observed during the visit to the community and from the different discussions made during need identification process. Secondary data can also be obtained from the nearest health service and the wereda health office. Such community has to be given priority with a community who has lesser problem in comparison.

Water quality of the source in use

There are communities who are using water from a very polluted sources in terms of physical, chemical and bacteriological quality aspects. The community who are using such type of water are at serious risk in terms of health and has to be given priority. A community using water from unprotected spring may not be at equal risk with a community who are using water from a pond which is stored from flood water originating from the village areas where sanitation is poor.

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4.2 Gender Approach /Issues

Involvement of women in WATSAN project can not be undertaken in isolation, but water supply, sanitation and environmental and domestic hygiene improvement are community issues, which require the involvement of all women, men and children. This means:-

- Women should not be treated as positive passive beneficiaries of WATSAN
- WATSAN activities should not only focus exclusively on women

WATSAN projects should take into account that men and women have different:

- Needs
- Expectations
- Roles and responsibilities with in community
- Decision-making and problem solving power
- Access to resources ..... in order to arrive at a more equitable

Sharing of project benefits among men & women. This gender approach is required to prevent:

- Women from getting a dominant managerial role
- Women from getting a dependent role

Therefore, men should be made aware of the advantages of improved Water & Sanitation for the Whole Family in general and the important roles and tasks of women in particular, since women are the main traditional carriers of water for domestic needs and the principal molders of the family's hygienic habits. Therefore, women's involvement in decision making in Water & Sanitation sector is of critical importance.

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5. Community Sensitization & Mobilization

The over riding goal and objective of CP & Management in WSS is not simply to ensure sustainability of a system by teaching people how to function in a committee or how to fix a pump and conduct O & M activities. Rather, it is to help people develop the outlook, competence, self confidence and commitment which will sustain a responsible community effort in Water Sanitation sector and beyond. In doing so, community sensitization and mobilization should be concentrated on over all human development aspects.

A vital difference between participatory approach and didactic method is the emphasis that is placed on establishing horizontal relationships and maintaining a cordial atmosphere. The introduced activities must be such that:

* consider all equally,
* resourceful respectful to each other,
* develop mutual understanding and good team work
* create a climate of trust and mutual respect
* respect for experience, ideas and potential
* encourage to participate actively in generating fresh ideas

Activities that can be used as tension breakers or as means to strengthen group interaction that will enable to:

* express expectations
* build peer relationships
* develop skill in team work and
* appreciate their abilities and other group members

Integrate participants from different backgrounds such as village people, trainers, technical experts to break down hierarchies among the members including everyone in discussion and assess different perspectives and capabilities, through participatory approaches.

The participatory approach, often known as learner - centered, has been used as a means of helping learners take greater control of their lives and their environment by developing their skills in problem-solving and resource management. Unlike traditional teaching method which is didactic style, some times also referred to as the "top-down" or "banking" approach, since its primary purpose is the transfer of knowledge, message or contents pre-selected by outside specialists, participatory techniques such as SARAR focuses more on the development of human capacities to:

ECRDA

6. Gender Approaches/ Issues in Water Sanitation Sector

6.1 General Remarks

Gender sensitivity is a consideration of existing culturally and traditionally influenced roles tasks and responsibilities of men and women in communities and consequently increased involvement of women in:

- Planning
- Designing
- O & M
- Management of Scheme

Will lead to reduce losses of investment because systems will be culturally accepted, supported and used.

Active involvement of women has proved:

- to have a positive impact of O & M functioning of Water Sanitation facilities and
- to lead to better hygiene

As consequence improved Water Sanitation facilities contribute to:

- improved the health of women and their families
- reduce time spend by women and children on Water collection

This, in fact, might have the advantage for women:

- to save energy and
- to participate more in social community activities

The traditional role of women and their knowledge are the basis of their active involvement in Water Sanitation Projects:

- involve women in project preparation, ask their views, use their traditional knowledge and skills
- provide they are informed, involved and empowered, as main interest group, they will give support to the projects and secure their sustainability.

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6.3 Gender and Change

Gender is not static. Works and positions of men and women are subject to change and Water Sanitary Projects might cause changes for men and women as well as in government, NGOs and other agencies working affairs of men and women. Women have proved that they are effective and efficient performing WSS project from the experience of Data and Mio-Gassera, equally with men. Therefore, projects should involve men and women in design, implementation and management of WATSAN-facilities that meet their needs and technical, financial and management capabilities.

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CHAPTER FIVE

SANITATION

HYGIENE EDUCATION

SOLID WASTE MANAGEMENT

HEALTH AND ENVIRONMENT

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CRDA - TRAINING ON COMMUNITY BASED WATER SUPPLY AND SANITATION

TITLE - **ENVIRONMENTAL HEALTH**
- **SANITATION**
- **HYGIENE EDUCATION**

1. INTRODUCTION

Good health is the state of complete physical, mental and social wellbeing, not merely the absence of disease or infirmity. However when tryint to improve the health a nation, the control and eventual eradication of disease and infirmity should be the priority. When diseases and infirmity are under control and the people in "reasonable health", the goal of attaining good health and eventually economic development will be pursued.

The aim of environmental health program is, therefore, the control of diseases and promotion of health by eliminating all factors that form a link in the disease transmission. Most of the communicable diseases in Ethiopia are water and sanitation related the control of which depends on the provision of safe and adequate water plus proper disposal of human excreta.

This handout can be used as a practical guide to technical sources of environmental health, especially, in sanitation, solid waste management and hygiene education.

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2. ENVIRONMENTAL HEALTH

"Environmental Health" encompasses what is also known as Environmental Engineering, Public Health Engineering and Sanitary Engineering. It is concerned with "the control of all those factors in human's physical environment, which exercise or can exercise a deleterious effect on the physical development, health and survival, with consideration of the physical and social impact of the control measures applied.

Included is the application of engineering principle to the control, modification, or adaptation of the physical, chemical, and biological factors of the environment in the interest of human health, comfort and wellbeing.

In addition, environmental health involves the maintenance of an environment that is suited to human being's performance, and the preservation of comfort and enjoyment of living today and in the future.

"Environment" is deified as the sum of all-external influence and condition affecting life and the development of an organism. It is generally considered as the surroundings, in which human beings live, work and play. It encompasses the air human beings breath, the water to be drunk, the food to be consumed, the shelter to be provided for the protection against adverse condition that affect life and health. It also includes the abolition of pollutants waste materials and other detrimental environmental factors, which adversely affect health.

2.2 Scope

It is apparent from the above definition that the filled of environmental health covers an extremely broad area of man's universe. The World Health Organization (WHO) and others have suggested what the scope should be and how the programs should administered. In all instances, a totality is envisioned with consideration of the impact of man on the environment and the impact of environment on man, with a balanced appraisal and allocation of available resources to both.

It has been suggested by WHO expert committee and others that the scope of environmental health should include or relate to the following:

Water supplies: with special reference to the provision of adequate quantities of safe water that are readily available and accessible to the user and to the planning, design, management and sanitary surveillance of community water supplies, giving due consideration to other essential uses of water resource.

Wastewater treatment and water -pollution control: including the collection, treatment and disposal of domestic wastewater and the control of the quality of surface and ground water.

Solid Waste Management: including sanitary handling and disposal.

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Vector Control: including the control of arthropods, mollusks, rodents and other alternative hosts of diseases

Prevention or control of soil pollution: by human excreta and by substances detrimental to human, animal or plant life

Food hygiene: basic sanitation requirement for food processing and food service establishment.

Control of air pollution: air resource management and air pollution control including sources, air quality, emission standards, airborne and air related diseases.

Occupational health: in particular, the control of physical, and chemical and biological **hazards.**

Radiation control: radioisotope and radiation environmental control including fallout, air, and food and land contamination.

Noise control: noise and vibration abatement

Housing and its immediate environment: in particular, the sanitary aspect of residential, public and institutional buildings.

Urban and regional planning: including planning for drainage, floods control and land use management.

Environmental health aspect of air waters and land transport

Accident prevention: natural and man made hazards including safety, slides, earthquakes, forest fires, reservoir, hurricanes and tornadoes.

Public recreation and tourism: in particular, the environmental health aspects of public recreation centers such as swimming pools and camping sites.

Sanitation measures associated with epidemics, emergencies, disasters and migration of people

Prevention measures required ensuring that the general environment is free from risk to health.

2.3 Environmental Health and Engineering Planning

It is important that environmental health and engineering planning take place within the context of comprehensive regional or area wide planning. It is equally important that comprehensive community planning fully recognize the environmental health and engineering functions and needs.

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The term planning refers to the systematic process by which goals (policies) are established, facts are gathered and analyzed, alternative proposals and program are considered and compared, resources are measured, priorities are established and recommendation are made for the development of resources designed to achieve the established goal.

There are many types and levels of planning ranging from community wide planning to national planning. It is not the aim of this course to provide methods of planning rather it s to highlight the importance of planning particularly the aspects of priority establishment, follow up of its implementation.

Three different types of planning are mentioned below:

1. **General, overall planning: includes** identification goals, aspirations and realistic objectives. Establishment of functional priorities.

2. **Functional planning:** such as water supply, sanitation, and solid waste, recreation or medical care facilities in which alternative functional solutions are presented including consideration of the economic, social and ecological factors, advantages and disadvantages.

3. **Project planning:** Detailed engineering and architectural specific project plan, specification, and drawing. Construction and maintenance; plan adjustment as construction is in progress.

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3. Excreta Disposal and Waste water Treatment

3.1 Necessity for Proper Excreta Disposal

A convenient supply of safe water and sanitary disposal of human waste are essential ingredients of a Leolthy, productive life. Water that is not safe for human consumption can spread diseases; water that is not conveniently located results in the loss of productive time and energy by the water carrier, usually women and children; and inadequate facilities for excreta disposal reduce the potential benefits of a safe water supply by transmitting pathogens from infected to healthy person. Over fifty infections can be transferred from a diseased person to a healthy on by various direct or indirect routes involving human excreta.

Invariably it is the people who live in rural villages and shanty towns who supper the most from the absence of safe water and sanitation, because they lack not only the means to provide for such facilities but also information on how to minimize the ill effects of the insanitary conditions in which they live.

As a result, the debilitating effects of insanitary living conditions lower the productive potential of proper. the necessity of for proper excreta disposal is limited to reducing diseases and improving health.

3.2 Health Aspects of Sanitation

Improved health is normally considered one of the principal benefits of improved sanitation. Excreta contains a wide variety of human pathogens and the removal of there pathogens from the immediate environment, which is achieved by proper excreta disposal. Can have a dramatic impact on community health.

These pathogens include viruses, bacteria, protozoa and helminths.

For the health benefits of sanitation to be realized, prior or concurrent improvements in water supply and solid waste collection and a vigarom an sustained compaign of community education in hygiene are normally required.

Excreted infections:

Excreta are related to human diseases in two ways. First, the agents of many important infections escape from the body in the excreta and eventually reach other people.

These are called the excreted infections. The second way in which excreta relate to human disease is where their disposal encourages the breeding of insects. These insects may be a herisance in themselves (flies, cockroaches, mosquitoes); they may transmit excreted pathogens mechanically, either on their bodies or in their intestinal tracts; or they may be vectors of pathogens that circulate in the blood mosquito).

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3.3 *Infections Diseases Related to Water Supply and Excreta Disposal.*

The most important simple advance in understanding the relationship between water supply, excreta disposal and disease is the reclassification of all water and excreta related diseases into categories which relate diseases directly to water. For convenience the more important water and excrete - related diseases are categorized in terms of appropriate interventions as described below.

1. *Water- borne disease*: Is one which is transmitted when the pathogen is in water which is then drunk by human which may then be infected. The majority of these pathogens reach the water through contamination with human excreta and ultimately enter the body through the mouth, hence, the term "fecal - oral transmission". The most important of these diseases include: amebic dysentery, shipellosis, cholera, diarrhea, hepatitis A Virus and typhoid fever.

2. *Water hygiene diseases*: These are diseases whose incidence, prevalence or severity can be reduced by using water to improve personal and domestic hygiene. Most of the diseases may also be transmitted by food, hand-to-mouth contact, and numerous other means. They also many of the focal - oral transmission diseases listed under water - borne.

   Other hygienic diseases include those of the skin, (example: tinea) and eyes, (e.g., trachoma). Some hygienic skin diseases are associated with ectoparasitism, i.e., insect infestation. For example, scabies is caused by sarcoptic mites, pediculosis by lice. Lice also can transmit typhus fever and Relapsing fever.

   For water hygiene diseases, sufficient water must be available fro hand washing and cleaning of cooking and eating utensils.

3. *Water contact diseases*: These are diseases transmitted by skin contact with pathogen infested with water. The most important of these diseases is schistosomiasis (bilharzia).

   Schistosome eggs in human excreta hatch on reaching water. The resulting larvae must invade suitable snail hosts or perish. Following a multiplication process with in the snail, the free - swimming schistosome larvae (cercariae) escape from the snail and find and invade man by penetrating his immersed or wetted skin. This important tropical disease infect over 200 million people.

4. *Water vector habitat diseases*: these are diseases which depend during part of their life cycle on animal vectors which live all or part of their lives in or adjacent to water habitat. Examples are: malaria (associated with mosquito), onchocerciasis (associated with aquatic) flies. Breeding of mosquito may be promoted by sullage, waste water, and uncovered water storage containers.

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5. *Excreta disposal diseases*: these are diseases whose transmission may be effectively interrupted by sanitary disposal of human feces and urine. They include most of the focal - oral diseases previously described under water borne diseases; helminthic infections of the intestinal tract example: ascariasis, hookworms, strongyloids, trichuris and several others.

3.4 Sanitation Technologies

A variety of sanitation technologies exist. They are classified into on-site and off-site technologies. The principal ones are:

On-site technologies:

- Pit latrines
- Ventilated improved pit (VIP)
- Reed odorless earth closet (ROEC)
- Double-vault composting (DVC) toilets
- Aqua privies
- Septic tanks
- Pour flush toilets

Off-site technologies:

- Vault toilet and cartage
- Sewered pour flush toilets
- Sewerage

Sanitation technology selection should be based on a combination of economic, technical and social criteria. The cheapest, technically feasible technology that the user can afford and maintain should be selected.

It is important that collection and evaluation of the following information items is needed for selection and design of suitable sanitation facility.

Climatic Condition

- Temperature ranges, precipitation, including drought or flood periods

Site Condition

- Topography
- Geology, including soil stability
- Hydrogeology, including seasonal water falls fluctuation
- Vulnerability to flooding

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Population

- Number, present and projected
- Density, including growth pattern
- Housing type
- Health status of all age groups
- Income levels
- Locally available skills
- Locally available materials and components
- Municipal services available, if any.

Environmental Sanitation

- Existing water supply service levels including accessibility, reliability and cost
- Existing excreta disposal, sullage removal and storm drainage facilities
- Other environmental problems such as garbage or animal wastes

Socio-cultural factors

- Peoples perception of present situation and interest in or susceptibility to change
- Levels of hygiene education
- Religions or cultural factors affecting hygiene practices and technology choice
- Location or use of facilities by both sexes and all age groups
- Attitude towards resource reclamation
- Attitudes towards communal or shared facilities

Institutional frame work

- Existence of local or municipal institution in providing the following services.
  - * Water
  - * Sanitation, sewerage, drainage, street cleaning
  - * Health
  - * Education
  - * Housing and urban up grading ... etc.

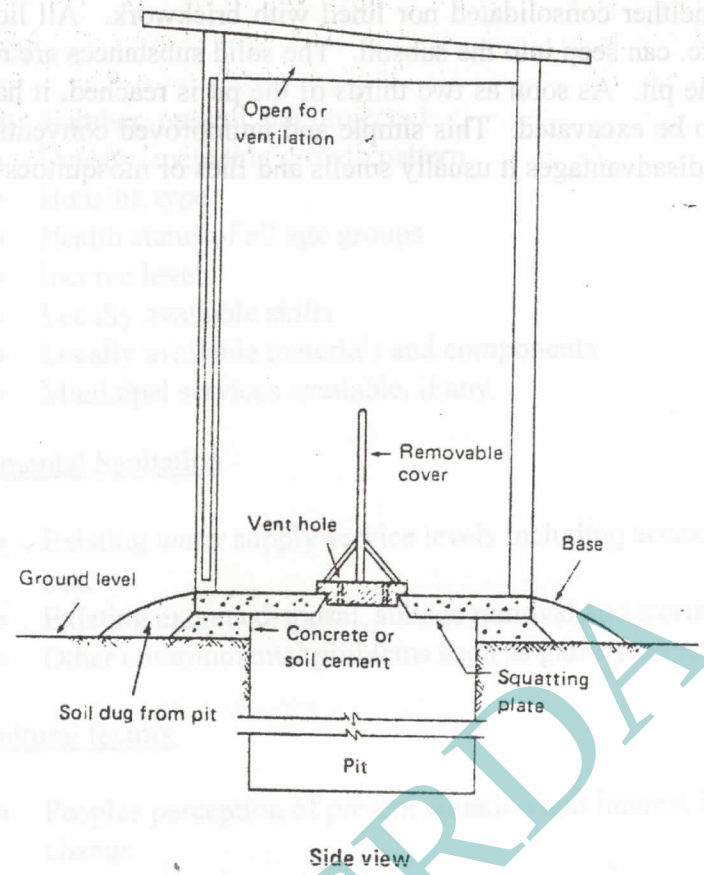
3.4.1 Pit latrines

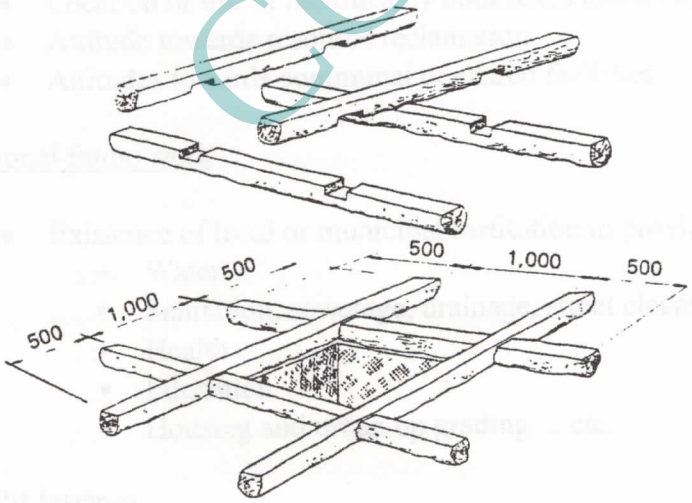
Pit latrines are the simplest and most widely distributed disposal systems for excreta. They can be utilized not only in rural/rustic areas, but also in municipal districts.

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Figure 1 shows a simple pit latrine. The excreta falls directly into an excavated pit which in many cases is neither consolidated nor lined with brickwork. All liquids like urine, cleansing water, etc. can seep into the subsoil. The solid substances are retained and will gradually fill up the pit. As soon as two thirds of the pit is reached, it has to be emptied or a new pit has to be excavated. This simple and unimproved conventional pit latrines has the two major disadvantages it usually smells and flies or mosquitoes readily breed in it.

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Alternative base using hewn logs

Fig. 1 Pit latrine

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Technological Description

The pit and the base slab are covered by a superstructure. In general, the same building materials are used as for the construction of the local houses.

The construction should satisfy at least the following:

SIZE

The latrine superstructure should have an area of at least 90 x 100 cm. This also determines the minimum area of the base slab. The height of the roof at the level of the entrance should be not less than 2m.

VENTILATION

The roof structure should not rest directly on top of the walls. It is necessary to provide a gap of 10 to 15cm in order to assure an efficient ventilation.

ILLUMINATION

Sunlight should be able to illuminate the interior.

The base slab:

The base slab covers the pit and should have at least twice the diameter of the pit. The slab is made of building material available locally and should have a smooth and easy-to-clean surface. The supporting surface on the right and left side of the soil opening should be elevated.

Construction materials include: brick or concrete blocks, corrugated iron or asbestos cement roof, ferrocement, sheet metal, timber mud and wattle, bamboo or palm thatch.

The pit normally has a depth of up to 3m and a diameter of about 2m. An increase of depth more than 3m increases the danger of collapse and ground water pollution. bound pits are better than rectangular ones.

For the calculation of the size of the pit we can take the following standard formula:

The volume required for excreta per year and per capita is $0.06m^3$ in the case of dry pit and $0.04m^3$ for wet ones. This means that a dry pit with a diameter of 1m and a depth of 3m could be used by five person family for a period of six years.

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3.4.2 Ventilated And off-set pit latrines

In principle, the method of construction and operation is the same as the conventional pit latrines. Ventilated improved pit (VIP) latrines are more hygienic, low cost and have minimal fly and mosquito nuisance.

Figure 2 shows VIP latrine. The pit is slightly offset to make room for an external vent pipe. The vent pipe should be at least 75mm in diameter (ranging up to 200mm); it should be painted black and located on the sunny side of the latrine superstructure.

The air inside the vent pipe will thus heat up and create an updraft with a corresponding downdraft through the squatting plate. Thus any odorous emanating from the pit contents are expelled via the vent pipe, leaving the superstructure odor free. The pit may be provided with removable cover section to allow dislodging.

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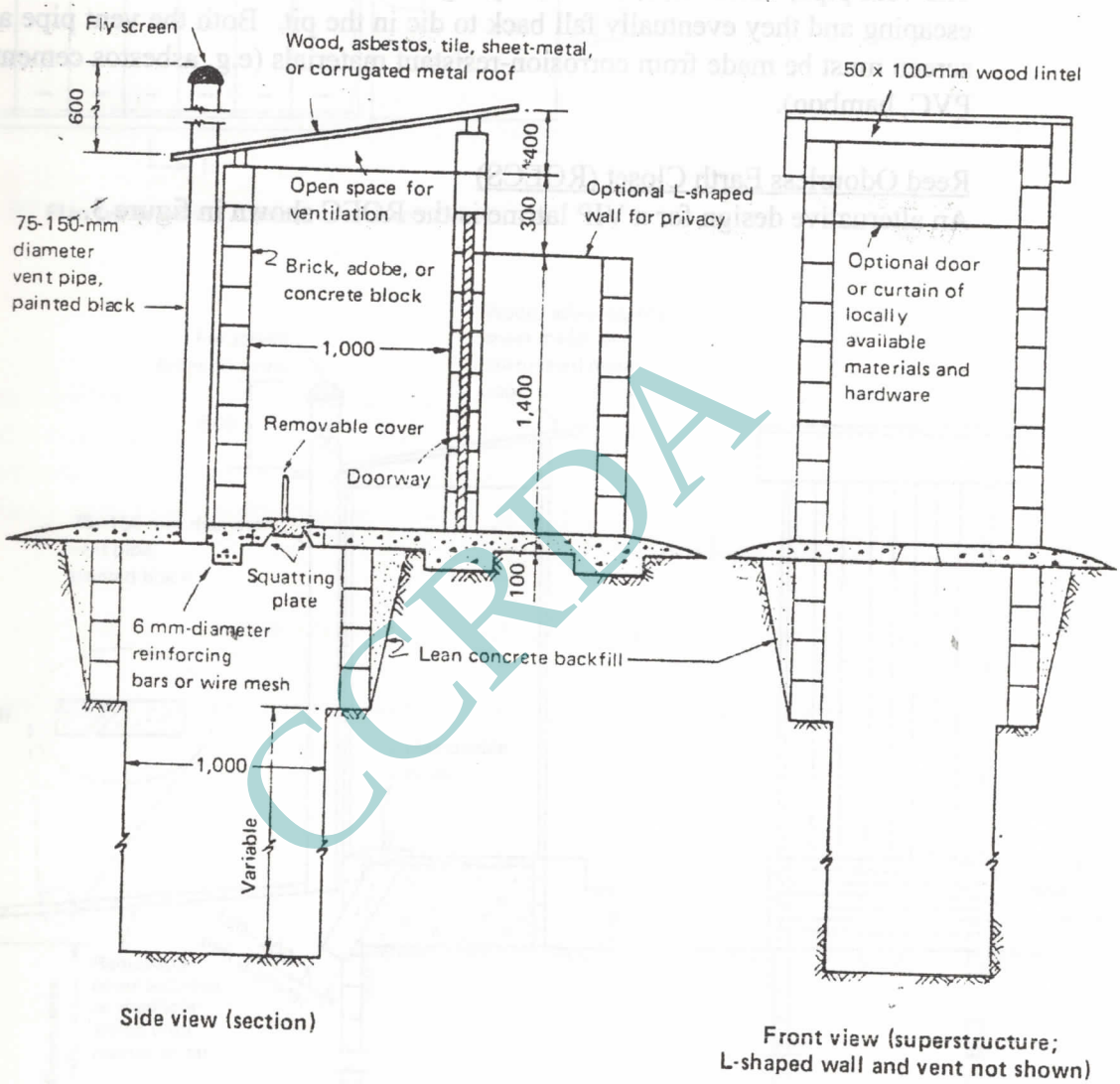


Fig. 2 VIP latrine

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Recent work has indicated that pit ventilation may also have an important role in reducing fly and mosquito breeding. The draft discourages adult flies and mosquitoes from entering and laying eggs. Nevertheless, some eggs will be laid and eventually adults will emerge. If the vent pipe is large enough to let light into the pit, and if the superstructure is sufficiently dark, the adults will try to escape up the vent pipe.

The vent pipe, however, is covered by a gauze screen so that the flies are prevented from escaping and they eventually fall back to dic in the pit. Both the vent pipe and the gauze screen must be made from corrosion-resistant materials (e.g. asbestos cement, fiver glass, PVC, bamboo).

Reed Odourless Earth Closet (ROECS)

An alternative design for a VIP latrine is the ROEC shown in figure 3.

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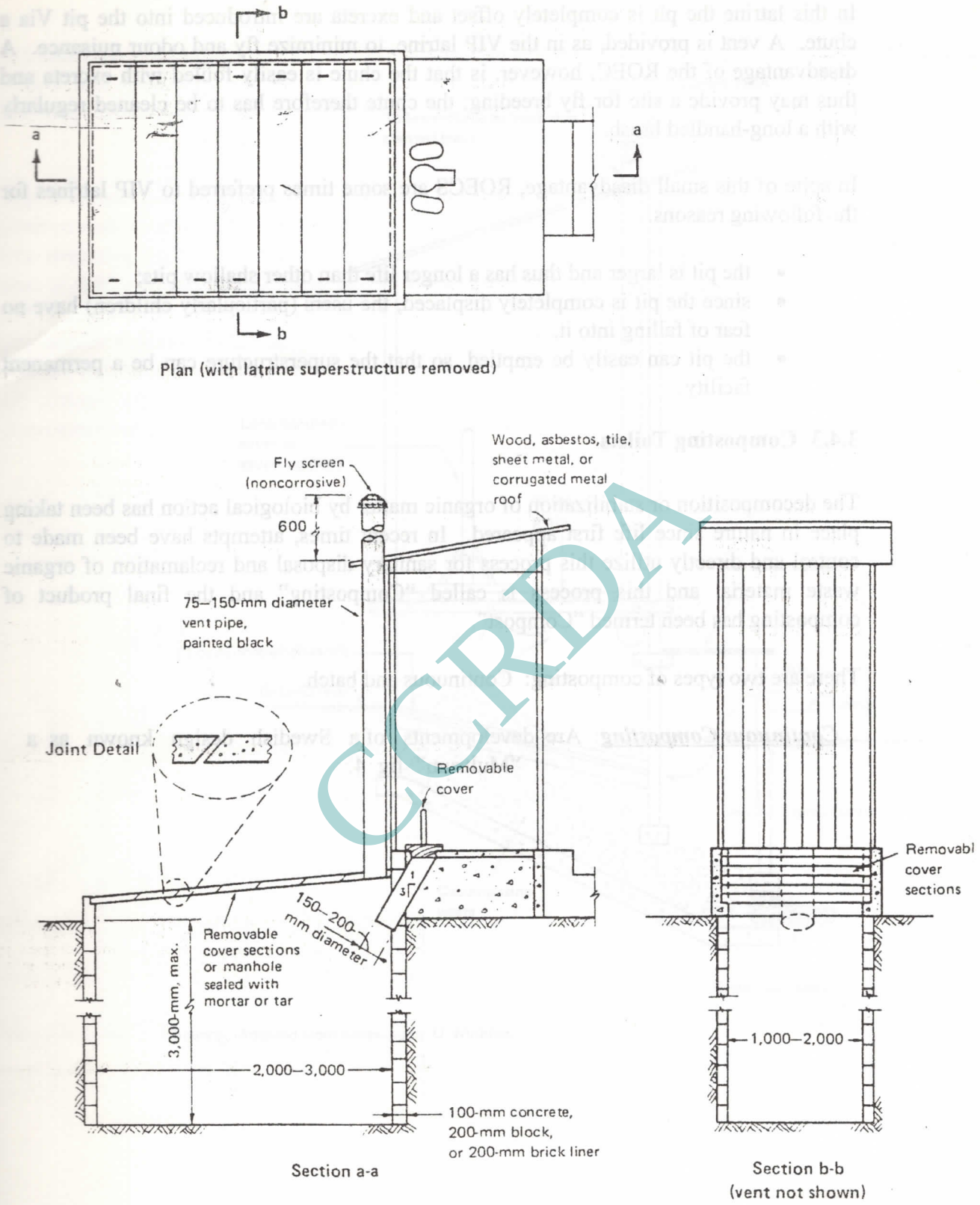


Figure 3 ROEC latrine

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In this latrine the pit is completely offset and excreta are introduced into the pit Via a chute. A vent is provided, as in the VIP latrine, to minimize fly and odour nuisance. A disadvantage of the ROEC, however, is that the chute is easily fouled with excreta and thus may provide a site for fly breeding; the chute therefore has to be cleaned regularly with a long-handled brush.

In spite of this small disadvantage, ROECS are some times preferred to VIP latrines for the following reasons.

- the pit is larger and thus has a longer life than other shallow pits;
- since the pit is completely displaced, the users (particularly children) have no fear of falling into it.
- the pit can easily be emptied, so that the superstructure can be a permanent facility.

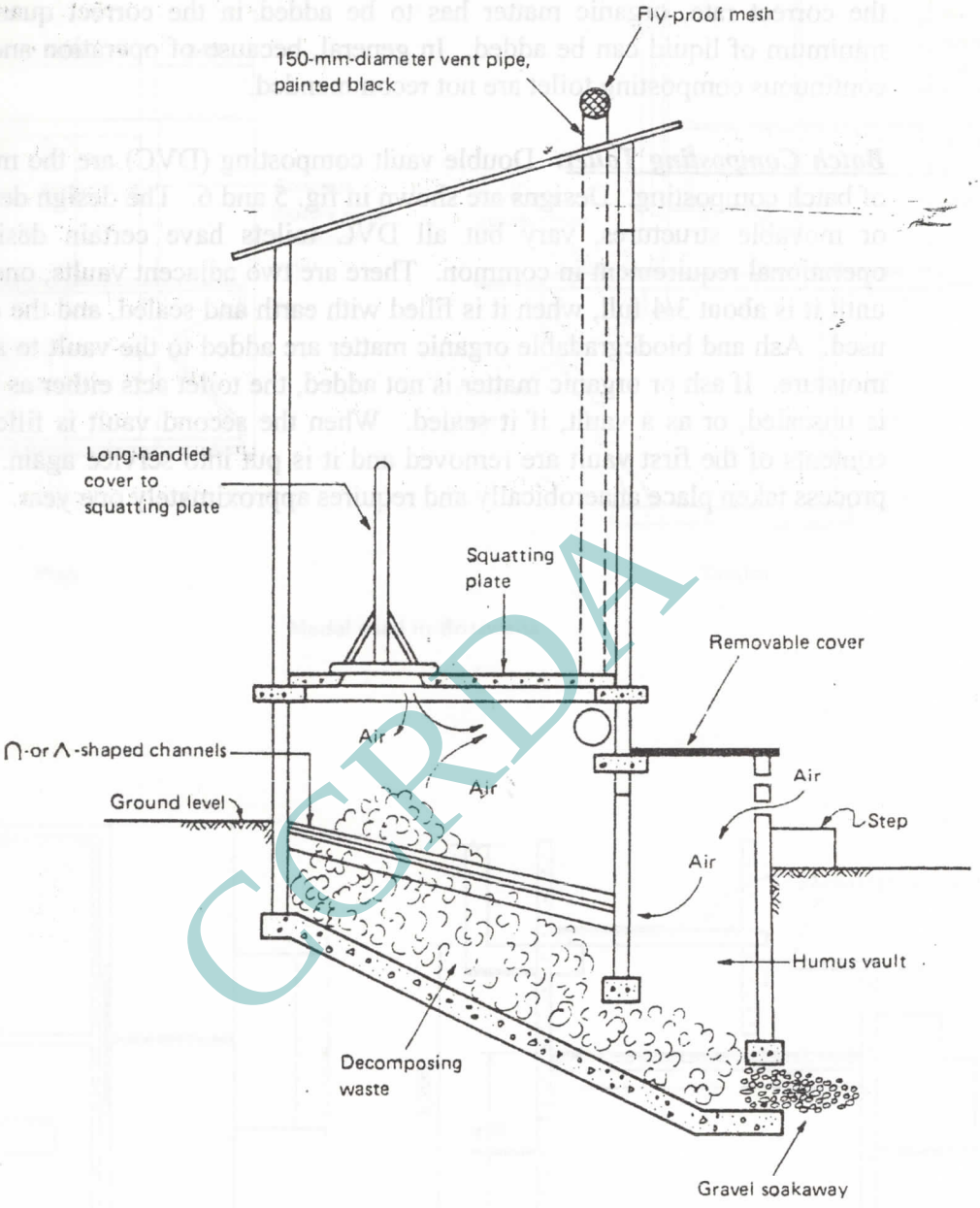
3.4.3 Composting Toilets

The decomposition or stabilization of organic matter by biological action has been taking place in nature since life first appeared. In recent times, attempts have been made to control and directly utilize this process for sanitary disposal and reclamation of organic waste material and this process is called "Composting" and the final product of composting has been termed "Compost".

There are two types of composting: Continuous and batch.

Continuous Composting: Are developments of a Swedish design known as a "Multrum" fig 4.

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Source: Adapted from a drawing by U. Winblad.

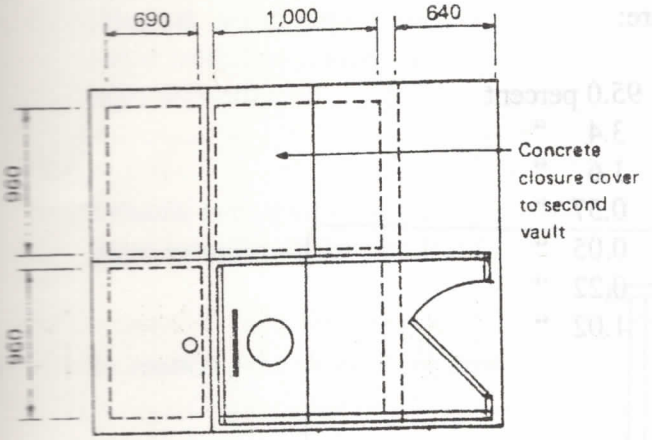
Figure 4 "Multrum" continuous composting toilet

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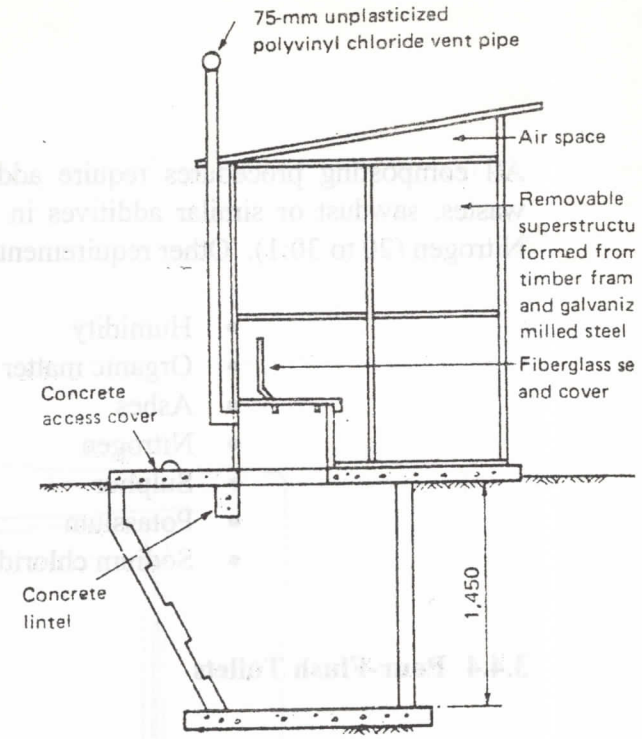
They are extremely sensitive to the degree of users care; the humus has to be removed at the correct rate, organic matter has to be added in the correct quantities and only a minimum of liquid can be added. In general, because of operation and control problem continuous composting toilet are not recommended.

***Batch Composting Toilet*:** Double vault composting (DVC) are the most common type of batch composting. Designs are shown in fig. 5 and 6. The design details such as fixed or movable structures, vary but all DVC toilets have certain design principle and operational requirement in common. There are two adjacent vaults, one of which is used until it is about 3/4 full, when it is filled with earth and sealed, and the other vault is then used. Ash and biodegradable organic matter are added to the vault to absorb odours and moisture. If ash or organic matter is not added, the toilet acts either as a VIP latrine, if it is unsealed, or as a vault, if it sealed. When the second vault is filled and sealed, the contents of the first vault are removed and it is put into service again. The composting process taken place anaerobically and requires approximately one year.

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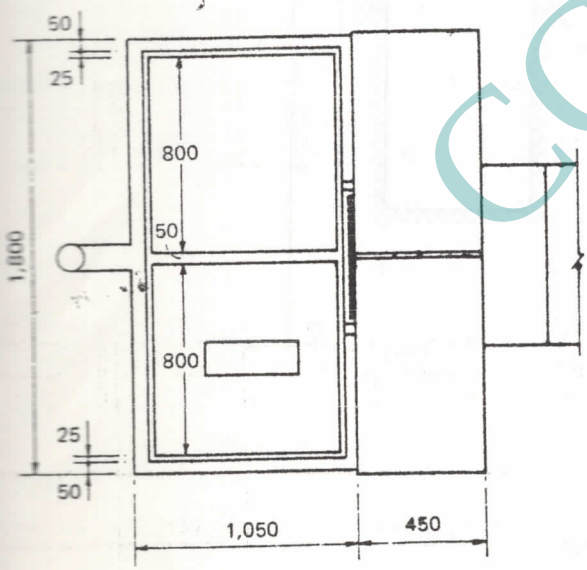


Plan

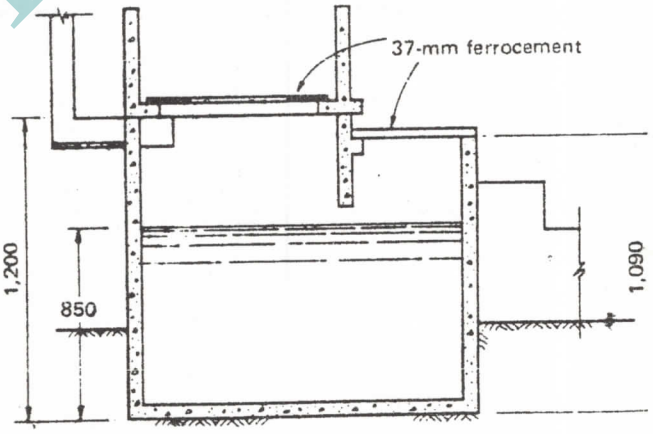


Section

Model used in Botswana



Plan



Section

Fig. 5 and Fig. 6

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All composting procedures require additional organic matter, for example, domestic wastes, sawdust or similar additives in order to obtain a favorable ratio of Carbon to Nitrogen (20 to 30:1). Other requirements are:

- Humidity 95.0 percent
- Organic matter 3.4 "
- Ashes 1.6 "
- Nitrogen 0.57 "
- Sulphur 0.05 "
- Potassium 0.22 "
- Sodium chloride 1.02 "

3.4.4 Pour-Flush Toilets

Pour-flush toilets have water seals beneath the squatting plate or pedestal seat and are available in many different designs. Approximately 1 to 2 litters of water (or sullage) are poured in by hand to flush the excreta into the pit. The basic type of pour-flush is shown in Fig. 7.

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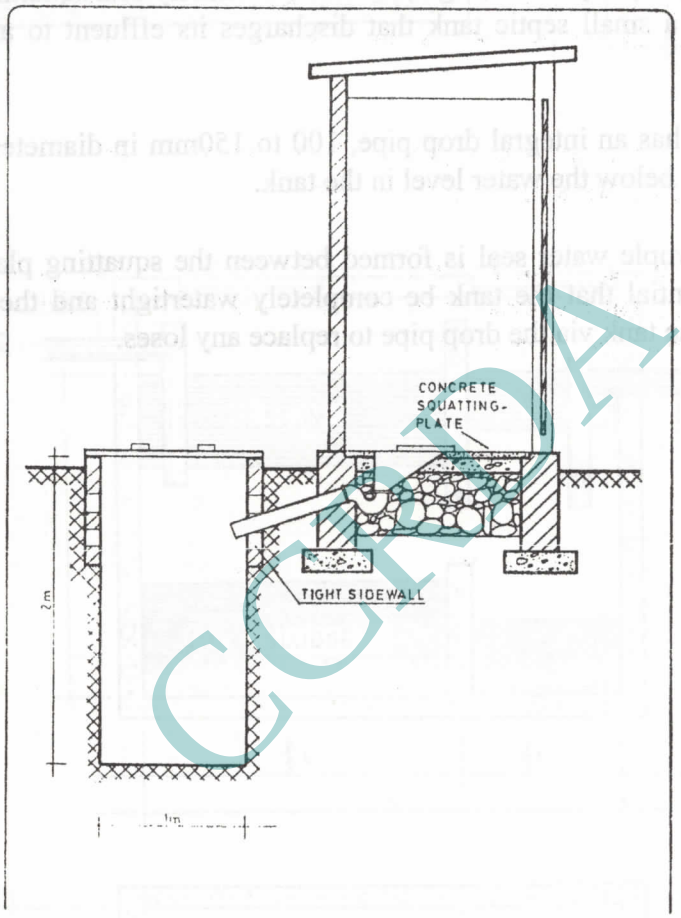


Fig. 7 Pour-flush toilet

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3.4.5 Aqua Privies

There are three types of aqua privies: the simple or conventional aqua privy, the self-topping or sullage aqua privy, and the sewered aqua privy. The second and third types are simple modifications of the first type designed to accept sullage, which the first type cannot.

The conventional aqua privy toilet (Fig.8) consists essentially of a squatting plate situated immediately above a small septic tank that discharges its effluent to an adjacent soak away.

The squatting plate has an integral drop pipe, 100 to 150mm in diameter, the bottom of which is 10 to 15cm below the water level in the tank.

In this manner, a simple water seal is formed between the squatting plate and the tank contents. It is essential that the tank be completely watertight and the toilet user add sufficient water to the tank via the drop pipe to replace any loses.

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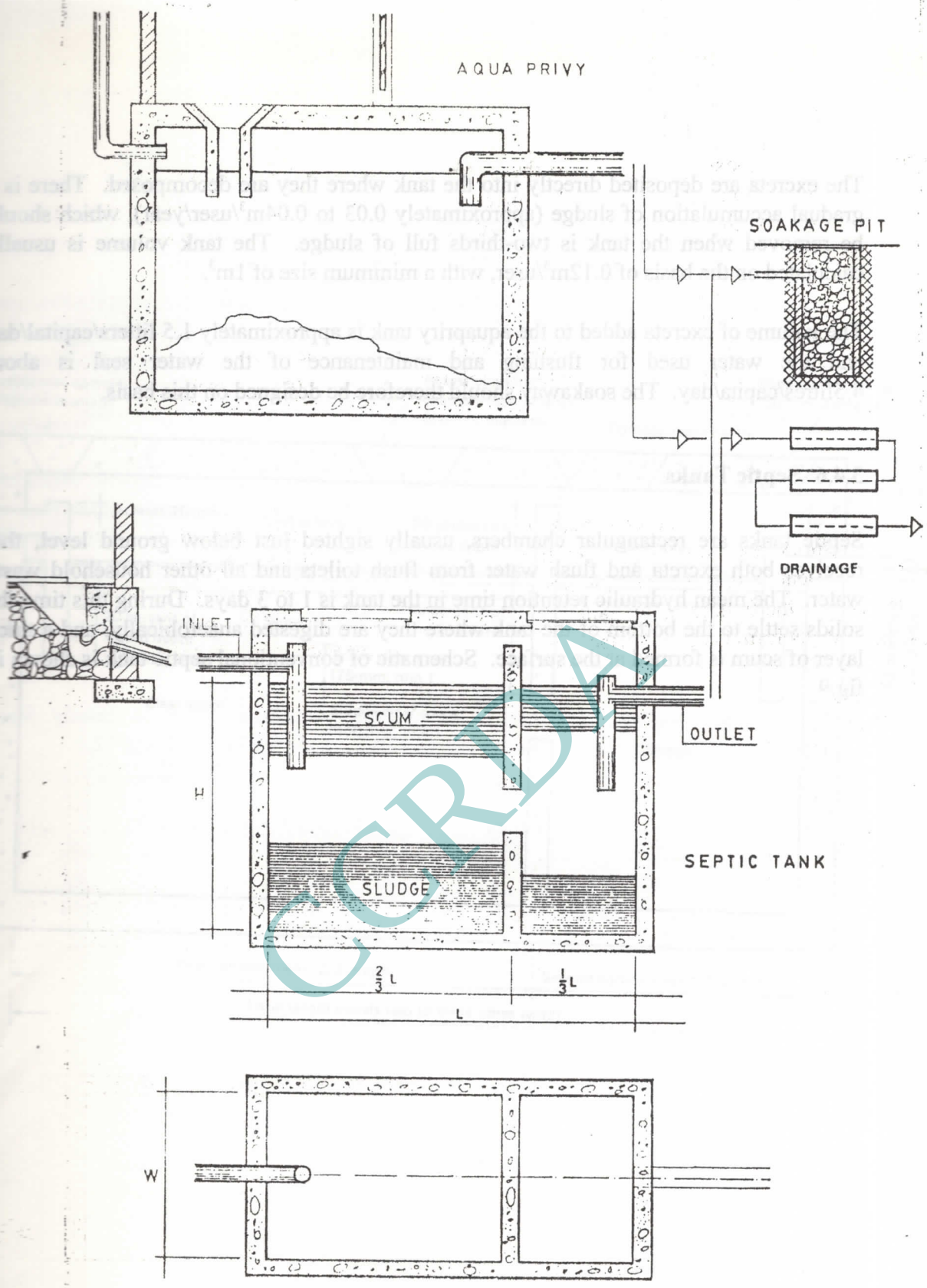


Fig. 8 Aqua privy

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The excreta are deposited directly into the tank where they are decomposed. There is a gradual accumulation of sludge (approximately 0.03 to 0.04m^3/user/year), which should be removed when the tank is two-thirds full of sludge. The tank volume is usually calculated on the basis of 0.12m^3/user, with a minimum size of 1m^3.

The volume of excreta added to the aquapriry tank is approximately 1.5 litters/capital/day and the water used for flushing and maintenance of the water seal is about 4.5litres/capita/day. The soakaway should therefore be designed on this basis.

3.4.6 Septic Tanks

Septic tanks are rectangular chambers, usually sighted just below ground level, that receives both excreta and flush water from flush toilets and all other household waste water. The mean hydraulic retention time in the tank is 1 to 3 days. During this time the solids settle to the bottom of the tank where they are digested anaerobically, and a thick layer of scum is formed at the surface. Schematic of conventional septic tank is shown in fig.9

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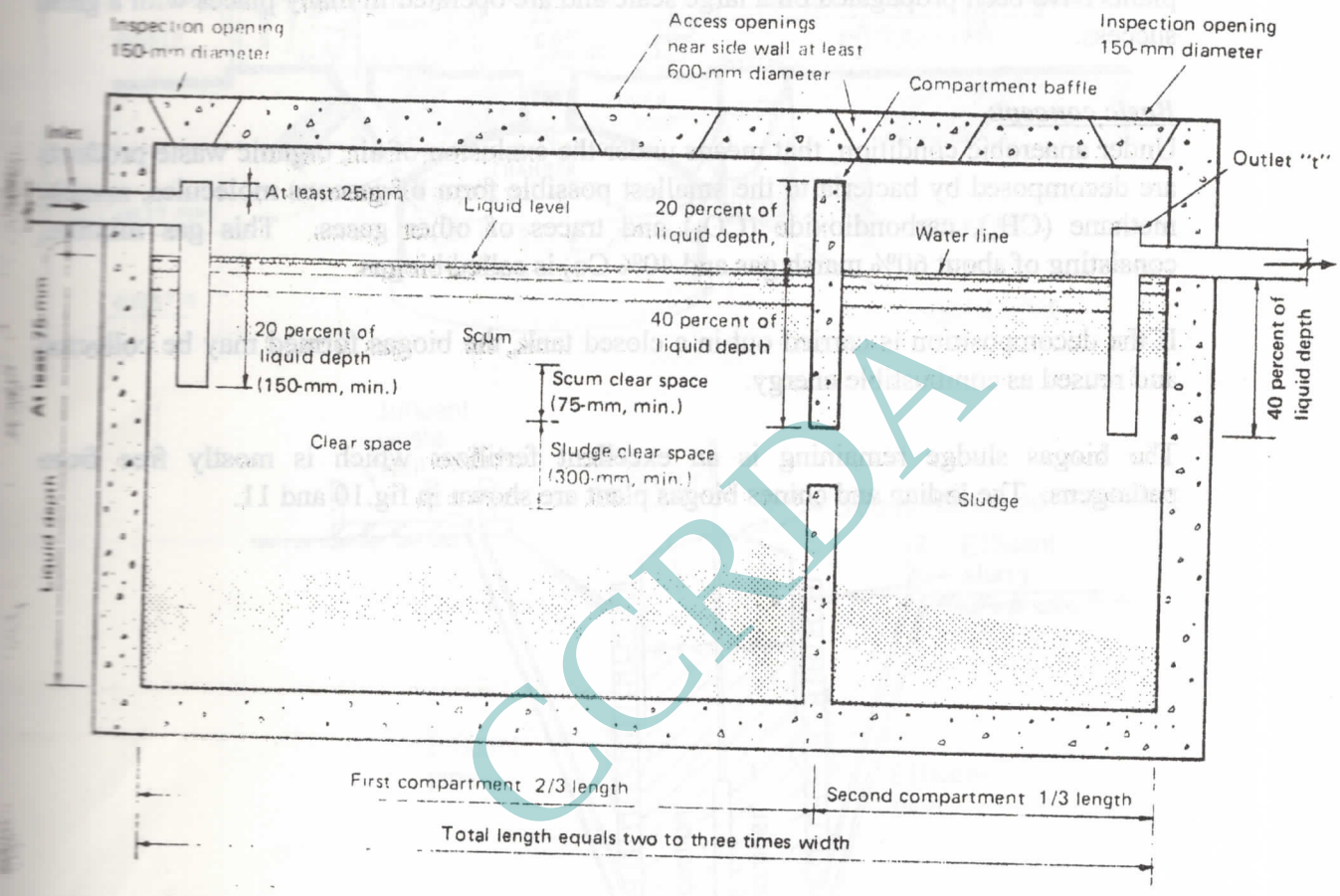


Fig. 9. Septic tank

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3.4.7 Biogas Plants

Promotion of biogas technology as a means of resource recovery and pollution control is underway throughout the developing world. In particular, India's and Chines biogas plants have been propagated on a large scale and are operated in many places with a great success.

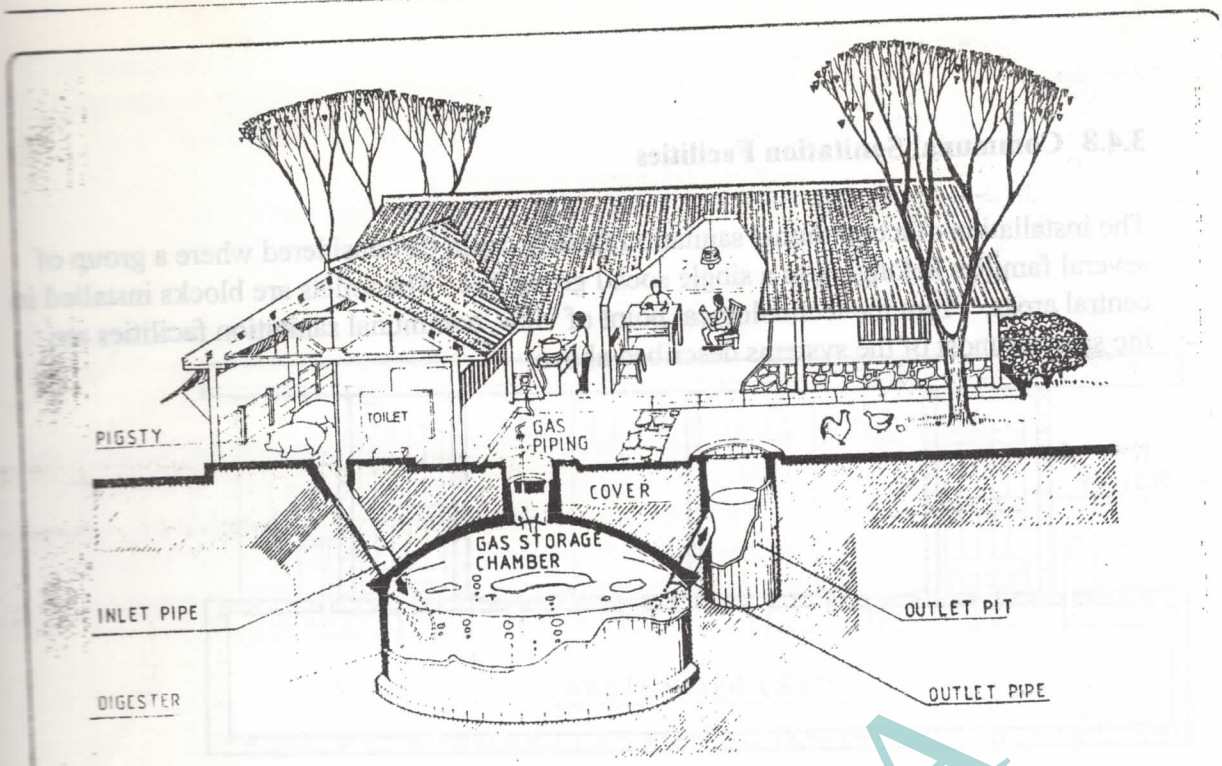
***Basic concept*:**

Under anaerobic condition, that means under the exclusion of air, organic waste products are decomposed by bacteria to the smallest possible form of gaseous molecules, namely methane (CH_4), carbondioxide (CO_2) and traces of other gases. This gas mixture, consisting of about 60% marsh gas and 40% Co_2 is called biogas.

If the decomposition is carried out in a closed tank, the biogas formed may be collected and reused as combustible energy.

The biogas sludge remaining is an excellent fertilizer which is mostly free from pathogens. The Indian and chines biogas plant are shown in fig.10 and 11.

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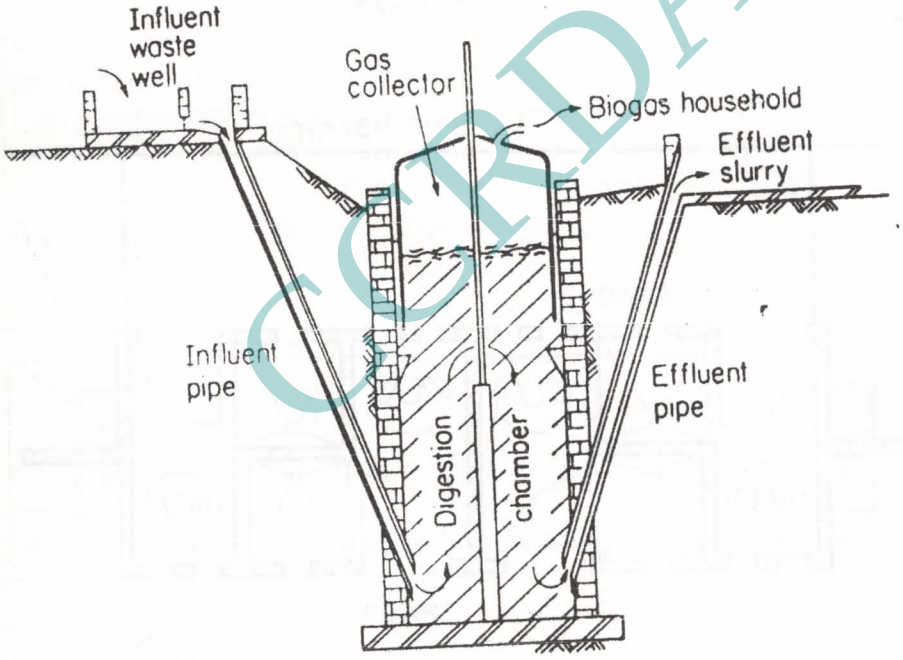


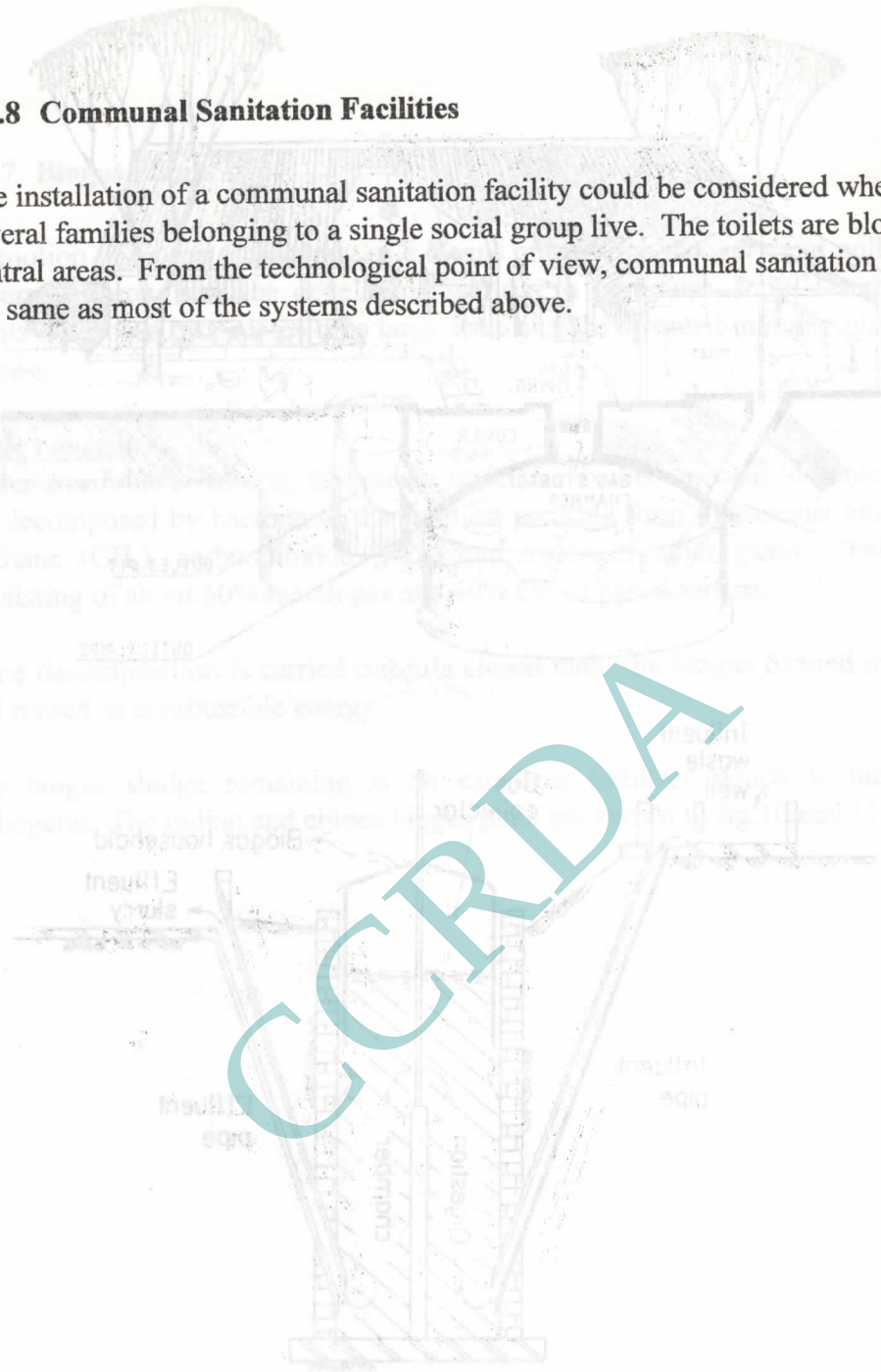
Fig. 19 Indian Biogas Plant

Fig. 10 & 11 Biogas plants

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3.4.8 Communal Sanitation Facilities

The installation of a communal sanitation facility could be considered where a group of several families belonging to a single social group live. The toilets are blocks installed in central areas. From the technological point of view, communal sanitation facilities are the same as most of the systems described above.



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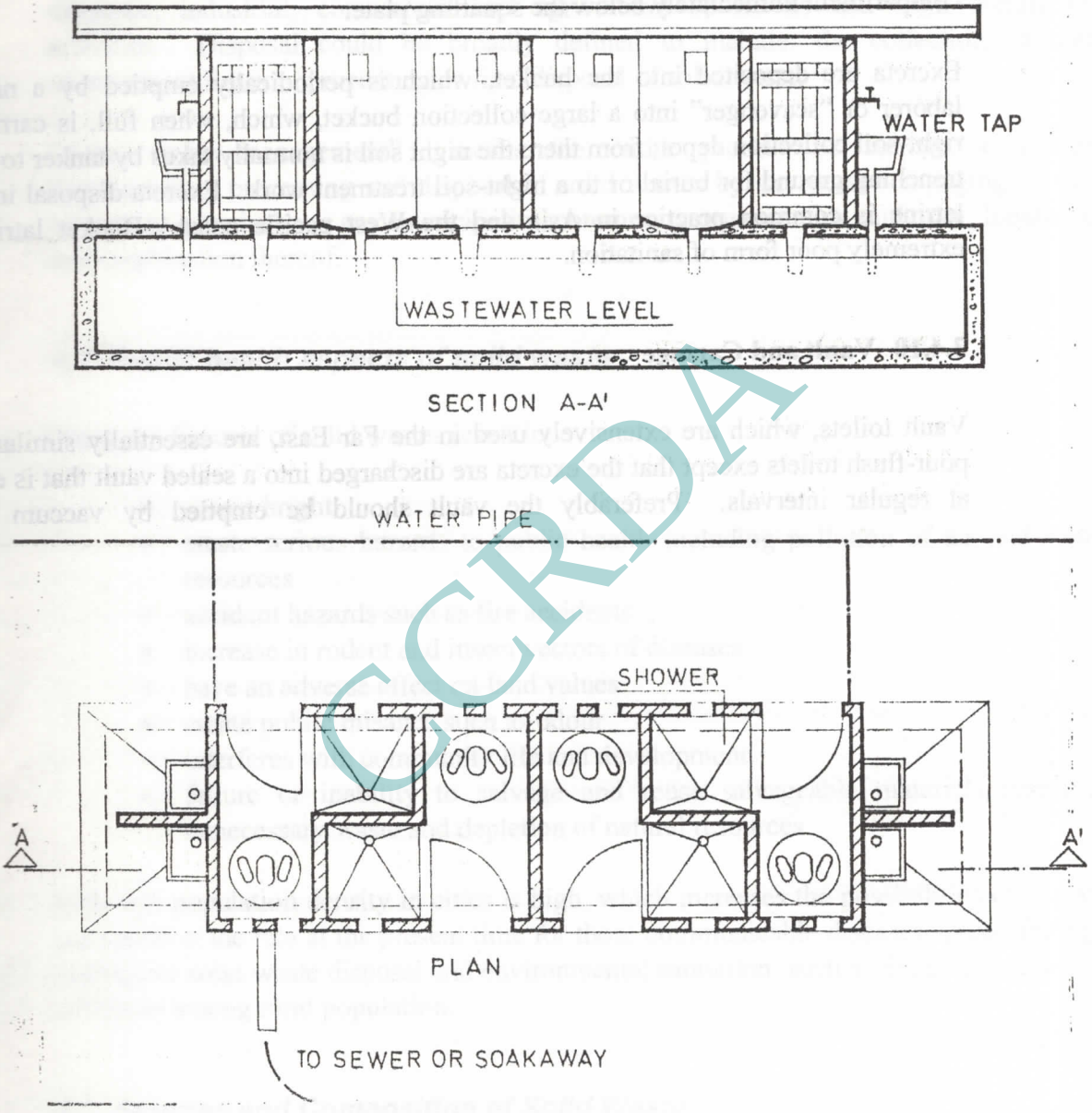


Fig.12 is a communal sanitation facility

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As a general rule it can be assumed that every toilet in a block has to be designed for 25 inhabitants. As a general rule, separate toilets for men and women should be provided. It is important the toilets be provided with lighting and hand washing facilities.

3.4.9 Bucket latrines

Bucket latrine consists of a squatting plate and a metal bucket located in a small compartment immediately below the squatting plate.

Excreta are deposited into the bucket, which is periodically emptied by a night-soil laborer or "scavenger" into a large collection bucket, which, when full, is carried to a right-soil collection depot; from there the night soil is normally takes by tanker to either a trenching ground for burial or to a night-soil treatment work. Excreta disposal in bucket latrine is common practice in Asia and the West pacific coast. Bucket latrines are extremely poor form of sanitation.

3.4.10 Vault and Cartage

Vault toilets, which are extensively used in the Far East, are essentially similar to the pour-flush toilets except that the excreta are discharged into a sealed vault that is emptied at regular intervals. Preferably the vault should be emptied by vaccum tanker.

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4. Solid Waste Management

Solid waste collection and disposal has long been a concern of public health agencies and those dealing with disease prevention.

Solid wastes is difined as "garbage, refuse, and other discarded materials resulting from domestic, industrial, commercial and agricultural operations and from community activities. Disposal could be broadly defined to include: the collection, storage, treatment, utilization, processing or final disposal of solid waste.

"Solid waste management" means the entire process of storage, collection, transportation, processing and disposal of solid wastes by any person engaging in such process as a business or any municipality, community organization, authority, locality or any combination thereof.

4.1 Public health aspects of solid waste

Improper disposal of solid wastes result in:

- scenic bright
- create serious hazards to public health including pollution of air and water resources
- accident hazards such as fire accidents
- increase in rodent and insect vectors of diseases
- have an adverse effect on land values
- create public misance such as odour
- interferes with community life and development.
- failure or inability to salvage and reuse salvageable materials result in unnecessary waste and depletion of natural resources.

Although population density in cities is high, which increases the possibilities of disease transmission the rate at the present time for those communicable diseases spread through inadequate solid waste disposal and environmental sanitation, such as the enteric diseases is highest among rural population.

4.2 Sources and Composition of Solid Waste

The solid wastes that is generated in rural villages differ both in quantity and composition from the solid wastes generated within municipal boundaries.

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The solid wastes generated within municipal boundaries could be categorized into:

1. *House hold waste*: Which consists largely of organic kitchen wastes; traditional cooking may also produce ash; in wealthier areas, discarded furniture, appliances and garden wastes.
2. *Commercial wastes*: Markets are a major sources of commercial waste, much of it organic. Other sources include modern stores, offices restaurants, warehouses and hotels. Large hotels or offer may arrange for private handling.
3. *Institutional refuse*: Sources range from hospitals, and schools to government offices and police barracks. Hospital wastes are sometimes handled privately.
4. *Street sweeping*: Street refuse includes dirt and litter. It may also include household refuse, drain cleanings, animal manure and human focal matter.
5. *Construction debris*: Soil and stone are often dumped into the street by builders.
6. *Sanitation residues*: Residues from privies and latrine.
7. *Industrial Waste*: Packaging materials; food wastes; discarded metals, plastics and textiles; fuel burning residuals; and spent processing chemicals are among the wastes in this category.

The solid wastes generated in rural village is less in quantity and consist of mainly household, agricultural and commercial wastes. Houshold and market solid wastes in rural areas is composed mainly of organic materials such as dry grass, weeds, leaves and animal droppings. The non-organic materials include; empty tins, broken glass and pottery; packaging materials, plastic containers and bags; old rubber tyres.

In general, the composition of solid wastes tends to differ in significant ways from that generated in industrialized countries. It contains more organic matter, it has a much higher density and moisture content and the particle size is much smaller. These characteristics have important implications for the choice of disposal methods and equipment.

Management aspect:

Managing solid waste is an inescapable requirement of urban life - a job that nearly everywhere falls to municipal authorities. Waste management is a costly service to provide.

When dealing with solid wastes in rural villages, its management aspect is left to individual households and communities. No sophisticated methods of storage, collection, transportation, processing or final disposal is involved.

The recommended disposal methods include: composting, land-filling, burning and burying.

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Material Recovery Operation

A great deal of materials in the solid waste are potentially recoverable, and an intensive search is underway for feasible and practicable materials recovery system. For example, agricultural residues may be returned to the soil or used for food, raw materials, industrial scrap could be returned directly to the manufacturing process rather than the waste pile.

Energy recovery system are designed to achieve resource conservation through the retrieval of the energy contained in the combustible fraction of the solid waste metals, plastics, wood, glass, textiles and papers could be recovered and recycled.

Solid Waste Disposal Methods

Depending on the composition and physical and chemical characteristics, solid waste disposal is carried out according to one of the following three basic methods: land-filling, composting and incineration.

Composting: is a method whereby the organic fraction of the solid waste material is subjected to bio chemical depredation, having as its end product a humus-like substances that is used primarily for soil conditioning. The major advantage of composting is the production of potentially useful by product (fertilizer) and fuel gas.

Composting process involves decomposition of and stabilization of organic fraction of the solid waste by biological action. There are two processes:

1. aerobic decomposition and stabilization and
2. anaerobic fermentation. In both process, microorganisms (bacteria, fungi, molds other saprophytic organisms) feed upon organic material such as vegetable matter, animal manure, night soil and other organic refuse and convert the waste to more stable form.

The process of composting depend on several factors. The most important factors are:

1. knowledge of the carbon-nitrogen relationship
2. moisture content, temperature, climatic condition
3. understanding the activities of microorganisms during composting and several others which must be controlled.

Composting in rural villages can be carried out using the following:

Construction

- dig a pit of 2 x 2m and 1-1.5m deep;

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- construct a simple shelter over the pit that creates shade
- construct a fence to keep animals out

Building up of compost pit

The best result will be achieved when the pit is filed up in layers as described below:

- first, a 15cm thick layer of grass, leaves, straw and household waste;
- a second, layer of animal dung and/or poultry manure
- a third, 3cm layer of ashes and/or soil

Composting procedure

- fill up the pit by repeating the three layer system;
- stir the contents of the pit every now and than;
- sprinkle a little water on the contents during dry weather to stimulate the composting process
- fill up the bit higher than ground level, to allow for shrinkage
- close and seal the pit with a layer of animal during and mud;
- leave the pit for 2-3 months before opening;
- use the decomposed material as fertilizer.

Note: Do not put plastic, tim, glass or earthen wait in the compost pit.

Land-filling:

is a method consisting of permanently placing solid waste under maximum density in the earth with daily cover. Solid wastes that can not be used for composting such as empty tins, broken glass and pottery, packaging materials, plastic containers and bags, old rubber tires ... etc. could be disposed of using land filling methods.

Burying: The easiest way to get mid of non-organic waste is burying.

Burring could take place at household level, in a small pit dug in the private yard or garden. Burying could also take place in a common pit for the hole community. A solid waste pit is not very attractive sight. Therefore, the location of a community solid waste pit should be at a safe distance (100 meters) from the community.

Location of solid waste pit:

From a health point of view, community solid waste pits must be located at least 100metres away from rivers, streams, ponds and any other water sources such as springs and wells.

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It is recommended that the contents of solid water pit be covered frequently with a layer of soil and it should be fenced off to keep out animals.

Incineration: is a controlled combustion process for reducing solid, liquid or gaseous combustible wastes.

Hospital wastes should be burnt to prevent the spread of infections diseases.

A local incinerator can be made from an oil drum in which an opening is cut near to the bottom. The opening allows the removal of ash and the inflow of air needed for the combination.

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5. Hygiene Education

Hygiene may be defined as the science of preserving and promoting health.

Hygiene education is concerned with helping individuals and communities to become aware of personal, family, occupational and community health problem. It is also concerned with providing the necessary skills and knowledge's with appropriate use of consultation and community resources.

The objective of hygiene education is the translation of what is known about the maintenance and promotion of personal and community hygiene into patterns of desirable behavior.

5.1 Purpose:

The purpose of hygiene education is to:

1. develop attitudes and appreciation: which provide willing compliance with hygiene regulation; satisfaction in carrying out hygiene practices; willingness to assume proper responsibility in the field of water supply and sanitation; recognition that health is a means of enriching life and that health practices bring rewards in growth and achievement.
2. develop sound hygienic practices: with reference to hygienic regimen, good emotional adjustment, nutrition, a healthful and recreative programme of activity, proper steps in avoiding disease and infection, and suitable participation in activities for the maintenance and improvement of community health.
3. develop a basin knowledge of important health hazards; hazards associated with poor sanitation and contaminated water and food.
4. provide skills and knowledge's on how to use water supply and sanitation facilities.

5.2 Background information of the community

To develop a practical hygiene education program, one must first find out as much as possible about the community before going there.

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Important information's would include:

- name and locations of community leaders and other respected person
- custom of addressing people which are considered polite and correct (if hygiene educator are all male, can they talk to the women; of they are all women, can they told to the men?)
- the correct time to visit without conflicting with important community activities.
- how hygiene educators can communicate with women to understand their beliefs and needs and encourage them to participate in the planning and execution of hygiene education.

It is important that community members must be familiar with hygiene educators before cooperation can be expected. Establishing identify and trust is crucial because people are often suspicious of strangers. A broad crossection of the people, from the formal leaders to the men or women in the markets and on street and in a few households should be approached.

5.3 Involving the Community

A survey of the community helps hygiene education workers understand community needs, behaviors, beliefs, attitudes, values and resources.

At the same time, community members can begin to understand the alternative technologies available and how they relate to their needs. It is important that the community become involved in hygiene education or other program in the early planning phase.

Community leaders: community leaders normally provide the encouragement and guidance for their communities to participate in a water supply and sanitation project and its hygiene education component.

Leaders are generally of two types: formal and informal. The formal leader is someone with a title who has been officially chosen for a position. Such leaders may be found in:

- local government
- traditional hierarchy
- religious or cultural organization
- trade association
- craft unions
- self-help societies
- social clubs

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- educational institutions

Informal leaders have no special title and appear at first glance to be ordinary citizens. But the opinions, requests and suggestion of these leaders are well respected by the community. Examples of informal leaders may be:

- a successful farmer or business man
- a primary health worker, midwife or volunteer who has been selected by the community
- the oldest person in the community with a wealth of knowledge about the history and custom of the people including those related to water and hygiene.

5.4 Planning for hygiene education

The promotion of hygiene education will require a specific body in the community which planning and action can be coordinated.

The community's water supply and sanitation committee may be able to do this work. Or, an existing group in the community, which is involved in development work, may be the likely candidate for planning hygiene education.

If there is no appropriate existing group, a committee can be formed drawing on people from representative groups and interests in the community, such as peasant association or market association.

In communities which do not have any organization like these, a completely new group will have to be formed. This new organization should have the broad goal of community development with water supply, sanitation and hygiene education as its first priority.

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5.5 Involving Outside Agencies

Although one agency will be in charge of the water supply and sanitation programme, other outside agencies may provide useful assistance in hygiene education. For instance, a public health center may be able to teach mothers the proper way to dispose of their babies excreta. An agricultural extension agency could explain to men the health risk of defecating in open fields. All such potential agencies should be contacted.

5.6 Finding other organizations in the community which can help the hygiene education effort

In almost every community there are formal and informal organizations whose aim is to improve condition in the community. Examples are "self-help" groups such as "welfare council" progressive union; development committees which could be valuable human resources and can provide moral support and materials that can aid in the development of water supplies, sanitation and hygiene education.

5.7 Paying Attention to Community beliefs

Hygiene education staff should pay close attention to the habits, beliefs and taboos of the villagers. This type of information, particularly when collected from the women, can provide a starting point for hygiene education message to change the way people use water and dispose of excreta. Examples

- Standard one-hole model latrines are not appropriate for certain communities, since there are taboos against males and females passing feces in the same place.
- Furthermore, it was not considered proper for in-laws to defecate in the same place.
- People tend to avoid certain areas for historical or religions reasons.

5.8 Who Should Get the Message

Reaching Women

Women have a special role in hygiene education and they reed to be involved in the early stages of the program.

Outlined below are some of the hygiene messages about household activities where women have the primary responsibility.

1. Water use and reuse:
   - Drinking: human, animals
   - Washing: hands, dishes/jars, vegetables, children, clothier, floors
   - Bathing: humans, animals
   - Watering: Vegetables, flowers, patios
2. Excreta use and reuse:
   - Defecation: actual and preferred practice, sex, age, class, prohibition, anal cleansing
   - Infant care and training: bathing, diapers, nappies, washing of soiled clothing
   - Handwashing: when, how, where
   - Care of toilet
   - Reuse: appropriate?

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Low cost teaching aids can be used in the special training programs for clinics and group of women.

Reaching parents through health centers

Material child health (MCH) clinics and midwives should receive hygiene education similar to those given to women.

Reaching children in the schools.

Schools should be encouraged to incorporate hygiene curriculum in education program. Low-cost teaching aids from locally available materials may be used. Models of clay and wood, hand-drawn posters and stories are examples. A workshop can be held to show people how to produce teaching models.

Water supply and sanitation planning should make sure that schools have access to water supply and sanitation facilities. Ideally, schools should have their own taps or well, latrines and refuse disposal system.

School children play an important role in helping their mothers, brothers and sisters change the hygiene behavior.

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5.9 How to Get the Message Across.

Achieving the goal of hygiene education involves using various types of mass media and a large group educational techniques.

These must be reinforced by personal contact and locally relevant materials to be effective.

The best result will be achieved by a mixture of communication methods that combine a presentation of information with instructions and demonstration of how parasites spread, how to use sanitation facilities ..etc.

Some of the communication methods may require electricity, literacy, or large audience and may be more feasible in urban settings.

For rural areas, traditional plays, story-filling or festival can be made part of the educational process.

Mass education programs should be in language most commonly used by the community. Presentation can be enhanced by familiar proverbs, songs or poems that are relevant to

the topic. The message should be simple and clear to the average audience. They may be presented in the form of talks, slide sound shows, discussions, or demonstration.

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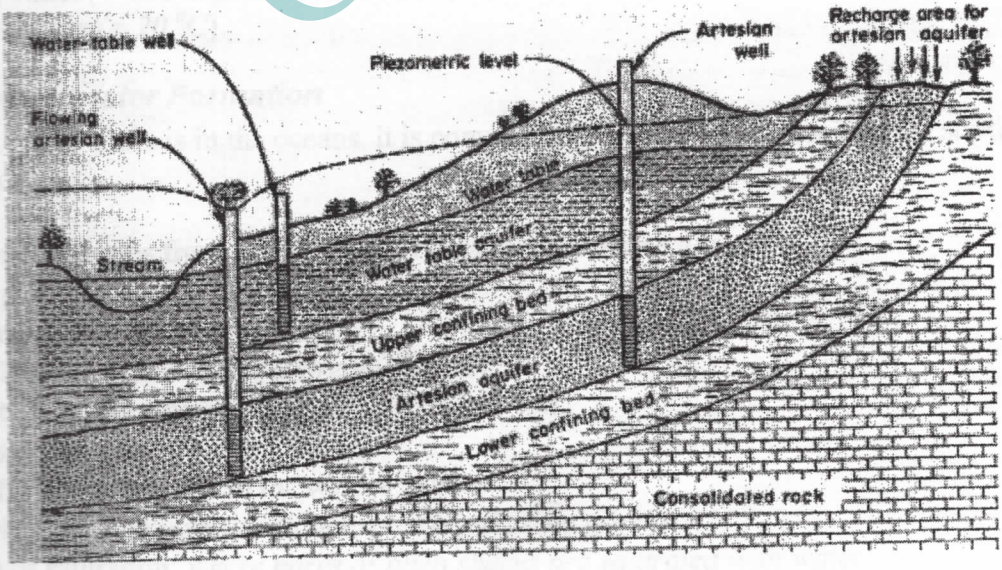
CHAPTER SIX

GROUND WATER SOURCE SITING AND DRILLING

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GROUNDWATER SOURCE SITING AND DRILLING

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1 Groundwater

1.1 Introduction

A normal person requires about 3 of potable water daily to maintain the essential fluids of the body. In developed countries daily water consumption per head exceeds 200 L per day. In our country the daily water demand set by the ministry of Water Resources is only about 15 to 25 per day per person for rural areas. The fulfillment this minimum water demand in our country is a very critical issue. Therefore, the identification, evaluation and allocation of our fresh water resource is the basic task to be undertaken.

Although about ¾ of the earth's surface is covered with water, more than 97% of the total volume of which is saline water. The rest less than 3% of the total volume of water is found on the land. About 77% of the water on land is comprised of ice caps and glaciers, which may enter into oceans and seas while melting. It is only about 22% of the water on land which is available as fresh water (groundwater, surface water and soil moisture). More than 97% of the fresh water available on the planet earth is groundwater, which far exceeds the fresh surface water. On the other hand surface water is relatively easy to locate and estimate its volume in a given locality. The cost of exploration and the difficulty to locate where and how much groundwater is stored at areas wanted to exploit is the main challenge for the hydrogeologists and water supply engineers. In this paper, attempt is made to out line the main techniques for the siting and construction of wells for water supply.

Groundwater is a subsurface water that fills up the open spaces (pores, joints or fractures) of the earth's shell. Its motion is determined by the **gravity and friction forces**. There are different types of groundwater:

- Shallow and renewable groundwater (*involved in water circulation*)
- Deep and or non-renewable (*virtually without motion*).
- Mineral water *(> 100 mg/l dissolved solids)*
- Thermal water *(> 20 °C)*

1.2 Groundwater Formation

As most of the water is in the oceans, it is convenient to take the hydrologic cycle starting with the ocean.

- Water evaporates from the surface of the ocean: - *due to solar energy*
- Precipitation: *rainfall, snow*
- Depression storage: *ponds, lakes*
- Overland flow: *flowing to a stream channel*
- Infiltration: *seeping through the pores of the soil*
- vadoze zone: *soil moisture, air*
- Interflow: *lateral flow in the vadoze zone*
- Gravity drainage: *excess soil moisture is pulled by gravity*
- Zone of saturation: *where pores or open spaces are saturated with water*
- Water table: *top of the saturated zone*
- Groundwater flow:
- Baseflow: *contribution of groundwater to a stream*
- Runoff: *the total flow in a stream*
- Surface water: *water stored on the surface*
- Magmatic water: *water contained in the magma*

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- Connet water: *water that has no contact to the hydrosphere*

The general hydrologic cycle is shown in Figure 1.

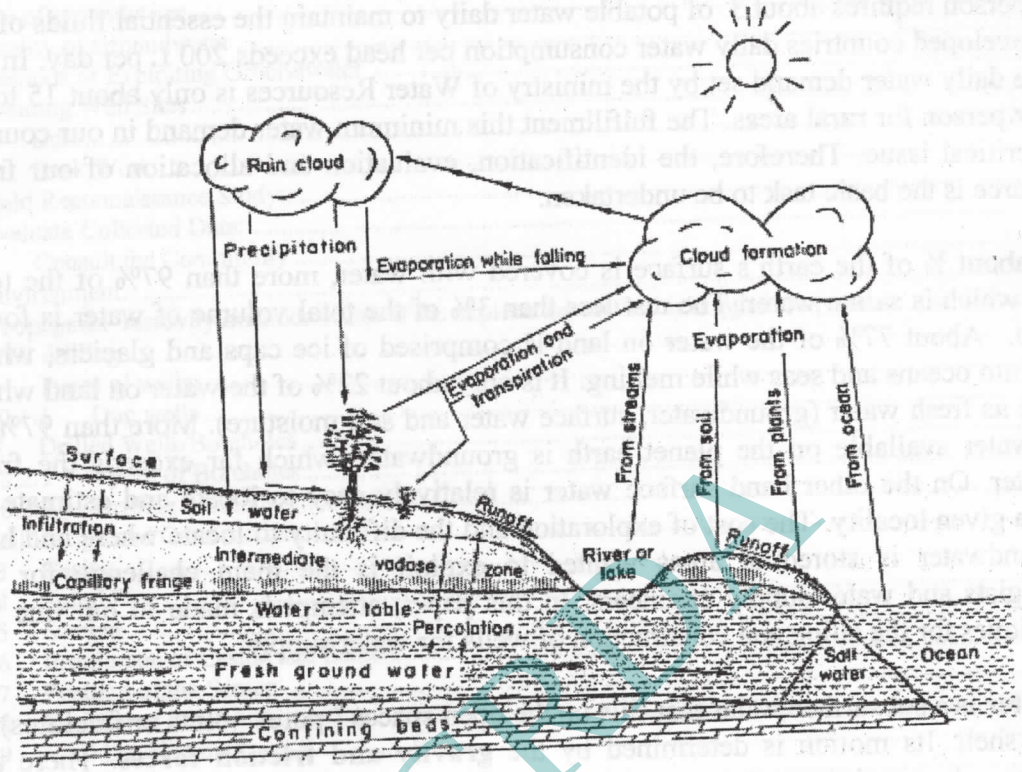


Figure 1: The general hydrologic cycle

The water infiltrated into the subsurface may not all contribute to the formation of groundwater in the saturation zone. The water is normally distributed in the subsurface as soil moisture, partial fill in the vadoze zone, capillary rise in the capillary fringe, pore fill in the saturated zone. The subsurface water distribution is shown in figure 2.

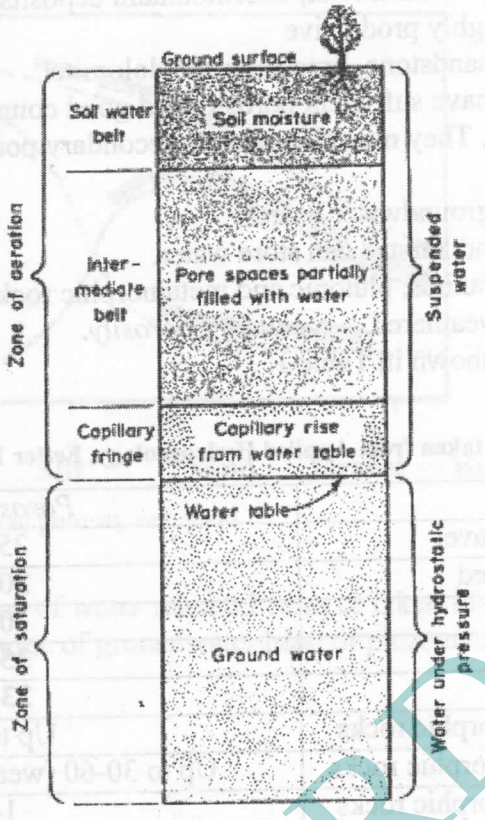


Figure 2: Subsurface distribution of water

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A geological unit/formation or bed that bears groundwater is known as ***Aquifer***. Water bearing zones/formations can be different in rock type. These are unconsolidated sands and gravels, sandstones, limestones and dolomites, basalts and intensively fractured plutonic and metamorphic rocks. They therefore can be classified as:

- aquifers with pores (porous formations, e.g. sandstone, unconsolidated sediments)
- aquifers with joints and fractures(jointed rocks; metamorphic, igneous and sedimentary rocks)
- karst aquifers (limestone)

Aquifers can be unconfined, confined or leaky depending on the confining layers and their interaction with the atmosphere. The productivity of an aquifer can also be defined in the following way:

- aquifer (highly productive)
- aquitard (poorly productive)
- aquiclude (highly retentive)

The open spaces that store water in a formation can be expressed as the ratio of voids to the total volume of material under consideration. These open spaces vary from formations to formations. The connectivity of the open spaces varies too.
Based on the open spaces/porosity and connectivity of the pores, one can still group different geological units on their productivity as:

a. unconsolidated sediments (alluvial/fluvial, intermountain deposits) with relatively uniform grain size distribution are highly productive
b. sedimentary rocks: include sandstone, limestone and dolomite:
i. the sandstone normally have sufficient porosity and good connectivity of the pores to transmit and store water. They may also possess secondary porosity due to jointing and fracturing.
ii. Sandstone are the main groundwater bearers
iii. Limestone if fractured and karsted can store water.
c. Crystalline rocks: basalts, granites, plutonic and metamorphic rocks can bear and transmit if the rock is fractured and weathered. – *secondary porosity.*

The porosity ranges of rocks is shown in Table 1.

Table 1: Range of porosity in rocks; taken from Applied Hydrogeology, Fetter 1994.

Type of rock	*Porosity [%]*
Well sorted sand or gravel	25-50
Sand and gravel mixed	20-35
Glacial till	10-20
Silt	**35-50**
Clay	**33-60**
Fractured plutonic and metamorphic rocks	Up to 2-5
Weathered plutonic and metamorphic rocks	Up to 30-60 (weathering of micas)
Unaltered plutonic and metamorphic rocks	1-2
Basalt	1-12
Pumice	Up to 87
Tuff	**14-40**
Volcanic ash	**Up to 50**
Weathered volcanic rocks	Up to 60

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The porosity of a rock can be determined in the following ways:
1. (wet weight –dry weight)/total volume: unconsolidated sediments
2. Tracer tests: lithified and unconsolidated rocks – send a tracer at one end and measure the concentration at the other end. The area above the BTC equal to the one pore volume.

The stored groundwater can be divided into two portions.
1. That portion of water which drains due to gravity (specific yield) – *the effective porosity*
2. That portion of water which does not drain due to gravity (adhesive water, specific retention). –*tension forces*

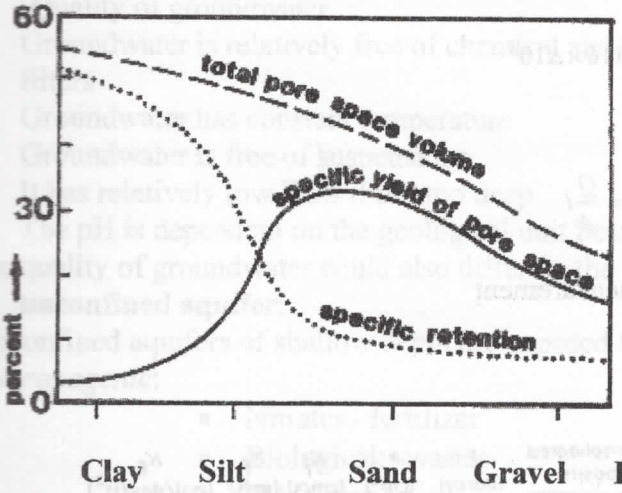


Figure 3: Relationship of porosity and yield

Storativity: Volume of water released from or taken into storage per 1 m^2 surface area of an aquifer per 1 m change of groundwater head or piezometric level.

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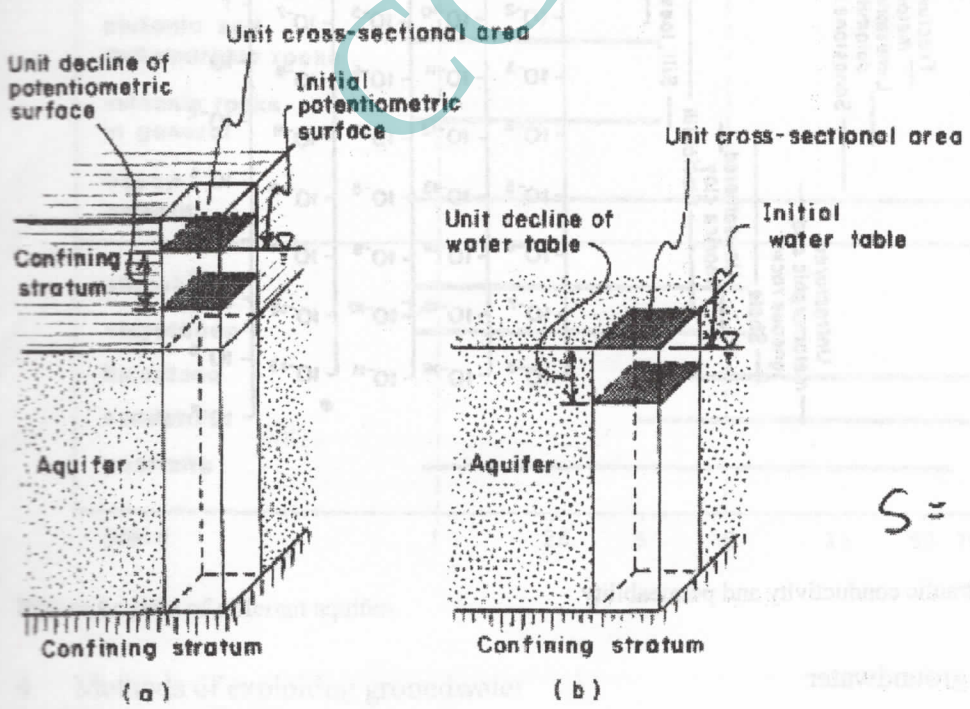


Figure 4: storativity; a = confined aquifer, b = unconfined aquifer

The yield of an aquifer is dependent on the hydraulic conductivity or permeability of the medium. The permeability of a formation can be determined in two ways:

1. Unconsolidated sediments:

- sieve analysis; $U < 20$

$$Kf = 0.0116 \times d10^2$$

- permeameter measurement;

$$Kf = \frac{Q}{A} i$$

2. lithified rocks; permeameter measurement

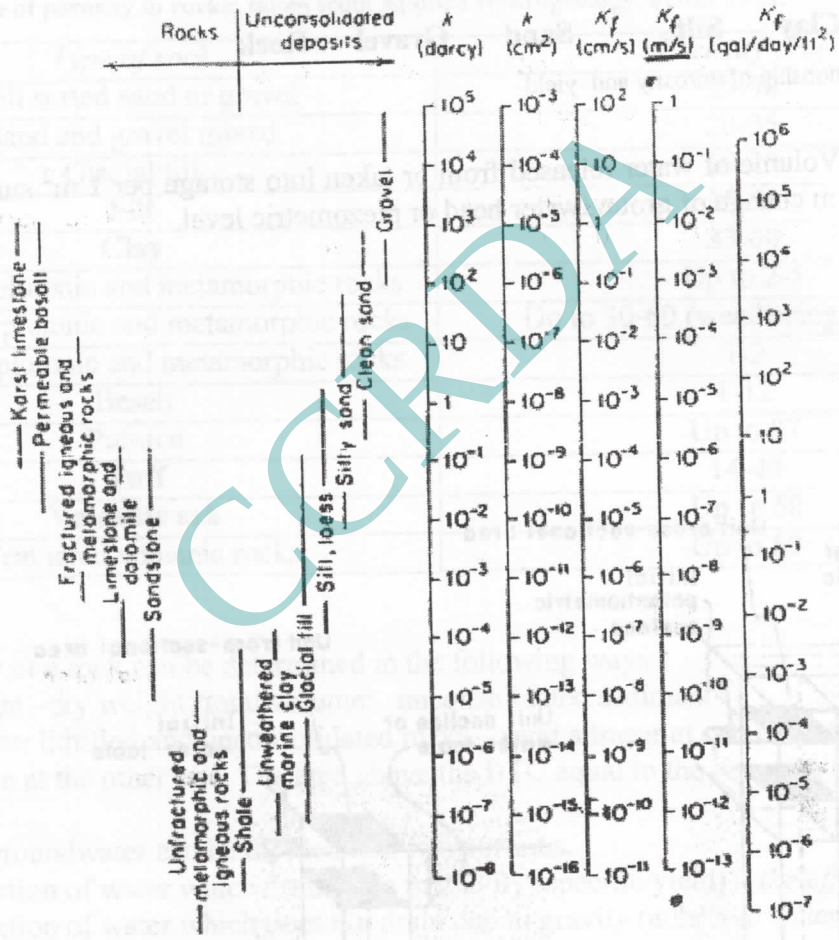


Figure 5: hydraulic conductivity and permeability

2 Use of groundwater

- house hold and drinking: springs, dug wells, drilled wells
- Irrigation and industry: drilled wells
- Ecological balance: base flow to streams.

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3 Quality of groundwater

- Groundwater is relatively free of chemical and biological contamination; soils serve as filters
- Groundwater has constant temperature
- Groundwater is free of suspensions
- It has relatively low TDS if not too deep
- The pH is dependent on the geological unit bearing the groundwater

The quality of groundwater could also differ on the aquifer type:

a. **unconfined aquifer**:

Unconfined aquifers of shallow depth are exposed to surface contacts.

Anthropogenic:

- Nitrates –fertilizer
- Biological: -wastes
- PO4: -fertilizer

Natural: flooding

b. **Confined aquifers**:

Relatively free of anthropogenic contamination, but could have higher chemical dissolution problems (Na, K, Ca) at greater depths

c. **Karst and fracture aquifers**:

Limestone: higher hardness

Crystalline: low pH

Volcanic: good quality – *variable*

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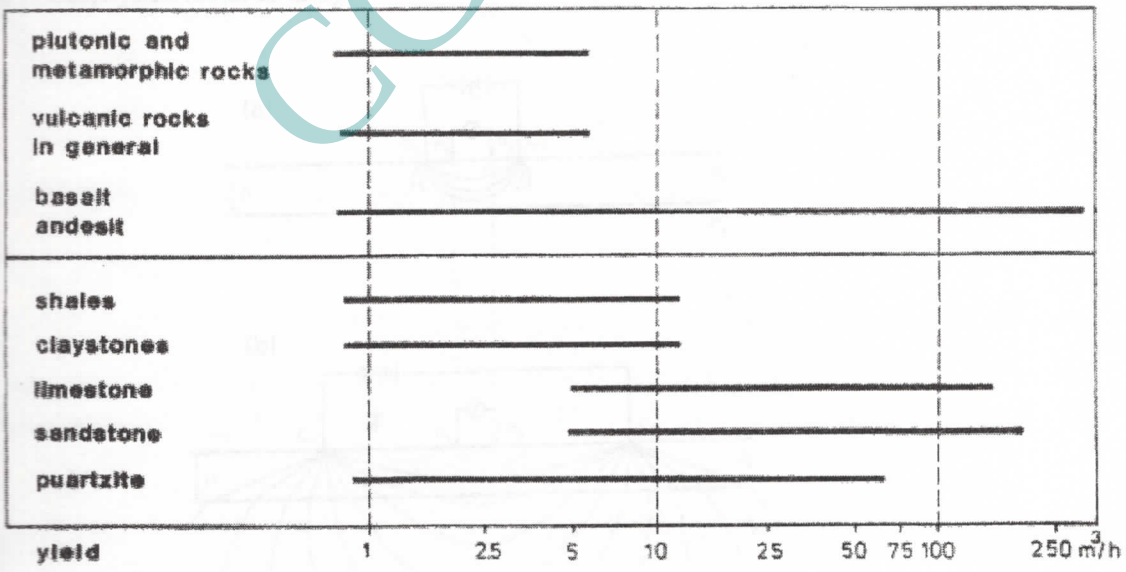


Figure 6: yield of different aquifers

4 Methods of exploiting groundwater

a. Spring taping: gravity and artesian springs

Gravity springs: boundary springs, overflow springs (faults, aquiclude), barrier springs and karst springs.

Artesian: confined aquifers- artesian fault spring, artesian depression springs (cut the impermeable top layer)

b. Dug wells

Resisitivity methods include: VES (thickness, bearing zone, overburden) and HEP (horizontal distribution)

There are two arrays commonly used:

1. Werner array: electrical profiling
2. Schrumberger array: vertical electrical sounding

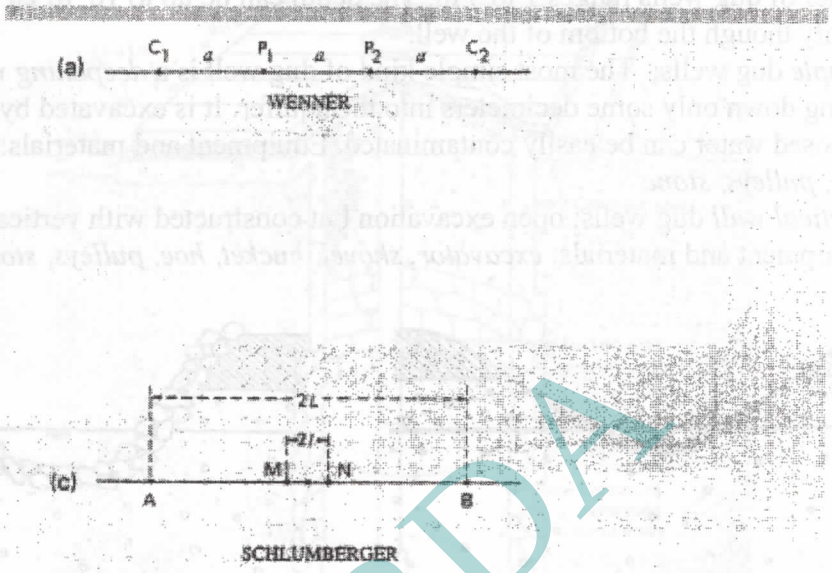


Figure 7: Geophysical methods: arrays

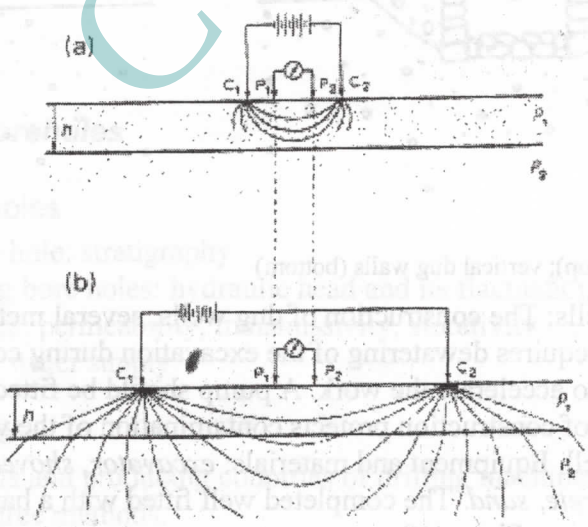


Figure 8: Electrode separation and detection depth: by increasing the electrode separation, it is posible to increase the detection depth.

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10 Well drilling

10.1 Types of wells:

Basically we have two types of wells - *dug wells and drilled wells*

10.1.1 Dug wells

The diameter of dug wells ranges 1 to 3 m. The depth can be up to 10 to 20 m. The water enters mainly though the bottom of the well.

i. *Simple* dug wells; The most simple kind of dug well is a *deepening with gentle slopes* going down only some decimeters into the aquifer. It is excavated by hand. The exposed water can be easily contaminated. Equipment and materials: *shovel, bucket, hoe, pulleys, stone*

ii. *Vertical wall* dug wells: open excavation but constructed with vertical walls. Equipment and materials: *excavator, shovel, bucket, hoe, pulleys, stone, concrete.*

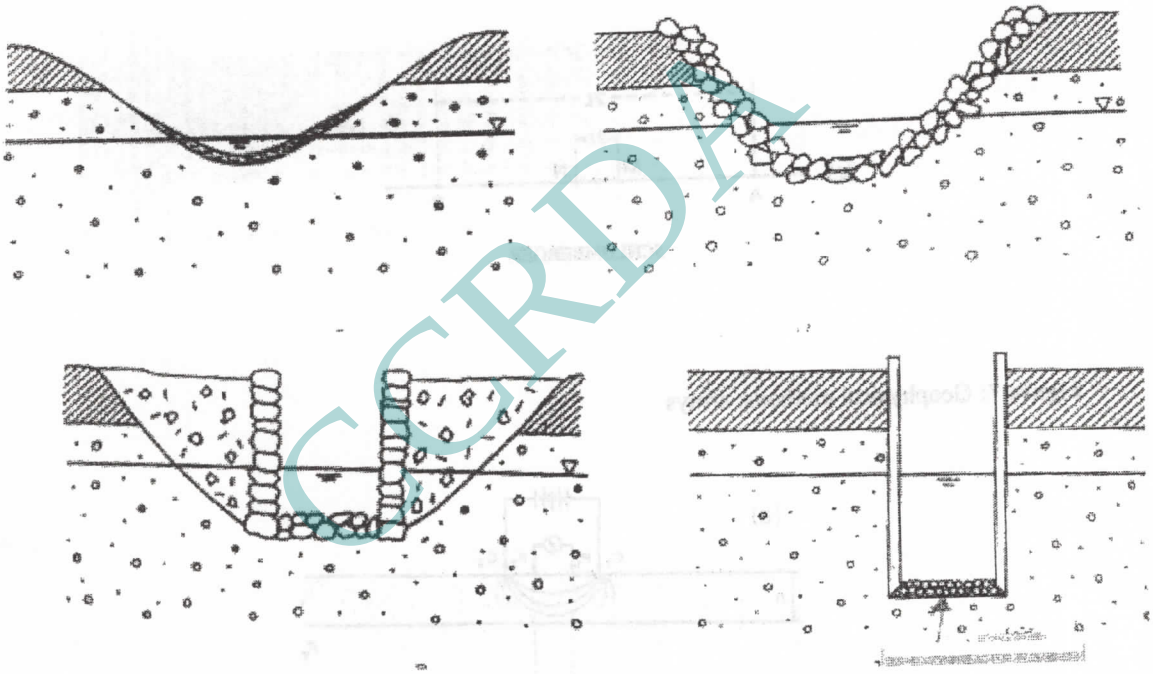


Figure 9: simple dug wells (top); vertical dug walls (bottom)

iii. *rock curb* dug wells: The construction of dug wells, several meters down into the yielding aquifer requires dewatering of the excavation during construction. Here you need excavators to accelerate the work. A pump should be fitted and sealed from above. This type of construction protects contamination of the water in the well damage of the well. Equipment and materials: *excavator, shovel, bucket, hoe, pulleys, stone,pump concrete, sand.* The completed well fitted with a hand pump of rock curb dug wells is shown in Figure 10.

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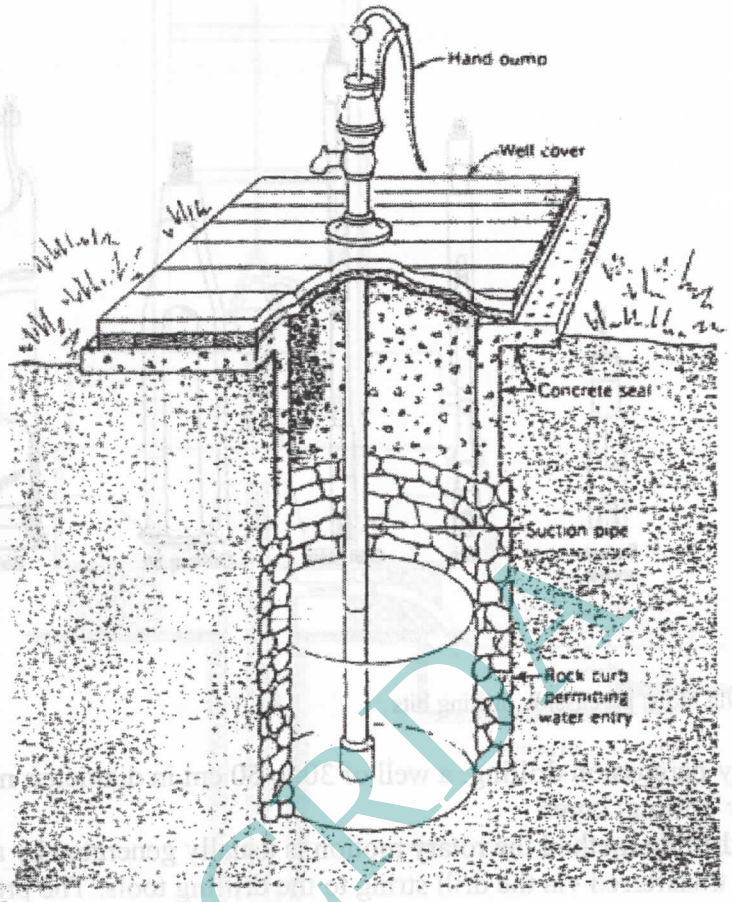


Figure 10: Sealed dug well

10.2 *Drilled Wells/Boreholes*

10.2.1 Types of Boreholes

i. Exploration bore hole: stratigraphy
ii. Water monitoring bore holes: hydraulic head and its flactuation
iii. Testing bore holes: permeability, transmissivity, storativity
iv. Producing wells: water supply

10.2.2 Drilling Methods

We have different models and producing countries of drilling machines. The methods are basically grouped into three methods.

i. percussion drilling: regularly dropping and lifting of a string of drilling tools into the bore hole. The cutting are removed with the help of a bailer. A well of up to 45 cm im diameter can be drilled using this method.

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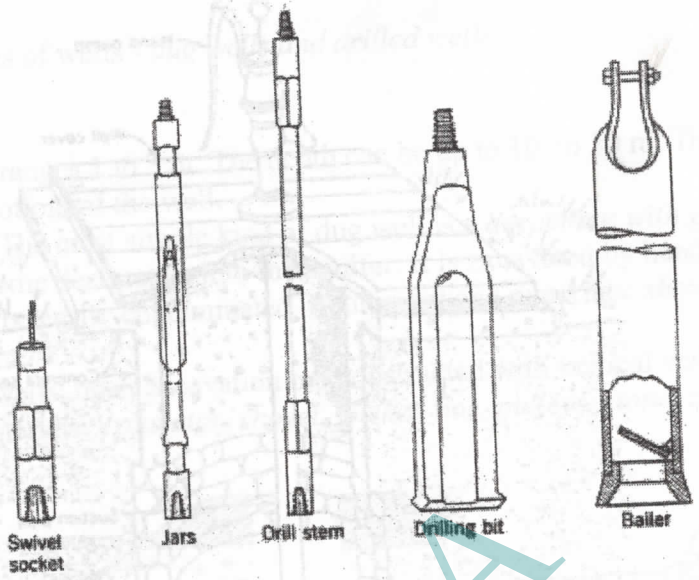


Figure 11: drilling tools: percussion drilling bits

ii. Rotary-percussion drilling: a well of 30 to 50 cm in diameter; mud can be added

iii. Rotary drilling: cores

At the rotary drilling method the rotary motion is usually generated by a machine above ground and is transferred via the drill string to the drilling tools. The pressure on the drilling bit is mostly applied through the weight of the drilling tools and the drill collars (Figure 12). The drill cuttings are removed with the help of mud circulation.

Reverse circulation: the mud circulates down within the annular space and rises up through orifices in the bit to the drilling string. The reverse circulation is attained by setting up a pressure difference between the mud column in the annular space and the mud column with cuttings inside the drill string.

Drilling mud: used for rotary drilling, serve the following purpoes:

- to stabilize the borehole
- to control the subsurface pressure
- to remove the cuttings
- to reduce water losses
- to cool and lubricate the bit and the drill string
- to avoid mud cakes; accumulation of the cuttings at the wall

Mud: bentonites, salts, foaming agents, etc.

Disadvantage mud additives: density, viscosity of the water may increase in and around the borehole.

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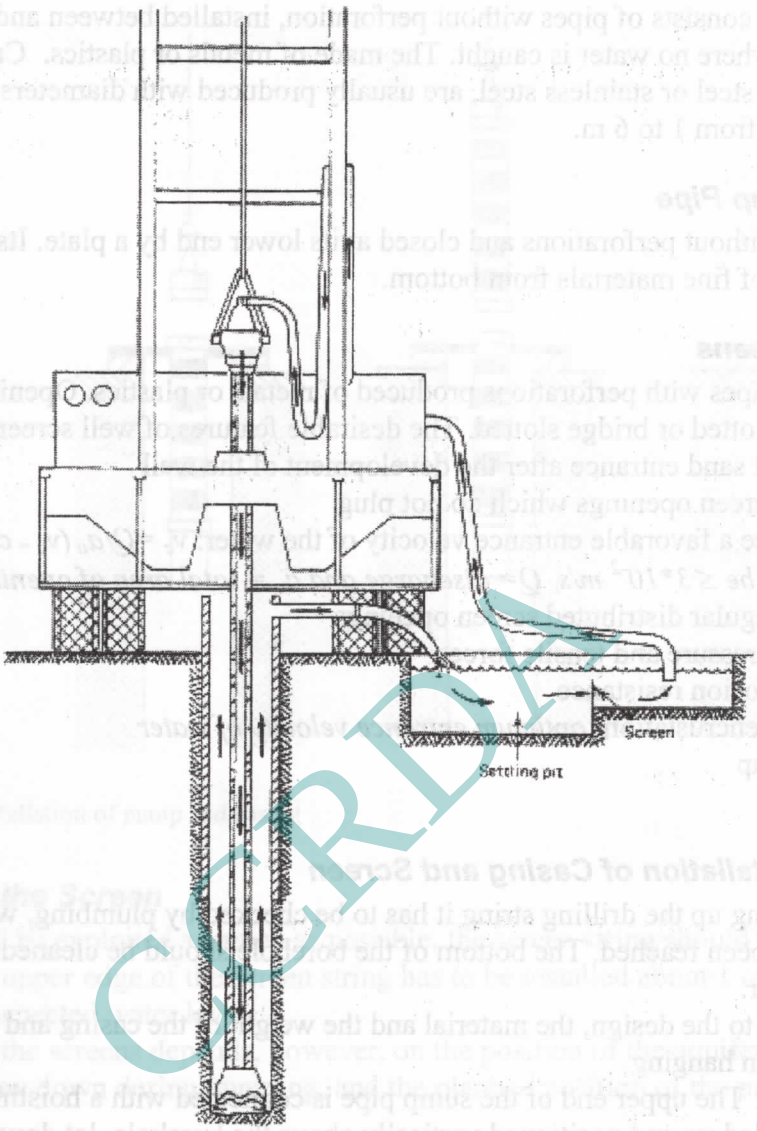


Figure 12: Rotary drilling with direct circulation of the fluid

11. Well Design and Construction:

Drilled wells normally have smaller diameters and greater depths than dug wells.

For the well construction, four parameters can be varied:

- depth depending on the transmisivity, water demand, = partial or full penetration
- diameter can varied from 200 to 1800 mm
- length and position of screen depending on the thickness and granulometric composition of the aquifer
- types of casing and screens, depending on the mechanical stress and chemical behavior of the groundwater
- the design should consider the demand, yield and reserve, cost of construction (materials and equipment to be used), formation type, organization and man power.

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10.3 Casing

The casing consists of pipes without perforation, installed between and above screens in positions where no water is caught. The made of metals or plastics. Casing pipes of metal, commonly steel or stainless steel, are usually produced with diameters from 80 to 1200 mm, and length from 1 to 6 m.

10.4 Sump Pipe

Is a pipe without perforations and closed at its lower end by a plate. Its function is to protect the influx of fine materials from bottom.

10.5 Screens

They are pipes with perforations produced of metals or plastics. Openings of screens could be: rounded, slotted or bridge slotted. The desirable features of well screens include:

- prevent sand entrance after the development of the well
- have screen openings which do not plug
- garantee a favorable entrance velocity of the water: $v_c = Q/a_o$ (v_c = *critical water velocity should be* $\leq 3*10^{-2}$ *m/s,* Q= *discharge and* a_o = *total area of openings)*
- have regular distributed screen openings
- resist pressure and tensile forces
- be corrosion resistance
- hinder encrustation; *optimum entrance velocity of water*
- be cheap

10.6 Installation of Casing and Screen

After pulling up the drilling string it has to be checked by plumbing, whether the planned depth has been reached. The bottom of the borehole should be cleaned with the help of a valve auger.

According to the design, the material and the weight of the casing and screens, the installation has to be in hanging.

Sump pipe: The upper end of the sump pipe is connected with a hoisting device. The sump pipe is pulled up and positioned vertically above the borehole, let down cautiously and held at its upper by a clamp.

The screen: The screen can pulled up by the hoisting device and connected with the sump pipe which hangs in the bore hole fixed by the clamp, and then after the opening of the clamp, the whole string is lowered into the borehole. This procedure is repeated until all screens and casings are installed (see Figure 13 below).

Gravel pack: After the installation of the casing and screens into the open borehole the filter pack dropped into the space between the borehole wall and the screen wall.

Sealing: The properties of clay to absorb water and to swell up considerably makes it suitable as a seal material.

Cementing: In certain cases, the cementing (or grouting) of well casing is employed to seal wells, protecting them against contamination of the surface water.

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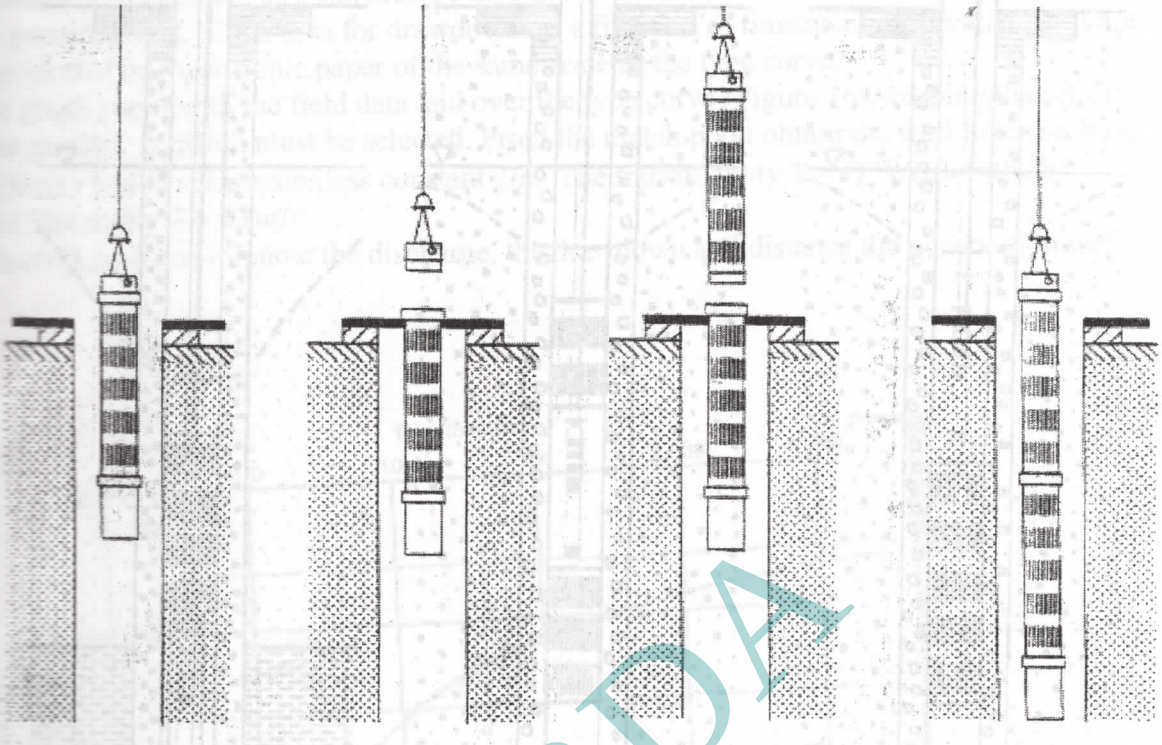


Figure 13: standing installation of pump and casing

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10.7 Position of the Screen

If the aquifer should be exploited as much as possible, the screen string should catch all water bearing layers. The upper edge of the screen string has to be installed about 1 or more metre below the deepest expected water level.

- the positions of the screens depends, however, on the position of the aquifer on the profile, the expected draw down during pumping, and the planned position of the pump.

10.8 Position of the Pump

In general, there are three possibilities for the installation of the submersible pump:

- above the upper most screen; if the aquifer has great thickness, good permeability, and small draw down (Figure 14a below)
- in the blank casing between the screens, for aquifers of small thickness and or deep draw down (Figure 14b below)
- within an extended sump pipe; it has to be guaranteed that the motor of the used submersible pump will be sufficiently cooled. A pipe has to be installed surrounding the pump and forcing the to flow around the motor towards the entrance area Figure 14c below).

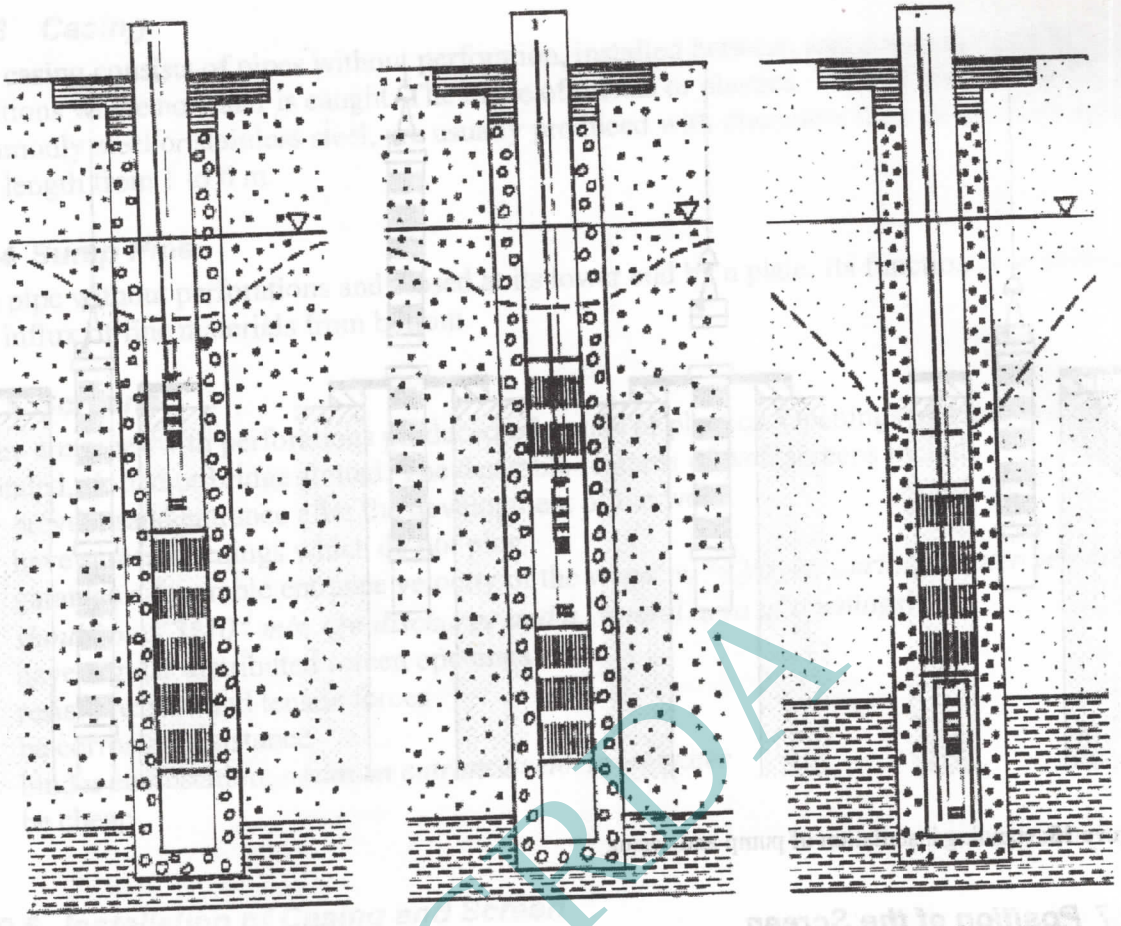


Figure 14: Position of a pump; left= small drawdown, middle = large drawdown and right = max. water pumping

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10.9 Well Development

After the construction of the well has been finished, the well must be developed; that means it is treated by high pumping rates in order to:

- increase the porosity and the permeability of the aquifer
- to stabilize the sediment around the well
- to remove plugging at the borehole wall or in the sediments adjacent caused by the drilling process.

After the development, the well delivers "technically sand-free water".

10.10 Well Testing

Pumping tests are carried out to reveal important parameters of the taped aquifer and the well. The relationship of drawdown and transmissivity is shown in Figure 15. When setting up a pumping test, the following data serve as a basis for the selection of the equipment for the pumping test:

- expected maximum discharge capacity of the pump (m^3/h)
- expected deepest draw down in the well (m)
- distance between well and water outlet (m)
- level of water outlet (m) asl
- energy supply during pumping

An aquifer test consists of pumping a well at a constant rate for a constant period of time. The drawdown is measured as a function of time in one or more observation wells and perhaps, the pumping well. Field data for drawdown, as a function of time at an observation well are then plotted on logarithmic paper of the same scale as the type curve.
The graph paper with the field data laid over the type curve (Figure 16), keeping the set of axes parallel. A match must be selected. From the match point obtain the well function *W(u)*, the time *t* and the dimensionless constant *1/u*. The transmisivity $T = Q*W(u)/4\pi(h_o-h)$
And Storativity $S = 4Tut/r^2$
Where Q, h_o-h and r denote the discharge, the drawdown and distance the observation well.

CHAPTER SEVEN
WATER SUPPLY SCHEME
COMPONENT
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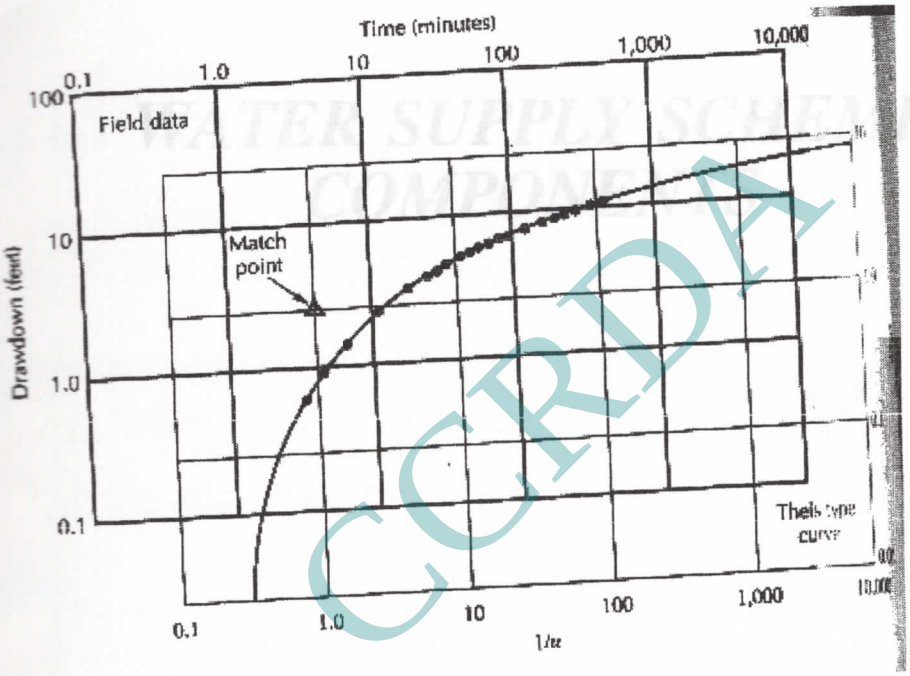


Figure15: determination of aquifer parameters

10.11 Water Level Measurement

The usual means of employed are the electric sounder, the wetted tape method), the air line method (*pressure of water column*).

CHAPTER SEVEN

WATER SUPPLY SCHEME COMPONENTS

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WATER SUPPLY SYSTEM COMPONENTS

1. General

The component of a water supply system depend on a number of factors. The most important factors to be taken in consideration in the design of the system are as follows:

1.1 Type of Source,

- river water ,
- lake,
- ground water, and
- spring

1.2 Raw Water Quality

- requiring no treatment
- requiring conventional treatment
- requiring special treatment

1.3 Topography of the Distribution Area

- suitable for gravity supply
- requiring lifting of water
- requiring elevated reservoir

1.4 Size of the scheme

- point service
- small scheme
- extended service covering large area

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2. Surface Water Source

2.1 General

A water supply system having a surface water as a raw water source will have the following components:

- intake structure
- raw water pumping station
- raw water main
- treatment plant
- clear water pumping station
- clear water main
- reservoir
- distribution network

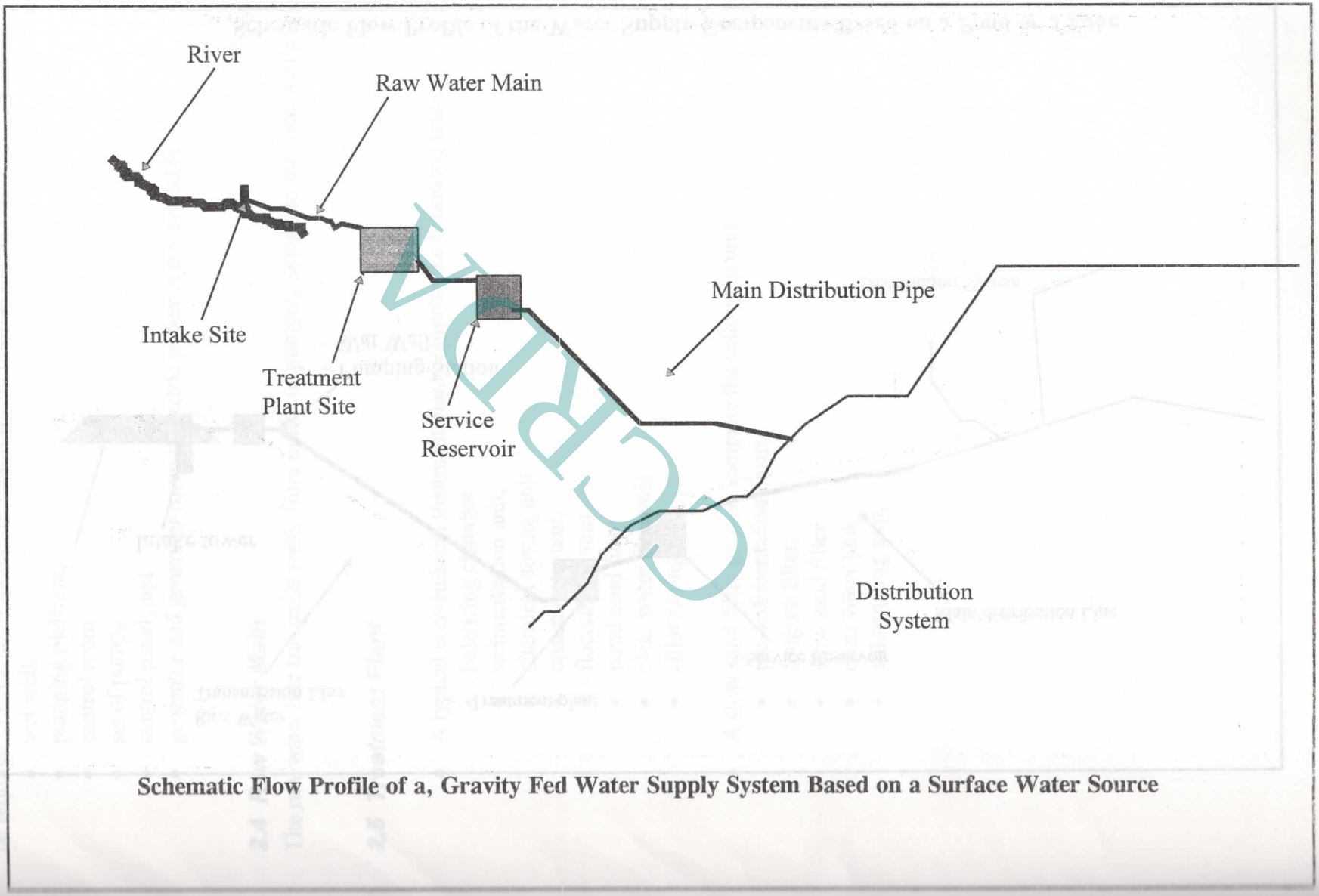
2.2 Intake Structure

- If the river has adequate flow all over the year the system components will be as follows:
  - river diversion structure
  - an inlet chamber,
  - intake water controlling device
  - intake channel or pipe
  - an outlet chamber

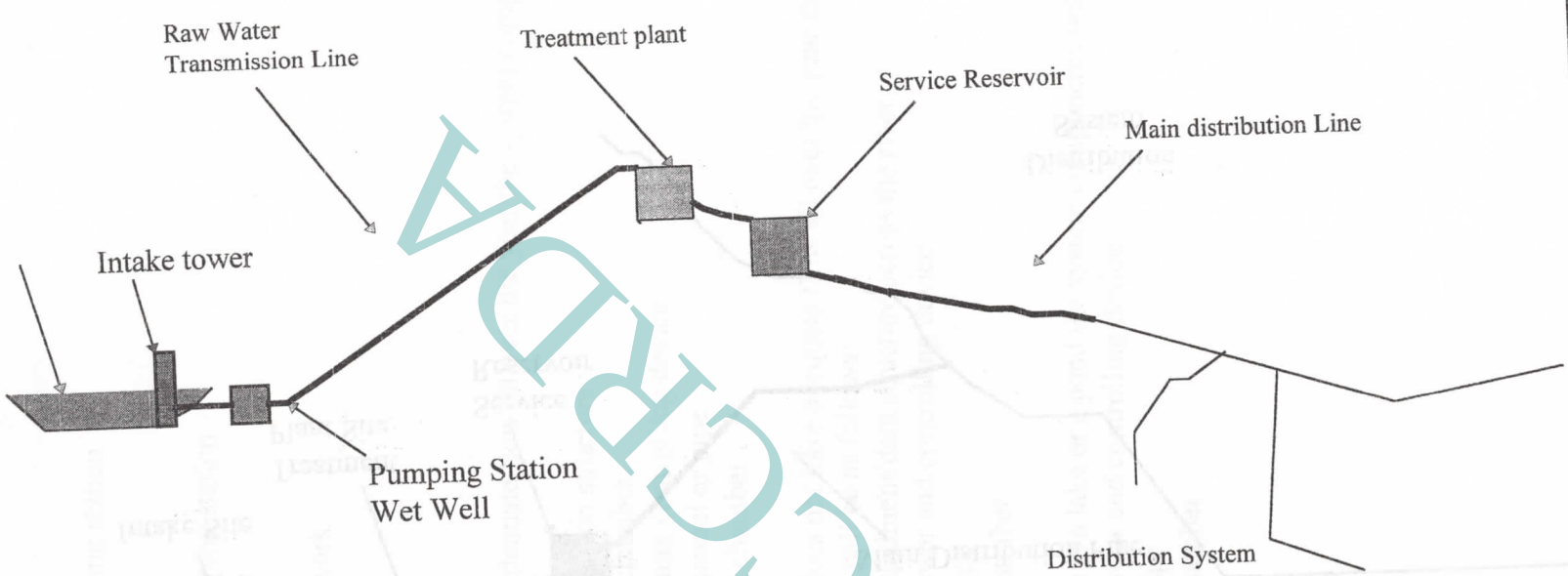
- If the river does not have adequate flow all over the year the system components will be as follows:
  - an impoundment/dam structure across the river
  - intake tower and controlling device
  - intake pipe
  - outlet chamber

- If the source is a lake or a pond the system components will be as follows:
  - intake tower and controlling device
  - intake pipe
  - outlet chamber

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Schematic Flow Profile of a, Gravity Fed Water Supply System Based on a Surface Water Source



Schematic Flow Profile of the Water Supply Components Based on a Pond or a Lake

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2.3 Raw Water Pumping Station

If the water cannot be transported to the treatment plant by gravity a pumping station will be required. Such kind of pumping station would normally comprise of:

- wet well,
- pumping platform,
- control room
- set of pumps
- control panel, and
- generator and generator room if electric power is not available

2.4 Raw Water Main

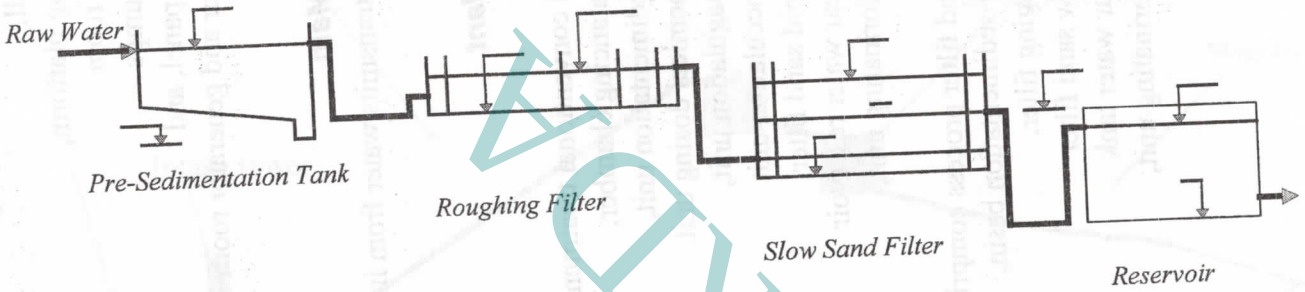
The raw water line transmits water from intake or pumping station to the treatment plant

2.5 Treatment Plant

- A typical conventional treatment plant comprise the following units:
  - balancing chamber,
  - sedimentation unit,
  - chemical dosing unit
  - coagulation unit,
  - flocculation unit
  - rapid sand filter
  - clear water reservoir
  - chlorinating unit,

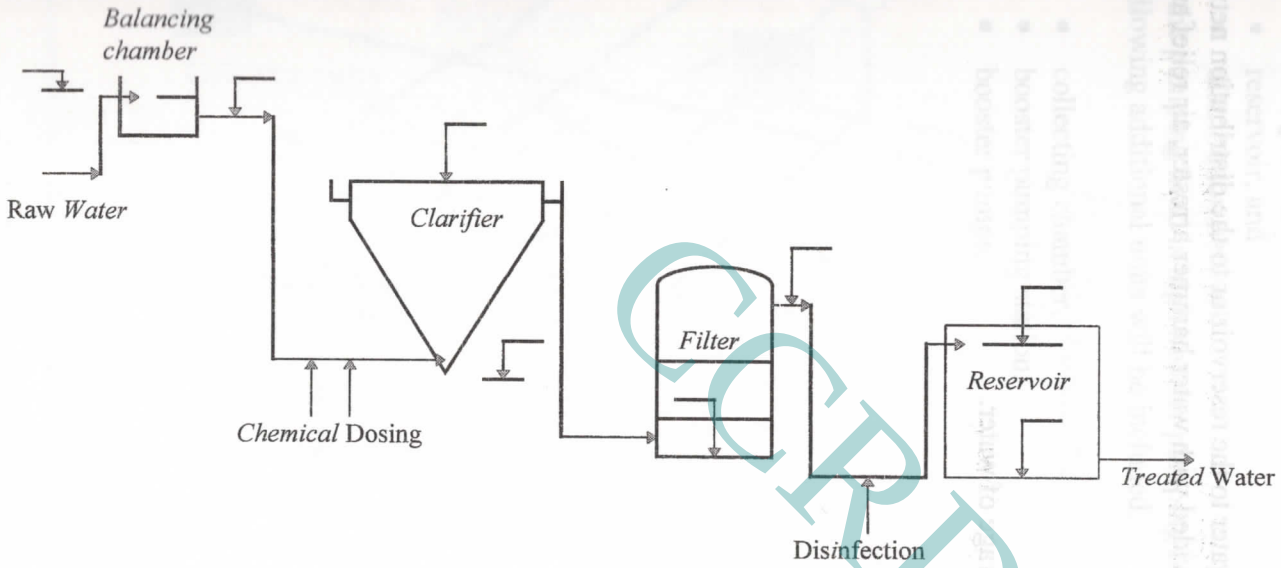
- A slow sand filter process comprise the following unit:
  - pre-sedimentation basin,
  - rouging filter,
  - slow sand filter
  - clear water tank
  - chlorinating unit,

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Schematic Diagram Showing the flow Profile of a Slow Sand Filter Treatment Plant

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Schematic Diagram Showing the Flow Profile of a Conventional Treatment Plant

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2.6 Clear Water Pumping Station

The clear water pumps, pump water from the clear water tank to the reservoir. Such a pumping station normally comprise the following:

- pumping platform,
- control room
- set of pumps
- control panel, and
- generator room if electric power is not available

2.7 Water Mains

The water mains transmit the water to the reservoir or to the distribution network. The transmission mains will be provided with water hammer arrester, air relief and flushing devices as required.

2.8 Reservoirs

Reservoirs are provided for storage of water.

2.9 Distribution Networks

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3. Ground Water Source

A water supply system based on ground water source will have the following components:

- bore-hole,
- riser main,
- bore-hole pump,
- pump control system,
- generator and generator room if electric power is not available,
- collector pipe if more than one bore-hole is used,
- rising main,
- reservoir, and
- distribution network

If the pumping head is high booster pumping might be required, in this case the following additional units will be included.

- collecting chamber,
- booster pumping station,
- booster pumps,

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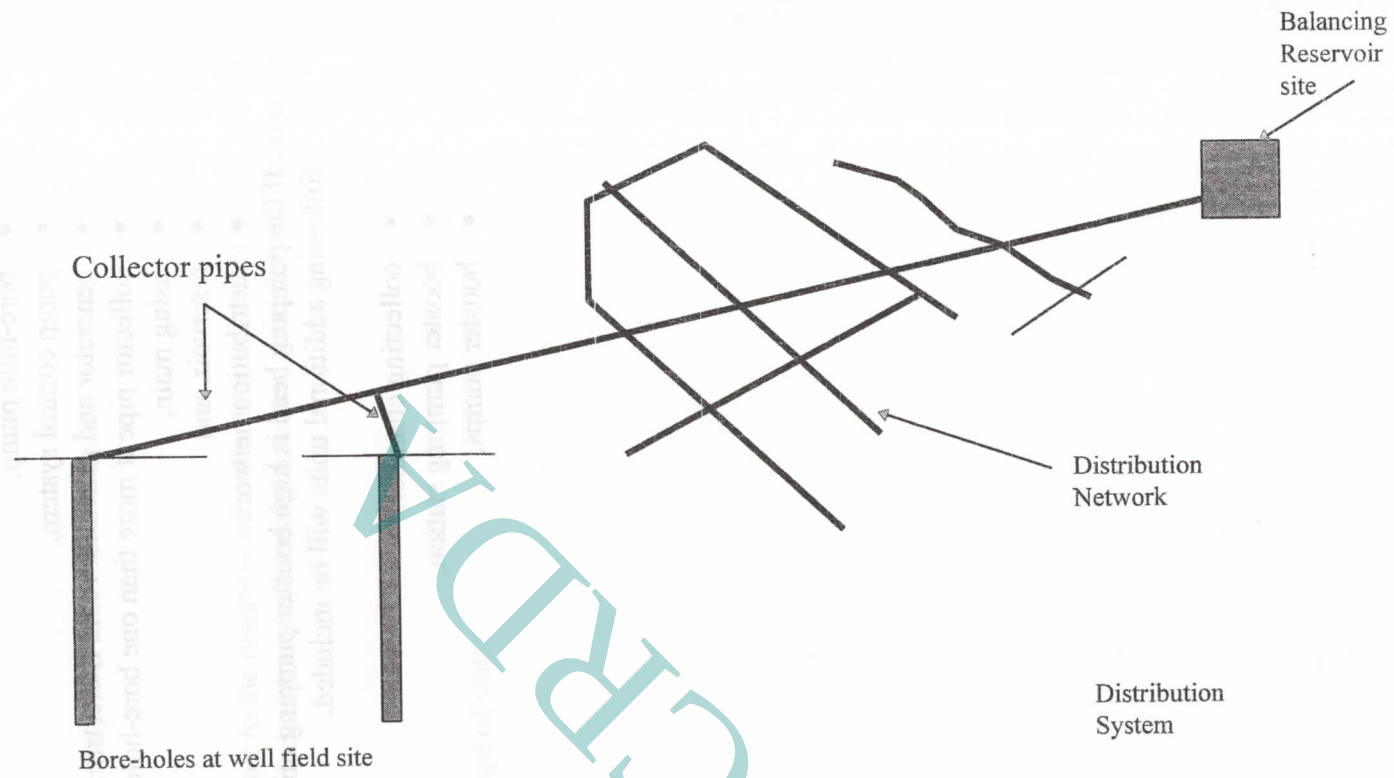


Figure 8 Flow Profile of a Ground Water Scheme

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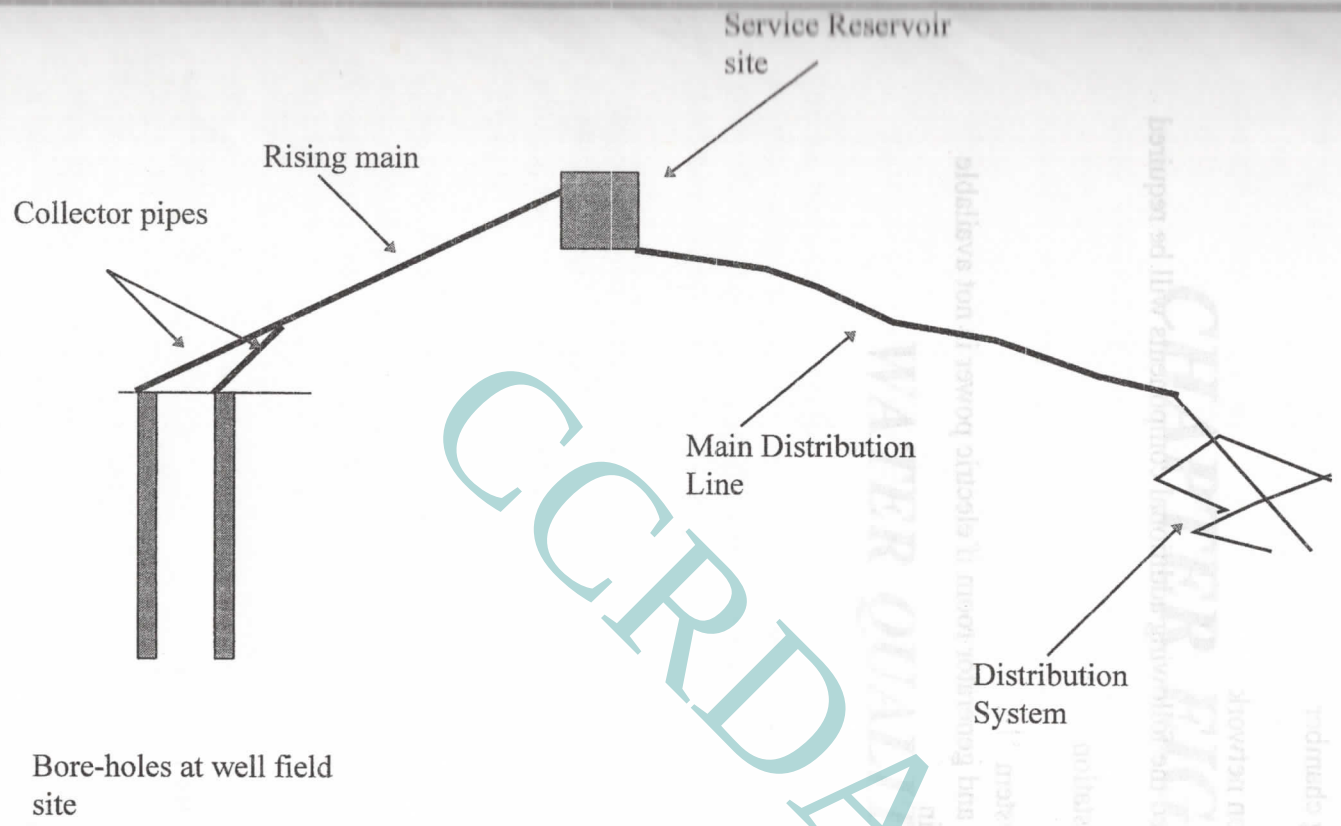


Figure 8 **Flow Profile of a Ground Water Scheme**

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CHAPTER EIGHT

WATER QUALITY

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WATER QUALITY

1 INTRODUCTION

Drinking water quality as described by the World Health Organization guideline is such that the water is suitable for human consumption and for all usual domestic purpose including personal hygiene.

In rural areas, not all water is fit for human consumption. The potential sources of drinking water in rural areas are:

a. Ground water from natural springs, wells or by other abstraction methods

b. Surface water from streams, rivers, lakes etc.

c. Rain water from roofs, paved areas or from large natural or artificial catchment areas

Ground water is naturally free from contaminating organisms. Many harmful organisms are retained and filtered by the soil. However, ground water may become unpotable as a result of contact with minerals in the soil formations. Certain minerals such as fluoride when they are present in excess cause debilitating illness.

Ground water can also become contaminated from deep waste pits and latrines located close to the wells or springs. Other contaminants such as dust, dirt, animal droppings, dead animals may enter an uncovered water source and contaminate the water in the well or spring.

Clean water from protected springs and wells is often contaminated during transport from source to home and during storage. Water stored in open containers is easily contaminated. Water can also be contaminated when drawing from the household storage with unclean utensils. *It is important to improve on water handling (safe water chain) to be able to maintain the water quality at point of drinking. Hygiene behaviour change/improved hygienic practices is an essential element to be communicated to communities during water quality surveillance (see Social Manual).*

Surface waters are nearly always subject to contamination by people and/or animals unless located in an upland catchment which is totally protected. Even in such cases surface water is subject to contamination from bird droppings and wild animals or vermin. For all practical purpose, surface water must be treated before consumption. Toxic chemicals, such as fertilizers and pesticides can pollute surface waters.

Rain water is naturally pure except in cases where atmospheric pollution in recent years is resulting in contamination. However, when it is collected from roofs it may be contaminated by bird droppings, dust and by pathogens in the air.

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2 DRINKING WATER QUALITY PARAMETERS

Ideally drinking water should:

- be free from micro-organisms known to be pathogenic. It should also be free from bacteria indicative of faecal contamination
- be free from turbidity, undesirable colours, odour and taste
- not contain excessive concentration of chemicals which may be harmful to health or economically undesirable
- not contain excessive concentration of undesirable dissolved gases.

In annex 2, WHO guideline drinking water quality values are presented however as stated in 2.5.d these are extremely difficult to achieve unless treatment is carried which would mean increasing the capital and operational costs, as well as the complexity of operating the water supplies. These guidelines therefore are treated as the desirable target. For every completed water supply the water quality should satisfy the temporary water quality standards presented in table 2.5.

3 WATER QUALITY SURVEILLANCE AND CONTROL

3.1 Definition

Surveillance as defined by WHO is the keeping of a careful watch at all times, from the public health point of view, over the safety and acceptability of drinking water. It requires a continuous and systematic programme of surveys. Surveillance also require legislation supported by regulatory standards and codes of practice. National and Regional Health authorities should be responsible for establishing surveillance and control programmes taking into account local economic and manpower conditions.

3.2 Methods for Evaluating Drinking Water Quality

Rural communities are often at risk from water-borne diseases and their water supplies need to be safeguarded through effective surveillance. However these requirements have to be balanced against the available resources and cost implications of this work. A pragmatic programme of surveillance and control to be carried out for this programme is as follows :

- analysis of all proposed new sources
- control and approval of all new schemes before commissioning

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- ideally routine inspection of all operating schemes once per year as part of a proactive preventative programme. Alternatively inspection on a reactive basis to suspicion or actual experience of pollution of a water supply.

There are three methods for determining the hygienic safety of drinking water:

- bacteriological analysis
- physical and chemical analysis
- sanitary survey.

The majority of surveillance and control will be based on tests utilising field kits and on physical inspections as described under sanitary surveys. However monitoring and control of the programmes will be under the overall administration of the regional or zonal laboratories who will carry out routine sample and special testing. Laboratories currently exist at all regional levels and it is planned in future that these are extended to the provision of facilities at all zonal levels.

Bacteriological analysis:

Contamination of drinking water by excreta constitute the most common mechanism for transmission of disease. The primary objective of the bacteriological examination of water is thus the detection of faecal contamination. Although it is possible to detect pathogens in water, the isolation and identification of many of them are extremely complicated and too costly. An indirect approach is taken using normal enteric organisms (indicator organisms) that will indicate the level of faecal contamination. The estimation of such organisms provide an indirect indication of the risk from water-borne pathogens.

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The indicator organisms most commonly measured are the coliform groups and faecal coliforms.

Two methods have been developed for the detection of coliforms and faecal coliforms:

- the multiple tube method
- the membrane filtration method.

Field application of the methods as well as description of the indicator organisms is available and supplied along with field kits like the "Delagua kit".

In case the sample exceeding the maximum limit the following should be carried out:

- Retest (to check sampling contamination or testing error). If retest confirms high E Coli, remove the obvious sources of pollution and continue monitoring

- If retesting, removal of obvious pollution and further monitoring (for at least 1 month) still show a level above the maximum limit then:

  a) Inform the Regional Health Bureau;

b) Advise people to boil water

c) carry out a major sanitary investigation and identify the source of pollution and/or construction or design fault. The problem should then be rectified.

Physical and chemical analysis

The physical and chemical parameters appropriate to rural water supply as referred in Section 2.5 should be examined by means of mobile Hach kits or similar. Control testing should be carried out at zonal or regional laboratories on the basis of one control per 500 field samples minimum. Regular calibration should be carried out by the user of the kit and be checked by the above mentioned laboratories.

Sanitation surveys

Sanitation inspection can also be utilised as an effective drinking-water quality surveillance intervention. By definition, sanitation inspection is on-site inspection and evaluation of all conditions, devices and practices in a water supply system that pose or may pose a danger to human health with a view to taking corrective action.

Rural water supplies are characteristically small in size typically from wells, springs or rain water storage. The sources of contamination for small-sized water schemes can be in particular effectively detected through sanitation inspections. Locally employed staff such as community health agents can perform sanitation inspection.

Sanitation inspections can be carried as follows:

a) A sanitation inspection form is designed for each of the main types of water systems

b) A check list of all the technical parts in each type of facility is identified on the form from which the technician carries on his inspections.

c) A sanitation inspection risk score ranging from 0 (no risk) to 10 (very high risk) is devised. The risk scores are then added and averaged out to determine the health risk associated with each facility.

An example of a sanitation inspection form for a handpump well is shown in Table 7.6.

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The overall contamination risk is then calculated by dividing the total risk score with the number of items inspected.

Check lists of all the technical parts of protected springs, drilled well and boreholes, infiltration galleries can be prepared using the above examples as format.

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TABLE 4 : Sanitation Inspection Form - Handpump

NO.	SPECIFIC DIAGNOSTIC INFORMATION	*RISK SCORE
1	Latrine within 15-20 meters of the well	----
2	Is the nearest latrine on higher ground than the well	----
3	Other sources of pollution within 15 meters	----
4	Poor drainage arrangement causing stagnant water within 2 meters of the well .	----
5	The drainage channel condition	----
6	The well cover adequately were tight	----
7	The well cover sufficiently raised above ground level	----
8	The water tight well lining extend to at least 3 m below ground level	----
9	Cracks around well cover	----
10	Rope and bucket condition	----
11	Pump condition	----
12	Condition of manhole cover	----
13	Diversion ditch provided	----
14	Fence around the well	----
15	Others (specify)	----
16		----
17		----
	Total risk score	------

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* Contamination risk scores:

9-10	very high	1-2	low
6-8	high	0	no risk
3-5	intermediate		

ANNEX WHO DRINKING WATER QUALITY GUIDELINES

Tables 1 to 5 show the WHO guideline values for drinking water quality. WHC guideline are divided into:-

a. Micro-biological and biological quality

b. Inorganic constituents of health significance

c. Organic constituents of health significance

d. Aesthetic quality

e. Radioactive substances

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TABLE 1 : Microbiological and Biological Quality

ORGANISM	UNIT	GUIDELINE VALUE	REMARK
I. Microbiological quality			
A. Piped water supplies			
A.1 Treated water entering the distribution system			turbidity < 1NTU; for disinfection with chlorine, pH preferably < 8.0; free chlorine residual 0.2-0.5 mg/litre following 30 minutes (minimum) contact
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	0	
A.2 Untreated water entering the distribution system			
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	0	in 98% of samples examined throughout the year in the case of large supplies when sufficient samples are examined.
coliform organisms	number/100 ml	3	In an occasional sample, but not in consecutive samples
A.3 Water in the distribution system	number/100 ml	0	
faecal coliforms	number/100 ml	0	in 95% of samples examined throughout the year- in the case of large supplies when sufficient samples are examined.
coliform organisms	number/100 ml	3	In an occasional sample, but not in consecutive samples
B. Unpiped water supplies			
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	10	should not occur repeatedly; if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible.

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ORGANISM	UNIT	GUIDELINE VALUE	REMARK
C. Bottled drinking-water			
faecal coliforms	number/100 ml	0	source should be free from faecal contamination
coliform organisms	number/100 ml	0	
D. Emergency water supplies			advise public to boil water in case of failure to meet guideline values
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	0	
Smeroviruses	-	no guideline value set	
II. Biological quality			
Protozoa (pathogenic)	---	no guideline value set	
Helminths(pathogenic)	---		
Free-living organisms (algae, others)	---		

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TABLE 2 : Inorganic Constituents of Health Significance

CONSTITUENT	UNIT	GUIDELINE VALUE	REMARKS
arsenic	mg/l	0.05	
asbestos	-	no guideline value set	
barim	-	no guideline value set	
beryllim	-	no guideline value set	
cadmium	mg/l	0.005	
chromium	mg/l	0.05	
cyanide	mg/l	0.1	
fluoride	mg/l	1.5	natural or deliberately added; local or climatic conditions may necessitate adaptation.
hardness	-	no health-related guideline value set	
lead	mg/l	0.05	
mercury	mg/l	0.001	
nickel	-	no guideline value set	
nitrate	mg/l(N)	10	
nitrite	-	no guideline value set	
selenium	mg/l	0.01	
silver	-	no guideline value set	
sodium	-	no guideline value set	

TABLE 7.3: Organic Constituents of Health Significance

CONSTITUENT	UNIT	GUIDELINE VALUE	REMARKS
aldrin and dieldrin	ug/l	0.03	
benzene	ug/l	10[a]	
benzo [a] pyrene	ug/l	0.01[a]	
carbon tetrachloride	ug/l	3[a]	tentative guideline value[b]
chlordane	ug/l	0.3	
chlorobenzenes	ug/l	no health -related guideline value set	odour threshold concentration between 0.1 and 3 ug/l
chloroform	ug/l	30[a]	disinfection efficiency must not be compromised when controlling chloroform content
chlorophenols	ug/l	no health - related guideline value set	odour threshold concentration 0.1 ug/l
2,4-D	ug/l	100[c]	
DDT	ug/l	1	
1,2-dichloroethane	ug/l	10[a]	
1,1-dichloroethene[d]	ug/l	0.3[a]	
heptachlor and heptachlor epoxide	ug/l	0.1	
hexachlorobenzene	ug/l	0.01[a]	
gamma-HCH lindane)	ug/l	3	
methoxychlor	ug/l	30	
pentachlorophenol	ug/l	10	tentative guideline value[b]
tetrachloroethene [d]	ug/l	10[a]	tentative guideline value[b]
trichloroethene [d]	ug/l	30[a]	odour threshold concentration, 0.1ug/l
2,4,6-trichlorophenol	ug/l	10[a,c]	see chloroform
trihalomethanes	ug/l	no guideline value set	

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a These guideline value were computed from a conservative hypothetical mathematica model which cannot be experimentally verified and values should therefore be interpretec differently. Uncertainties involved may amount to two orders of magnitude (i.e., from 0.1 to 10 times the number).

b When the available carcinogenicity data did not support a guideline value, but the compounds were judged to be of importance in drinking water and guidance was considered essential, a tentative guideline value was set on the basis of the available health - related data.

c May be detectable by taste and odour at lower concentrations.

d These compounds were previously known as 1,1 dichlorethylene, tetrachloroethylene and trichloroethylene, respectively.

Table .4 : Aesthetic Quality

CONSTITUENT	UNIT	GUIDELINE VALUE	REMARKS
aluminium	mg/l	0.2	
chloride	mg/l	250	
chlorobenzenes and chlorphenols	-	no guideline value set	these compounds may affect taste and odour
colour	true colour units (TCU)	15	
copper	mg/l	1.0	
detergents	-	no guideline value set	there should not be any foaming or taste and odour problems
hardness	mg/l (as $CaCo_3$)	500	
hydrogen sulphide	-	not detectable by consumers	
		0.3	
bor	mg/l	0.1	
manganese	mg/l	no guideline value set	
oxygen - dissolved	-	6.5 - 8.5	
pH	-	200	
sodium	mg/l	1000	
solids - total dissolved	mg/l	400	
sulphate	mg/l	inoffensive to most consumers	
taste and odour	-	no guideline value set	
temperature	-	5	
turbidity	nephelometric turbidity units (NTU)	5.0	preferably < 1 for disinfection efficiency
zinc	mg/l		

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TABLE .5: Radioactive Constituents

CONSTITUENT	UNIT	GUIDELINE VALUE	REMARKS
gross alpha activity	Bq/l	0.1	a) If the levels are exceeded more detailed radionuclide analysis may be necessary.
gross beta activity	Bq/l	1	b) Higher levels do not necessarily imply that the water is unsuitable for human consumption.

As the parameters of measurement mentioned in the WHO guidelines are many and require sophisticated laboratory facilities, only those parameters that have significance for rural water supplies should be considered. Emphasis is placed first and foremost on the microbiological safety of drinking water. A limited number of physical and chemical parameters such as colour, hardness, pH may also be considered to be of general significance for small - community water supplies.

These small number of physical and chemical parameters can be determined with field kits which can be easily purchased.

The concentration limits recommended by WHO guideline, especially the microbiological limit are too stringent for the conditions of rural water supplies in Ethiopia. There is a need by national or regional health authorities to make their own choice of parameters and set local standards taking into account the variety of local geographical, socio-economic, technological and environmental conditions prevailing.

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CHAPTER NINE

DESIGN PARAMETERS

CCRDA

CRDA - TRAINING ON COMMUNITY BASED WATER SUPPLY AND SANITATION

COURSE TITLE - DESIGN PARAMETERS

1. INTRODUCTION

1.1 Background

The design criteria currently in use in the country varies from region to region and are not consistent and uniform to one another in content as well as values and conditions. Until recently most of the Regional Water Bureaus did not have a well established design criteria and procedure for the planning and design of water supply schemes particularly for rural water supply schemes.

Most of the regions use some kind of design criteria established from experience but not known to every planner or designer working in the region. Some regions use design criteria not properly established by the region but refer from texts and standards while some are using the design criteria followed in the planning of specific urban and rural projects implemented by different organizations.

In some regions the Water Bureaus are trying to establish their own design criteria and procedure to be used in the planning and design of water supply schemes. However, there are not any kind of design criteria guidelines properly prepared and compiled together so far.

Other than the regional bureaus, NGOs and other private organizations are implementing water supply schemes, particularly in rural areas. Most of these organizations do not also have properly established design criteria and follow their own assumptions and procedures or use similar design criteria used by the region in which they are working. This type of works have for instance created a problem in the commissioning of some projects in some regions.

Uniform design criteria at least at regional level and if possible in the whole country would be essential for standardization of design and construction of water supply facilities within a specific program. This would greatly assist designers and implementers in avoiding the necessity of considering design criteria specifically each time a new water supply project is planned.

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1.2 Need For Design Criteria

The objective of any water supply system is to supply safe water in adequate quantity at a convenient location from the dwelling and at a reasonable cost to the users. In order to achieve these objectives, design of water supply system has to be based on sound technical and social design criteria.

The design criteria to be used in the design of the water supply scheme has to enable the decision makers to make sound technical and social decisions. The basic considerations for appropriate and sound technical and social decisions are:

- The local condition of the area
- Population to be served
- The design period
- The different types of water demand
- Selection of the type of water source
- Type and location of the facilities to be provided

Establishing appropriate design criteria will help in fulfilling the objectives and targets of the intended water supply projects. In other words the design criteria to be established has to take in to account the basic considerations mentioned above and incorporate the willingness and affordability of the beneficiaries to be served while running the schemes sustainable.

The basic considerations mentioned above varies from one region to another or even within the region depending on the size, culture of the people, climate, water resources potential and other factors. In such cases the design criteria has to be carefully prepared in order to satisfy the targets and objectives of the supply of water to the communities. Accordingly the design criteria to be prepared may not have to be the same but has to follow the principles required for the planning and development of water supply schemes.

In general it is important to ensure the best possible design to provide the community with a water supply system which is sustainable, safe and adequate, least cost and located at a reasonable walking distance from the villagers. This can be achieved by using appropriate and realistic design criteria in the planning of the projects.

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2. ASSESSMENT OF EXISTING DESIGN CRITERIA

2.1 General

As mentioned above there are no properly established and bound design criteria guidelines so far. Some of the design criteria being used by the different organizations or regions are available in some form either in specific project documents or as a guiding letter for some specific projects.

The attempts to establish a water supply system design criteria and procedure is very limited in the past and not also encouraging until recently. This might be probably due to frequent changes in organizational structures setup of the water sector organizations. As a result there are only very few attempts made to establish some kind of design criteria at federal and regional levels. The design criteria established, as attempted by some organizations are highlighted below to get a feeling of the type of parameters and levels considered in the design criteria .

2.2 Ministry of Water Resources

There is no properly established design criteria prepared by the Ministry of Water resources Development until very recently. Design criteria will be established for specific projects when ever there is such activities and this will be referred to the ministry for approval prior to the utilization of the criteria and this is done mostly for urban water supply projects. Design criteria for the rural water supply is not also used The design criteria followed by the Ministry of Water resources for rural water supply activities as given in the Draft Letter of Sector policy of January 1996 is highlighted as follows.

- Water demand from 15 - 25 liters/ capita/ day.
- Availability within 0.5 - 1.0 km from a dwelling.
- Establishment of an Ethiopian water quality standard with view to achieving the WHO guideline.

Additionally the draft letter of the sector policy of the ministry refers to the levels of service for water supply in the country with a view to establishing a national standard. The referred level of service may not take in to account the appropriateness of other factors in each locality and is given as indicative to be used in the country in line with the letter of the sector policy. The level of service indicated by the Ministry is shown below in Table 1.

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Table 1. Level of Service - Draft Letter of Sector Policy

Size of group of population	Type of Service	Level of service
<100	Dug well	Provided by community self help
101- 400	Dug well large diameter	Hand pump fitted
401 - 2000	Drilled well	Hand pump fitted, 300-350 persons/well
2001-5000	Piped supply	95% served by public fountain, 400-500 persons/fountain
5001-10000	Piped supply	80% served by public fountain, 400-500 persons/fountain
10000 and above	Piped supply	60% served by public fountain, 400-500 persons/fountain

2.3 Southern Region

The then called Water Resources Development and Conservation Department, of the Southern Ethiopia Nations and Nationalities Regional State, March 1994 has prepared a technical design guidelines and procedure in which some design parameters are described. The per capita daily water demand is shown below in Table 2.

Table 2. Per capita Consumption - Southern Region Water Resources

Item No.	Design population Range	Per Capita Daily Water Demand (L/cap/day)	
		Present average day	15 years average day
1	0 -1,500	15	20
2	1,500 - 4,500	20	25
3	4,500 - 10,000	25	30

The Water Resources and Conservation Department also stipulate maximum daily and peak hourly demand factors as 1.2 times the average daily demand and 2.5 times the average hourly demand on the average day respectively.

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In addition to the above mentioned criteria, the level of service is also established based on type of source and population size by the Water Resources and Conservation Department of the Southern Region as shown in Table 3 below.

Table 3. Level of Service - Southern Region Water Resources

Item No.	Type of Water Supply	Type of Water point	Number of People Served Per Water Point
1	Sallow Well with Hand Pump	Hand Pump	250
2	Bore Hole with Hand Pump	Hand Pump	250
3	Pipe Network	4-6 faucets fixed per water point	800 for 4 faucet water points. 1200 for 6 faucet water points

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2.4 ESRDF

The Ethiopian Social Rehabilitation Development Fund (ESRDF) has developed Technical Design Manual and Hand Book for water supply and sanitation projects which can be used by the technical staff working on the projects funded by the organization. In this technical manual design parameters which could be used in the planning and design of water supply and sanitation projects for rural water supply are described. In the technical design manual, a lot of parameters are being treated as design criteria and are briefly presented below.

Population projection is one of the parameters discussed in the technical manual and the target population is defined as "the rural poor" and taking the objective of community participation the maximum design population group of 10,000 persons, equivalent to the present population of about 7,000 has been considered as a limiting range for the rural water supply scheme under that specific project. It also considers other factors in the population projection such as site conditions and characteristics of growth in the specific community.

The criteria also specifies that water supply projects must be designed to meet the water demand requirements of the consumers for a specified period of years which varies from 5 to 30 years depending on different conditions. The recommended design period for the rural water supply systems which will accommodate the water requirement of the community is 15 years. Based on the 15 years design period it also recommends for phasing of the different components of the water supply scheme to be 8 years or as appropriate as shown in Table 4 Below.

Table 4. Phasing of Project Water Supply Component - ESRDF

Water Supply Type	Phasing	Remark
Springs	Dependent	On yield/distance balance
Hand dug wells	Dependent	On yield/distance balance
Bore holes	Dependent	On yield/distance balance
Infiltration galleries	No	
Pipelines	No	
Storage tanks	Yes	
Public fountains	Dependent	On distance criteria
Hand pumps	Dependent	On source decision
Solar pumps and panels	Yes	The pump has to be replaced
Motorized pumps	Yes	The pump has to be replaced

The criteria for the per capita water demand is also set in the ESRDF manual based on the following factors affecting the demand.

- Distance to source
- Type of source
- Development stage of the community
- Hygienic practices of the community

Accordingly the per capita water demand established in the manual is shown in Table 5.

Table 5. Per capita Water Demand - ESRDF Technical Manual

Supply Type	Design Population Range	Average Daily Demand	
		Present l/c/day	Projected 15 years l/c/day
Point springs/hand pumps	All	15	20
Public fountains	Up to 5000	20	25
Public fountains	5,001 - 10,000	25	30

The level of service and the distance to improved water sources recommended in the manual are presented in Table 6 and Table 7 respectively below.

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Table 6. Number of Population Served per Water Point - ESRDF

Item No.	Type of Water Supply Scheme	Type of Water point	Number of users Per Water Point
1	Spring at point	point	400 per outlet
2	Spring by gravity	Public fountain(6 faucet)	900
3	Spring motorized	Public fountain(6 faucet)	900
4	Shallow hand dug well with hand pump	Hand pump	300 - 350
5	Shallow machine augured well with hand pump	Hand pump	300 - 350
6	Deep bore hole with hand pump	Hand pump	300 - 350
7	Deep bore hole with Mechanized pump	Public fountain(6 faucet)	900
8	Deep bore hole with solar or wind pump	Public fountain(6 faucet)	900
9	Infiltration galleries or sub surface dams	Public fountain(6 faucet)	900

Table 7. Max. Distances to Water Point by Type of Sources - ESRDF

Type of Source	Maximum Distance to water source
Hand dug well with hand pump	1.0 km
Shallow bore hole with hand pump	1.0 km
Shallow bore hole with submersible pump point supply	1.0 km
Deep bore hole with submersible pump public fountain	0.5 km
Spring point supply	1.5 km
Spring with public fountain	0.5 km
Difficult supply situations	1.5 km

The technical manual also describes design criteria on water quality levels to be followed and type of technology options to be used in the rural water supply and sanitation planning and design for the projects to be implemented by ESRDF funds.

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3. BASIC WATER SUPPLY DESIGN PARAMETERS

3.1 Definition and Use of Design Parameters

Design parameters are the basic established conditions or factors which are used in the planning and design of a water supply system in an economical way and the provision of safe and adequate water supply scheme for a given area or community. The conditions or factors to be considered during the planning and design could vary from place to place and community to community but will be based on the basic principles set for the preparation of the design parameters.

Design parameters are used in the determination of different conditions when designing and planning a water supply system for certain community some of which are:

- Estimation of population to be served over a given time span
- Estimation of the water requirement
- Sizing of the water supply components
- Determination of type of water source to be developed
- Planning of the economic and financial conditions

There could be other uses of design parameters which can be considered as relevant depending on the specific conditions of a project.

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3.2 Basic Design Parameters

As stated in chapter 2 above there are a number of parameters used in the design criteria by the different organizations. Most of the criteria are not uniform and complete in terms of basic requirements for the establishment of a design criteria.

A design parameter which is applicable in one area may not be used in other areas. However, the general and basic design parameters which has to be considered in the design and planning of water supply scheme are out lined as follows.

1. Fixing Design horizon: Design horizon is a time scale for which the water supply components planning will be done. In most cases urban water supply services are planed for 20 years in two phases and rural water supply services are planed for 15 years mostly in one phase.

2. Population Projection: Determination of the size of population at a given design period is very important. Population projection has to be based on a population count and growth rate established by a known statistical office or a properly established population survey study such as the master plan study or population census for elections, etc.
3. Establishing Per Capita Water Demand: In order to establish the per capita water demand for a given project area it is important to first of all determine the following conditions:
    - The size of the community
    - The housing conditions of the area
    - The economic and business activities in the area
    - The per capita annual income of the community
    - The living standard of the community in general
    - Climatic condition of the area
    - Basic water requirement for hygienic and other purposes
    - Future development potential of the area and other factors

    Ones the above mentioned conditions have been studied then the per capita water demand for the given community can be established. The per capita water demand may increase with the improvement of the standard of the living condition of the community particularly with the enhancement of the level of awareness regarding the use and hygienic benefit of safe and adequate water.

    The per capita water demand for the rural areas vary from 15 l/c/day to about 30 l/c/day depending on the design period and the conditions mentioned above.

    For urban areas the per capita water demand could vary from 15 l/c/day for public fountain users to as high as 100 l/c/day for house connection users and the per capita water demand may grow by up to 2% annually.
4. Establishing Water Demand Variation Factors: Water demand varies from day to day and hour to hour depending on the activities of the community and the level of water supply service. The variation of the water demand is established for a given project area as a factor of the average day water demand. Such factor is normally established based on water consumption survey. The survey is carried out when there is sufficient and normal water supply condition in the study area. The factors are described below:

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- The water demand which will be obtained by multiplying the projected population with the projected per capita water demand is an average day water demand.
- The water demand in certain day of the week may rise above the normal average day demand. Such demand is called maximum day water demand. In order to determine the maximum day water demand the average day water demand is multiplied by a factor.. The maximum day factor varies from 1.1 to as high as 1.8 in some cases. The smaller the community the higher the factor could be.
- Similar to the maximum day demand the water demand may rise above the normal average day hourly demand. Such demand is called peak hour water demand. In order to determine the peak hour water demand the average day water demand is multiplied by a factor. The peak hour factor normally varies from 1.5 to as high as 4.0 in some cases. The smaller the community the higher the factor could be.

5. Establishing The Level Of Service: The level of water supply service mainly depends on the size of the population and the living standard of the community. The level of service could be point source from hand pump or public fountain depending on the type of source for rural area. For large community living in semi urban or urban type, the level of service could be a combination of public fountain, yard connection or house connection type. This has to be established by taking the living standard of the people, the affordability and willingness to pay, the development potential of the area and other factors as appropriate. The level of services indicated by the Ministry of Water Development as shown in Table 1, in combination with the others, could be a good guideline for use in the design of a water supply system.
6. Other Design Conditions: The most relevant design conditions which have to be taken in to account in the design of a water supply system are:
   - Animal demand has to be taken in to account if a traditional water source is not with in a 5 km radius from the community for watering the animals. The per capita water demand for different animals could be referred on standard books.
   - Public and Business demands can be incorporated if there are such institutions in the area such as schools, restaurants, etc. Such demand could vary from 20% up to 60% of the domestic demand and the smaller the community the higher the percentage could be.

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- Water losses due to leakage and other reasons could be taken in to account if the system has a distribution pipe line and the losses could vary from 5% up to 20 % of the average domestic water demand for a new scheme and old scheme respectively.

7. Phasing Of The water Supply Components: The water supply components will be phased during the design based on the economical condition and service life of the components. Accordingly the following phasing and sizing conditions could be used for the different water supply components:
    - River or Spring intake structures can be designed for the second phase maximum day water demand
    - Hand dug wells and shallow bore holes for the phase two maximum day water demand over 10 hours as rural schemes can operate only during day time.
    - Hand pumps to supply the maximum day hater demand of the community in not more than 10 hours or a minimum discharge of 0.25 l/s.
    - Motorized pumps for maximum day water demand of the first phase demand in not more than 12 hours.
    - Deep bore holes for the maximum day water demand over 12 hours for the second phase.
    - Transmission pipe lines for the second phase maximum day water demand over 24 hours or depending on the pump operation time.
    - Storage reservoirs for a capacity of one third of the maximum day water demand for phase one.
    - Distribution network for the second phase peak hour demand.

Other design factors or conditions which are not mentioned here could be referred to in text books, specific project documents and the existing design criteria described above. In addition to this the design parameters indicated here are to give ideas on how to establish them and may not apply to all types of projects. Therefore one has to assess the site specific condition prior to adopting the criteria.

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CHAPTER TEN

WATER LIFTING DEVICES

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CRDA - TRAINING ON COMMUNITY BASED WATER SUPPLY AND SANITATION

COURSE TITLE - WATER LIFTING DEVICES

1. INTRODUCTION

1.1 Background

Water can be found in a river flowing on a flat area or in a gorge, in a lake located on a flat area or in mountainous area or under ground. The location of the community settlement may not allow water to flow by gravity to where the community is living. In such cases water has to be lifted from one of the above mentioned sources by some devices so that it can reach the community at a closet point for abstraction. The water lifting can then be accomplished by using pumps.

The use of pumps have started very long time ago. Reciprocating hand pumps were used in Roman times, often for fire fighting and pumping out water from the bilge of boats. The concept of the perforated plunger valve and leather seal were already conceived by Agricola in the 16th century, and were widely used in Europe after this date. Pumps were made of wood at first, but metal-bodied pumps became more common in England in the 17th century and many were made from lead.

Presently both hand pumps and motorized pumps are widely used in the water supply sector and with out them, the supply of safe and adequate water supply to the human being could be difficult as there are no other solutions found so far. There are also very many different types of pumps used not only to pump water but also any liquid weather acidic or alkaline, thick or light, mud or clean.

1.2 Most Commonly Used Pumps in Ethiopia

Hand pumps and motorized pumps are the most commonly used types of pumps for the water supply activities in Ethiopia. There are also few solar pumps and wind driven pumps installed in the country for the water supply activities. Hand pumps, solar pumps and wind driven pumps are used for rural water supply service. Motorized pumps are used both for rural and urban water supply services.

There are different make of hand pumps in use in the country of which the most common ones are Indian Mark II (standard), Indian Mark II (modified), Afridev, Moyno, Monolift and some others.

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Centrifugal surface and submersible motorized pumps are the most commonly used. Diesel driven Monolift pumps are also very common for use in the rural water supply scheme where water pumping is required from bore holes.

1.3 Existing Problems Related to Pumps

The pumps in use so far in the country are installed without any kind of standardization. An organization working on the water supply sector can come with any brand available in his store and install it . Such situation has created serious problems in the sustainability of the schemes particularly after the organizations hand over the schemes to the community. This is because spare parts are not easily available and local mechanics or technicians from the village can not repair the pumps due to lack of tools and some pumps are beyond their knowledge. This condition is more reflected on rural water supply schemes where most of the hand pumps are used and has contributed to the malfunctioning of most of the rural water supply schemes.

2. WATER PUMPS

2.1 Necessity of Pumping

Pumping is usually required to raise water to a certain point in the system where water can not reach by gravity flow. Pumping is also done when the pressure in a system is required to be increased or from a lower point to a higher point. In general the pumping may be required for the following purpose:

- To pump raw water from a source to the treatment plants, called raw water pumping station.
- To pump treated water to a reservoir on higher ground or elevated tank, called pure or treated water pumping station.
- To pump directly in to a distribution mains.
- To pump water from a well in to a container or an overhead tank.
- To boost water in the distribution system to high points to improve pressure, called booster station.

The pump to be chosen to lift the water has to be reliable, efficient, simple to maintain and economical.

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2.2 Consideration for Installation of Pumps

The installation of pumps will be based on the design of the system. During the design the following important points have to be taken in to consideration.

- The quantity of water to be pumped usually expressed in liters per second.
- The geodetic level difference between the surface of supply source and the highest point in the line or delivery point in meters.
- Nature and condition of liquid to be lifted such as chemical and physical quality.
- The size and type of suction and delivery pipes.
- Method of driving the pump; manual, solar, wind, diesel or electric.

In case of surface pumps the pumping station has to be located at appropriate place in order for the safety of the pump and the simplicity of operation. Some major points to be taken in to consideration are:

- The pump has to be placed above the highest flood level of a river or lake.
- Availability of space for future expansion.
- Suitable for construction of the water collection chamber and pump house.
- Economical position in case of booster stations.

2.3 Type of Pumps

Pumps are classified based on the operating principles as follows

- Displacement pumps
- Centrifugal pumps
- Air lift pumps
- Miscellaneous pumps

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2.3.1 Displacement Pump

Displacement pumps are further divided in to reciprocating pumps and rotary pumps. The reciprocating pump has a piston or a plunger which alternately draw water in to a cylinder on the intake stroke and forces the same out in the discharge stroke. The rotary pump has two rotating pistons or gears which mesh together and draw water in to the chamber and force it practically continuously in to the discharge pipe.

2.3.2 Centrifugal Pump

Various type of centrifugal pumps are available out of which the volute centrifugal pump and the turbine pump are common. The centrifugal pump essentially consists of a circular casing with an impeller which has a number of spiral vanes inside it fixed on a shaft which is driven by some power. When the shaft force is produced by rotation of vanes which force the water up in to the delivery pipe.

2.3.3 Air Lift Pump

The air lift pump is operated by compressed air. The working principle is that by mixing the water with air in the discharge. The density of mixture is less than that of the water itself. Accordingly the pressure of the column of air and water in the bottom of suction pipe or delivery pipe is less than that of the solid water outside in the well and an upward flow is created. Compressed air is used to create the air - water mixture.

2.3.4 Miscellaneous Pumps

The other type of pumps which are used for lifting water are Pulsometer steam pump and hydraulic ram. The other pump is the bore hole pump where the motor is kept on the top of the well and the pump is lowered in to the well and a vertical shaft drives the pump.

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3. SELECTION OF PUMPS

3.1 General

As mentioned earlier the working principles of pumps differ from one an other. The difference in the working principle has got also an impact on the use of pumps for different water lifting characteristics.

To lift water from shallow wells hand pumps could be used if the amount of water to be lifted is small and for a small community. If the amount of water to be lifted is large then a motorized pump will be required to lift water from the shallow well or low head. On the other hand water may be lifted from the surface or a deep bore hole to a high point in which case motorized pump will be required.

The type of pumps to be used for the different lifting height and amount of water also varies both in the working principle and the driving force.

Hand pumps of different working principle are used to lift small community water supply from shallow wells or relatively deeper wells. (Please refer to the copied hand outs).

Motorized pumps are also operating based on the working principle and depends on the lifting height and quantity of water to be lifted. Proper calculations and selection of pumps have to be made regarding the lifting height and the water quantity as a result the power requirement (Please refer to the given hand outs).

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5. WATER LIFTING DEVICES

5.1 HAND PUMPS

a) Hand pumps are used for pumping water from shallow hand dug or machine drilled wells which are generally varying from a few meters to not more than 90 meters deep. Hand pumps use different operating principles but are commonly classified in accordance with the depth from which particular pumps can draw water, namely Low, Intermediate and High lift respectively.

b) Suction or direct action pumps are suitable as low lift pumps. Suction pumps depending as they do on atmospheric pressure to drive water up to the surface, are only suitable for lifts of maximum 7 meters and subject to the actual barometric pressure on site. Direct action pumps are reciprocating type where the operator's effort is applied directly to the plunger. This means the suitable depth is limited to the height to which an individual can physically lift the column of water and in practical application works out to around 12 meters. The mechanical simplicity of the pumps however make them particularly suitable for village level operation and maintenance and the fact that they do not need to be primed gives them an advantage over suction pumps.

c) Intermediate and high lift pumps are generally of the reciprocating, diaphragm or progressing cavity type. Deepwell reciprocating pumps are suitable for lifts of up to 45 meters or more dependent on design and the acceptability of getting progressively less water relative to effort as the depth increases. The submerged cylinder eliminates the need for priming but means that components must be removed from down the well for repair or maintenance. Diaphragm and progressing pumps have particular features of advantage but durability and maintenance costs and complexity means that most models are not suitable as a true VLOM pump.

d) As the groundwater table in the country varies from few meters below ground in some areas to up to 150 meters in other areas, the type of hand pumps to be used could be varied according to the pumping lift. However, the selection of hand pump should not only be based on the lifting characteristics but should also take into account the resistance to corrosive water, the discharge rate, ease of maintenance, reliability and other factors which will contribute to its sustainability.

e) There are several types of handpumps installed in Ethiopia both by the various government organisations and NGOs. There previously has been no standardisation of pumps and many implementers use hand pumps of different makes without fully taking into consideration the operation and maintenance implications, especially in relation to the availability of spare arts.

f) The currently most widely used handpump in the country is the Indian Mark II. However, according to the evaluation report by the UNDP/WB for different pumps the Indian Mark II is not an ideal VLOM type as it requires well organised skilled

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personal and use of heavy lifting equipment, which can not be made easily available at village level, for the installation and maintenance works.

g) Most regions in the country are now implementing a policy of standardisation of hand pumps. The Southern Ethiopia Peoples' Region in its Technical Design Guidelines and procedures has adopted the Aquadev/Afridev for wells up to 45m depth and Moyno model 2V12L or the modified Indian Mark II Extra Deep Well pump for deep wells. The Oromiya,Tigray and the Amhara Regions have also indicated the intention of standardisation on the Afridev pump.

h) In the selection of handpumps for standardisation the following factors should be considered:

- capability and efficiency of lifting water from a few meters below the surface up to a maximum of 45 meters
- resistance of the pump rods and rising main materials to corrosive water.
- discharge rate with respect to the lifting depth and the level of service.
- ease of maintenance and running cost in order for the system to operate in accordance with VLOM principals
- the reliability of the pump has to be very high as the number of breakdowns is less important than the time and cost which it takes to bring the pump back to normal operation.

i) Other software related issues have to be taken into account such as community acceptance, technical capacities, reliability of support services by the water bureaux, spare parts quality and availability etc.

j) Taking all the above mentioned factors into consideration the Afridev hand pump (a public domain pump) is recommended for use as a standard handpump for rural community water supply within the ESRDF programme. The use of the Afridev as a standard hand pump also falls into line with the intentions and plans of the Regional bureaux as previously outlined.

k) Similar experience in Malawi and other countries has indicated that the selection of the Afridev handpump was the right decision.

l) The Afridev handpump has a lifting capacity of up to 45 meters and a pumping rate capacity of 0.38 l/s (adequate) for low lift, 0.19 l/s (good) for medium and 0.14 l/s (good) for high lift conditions.

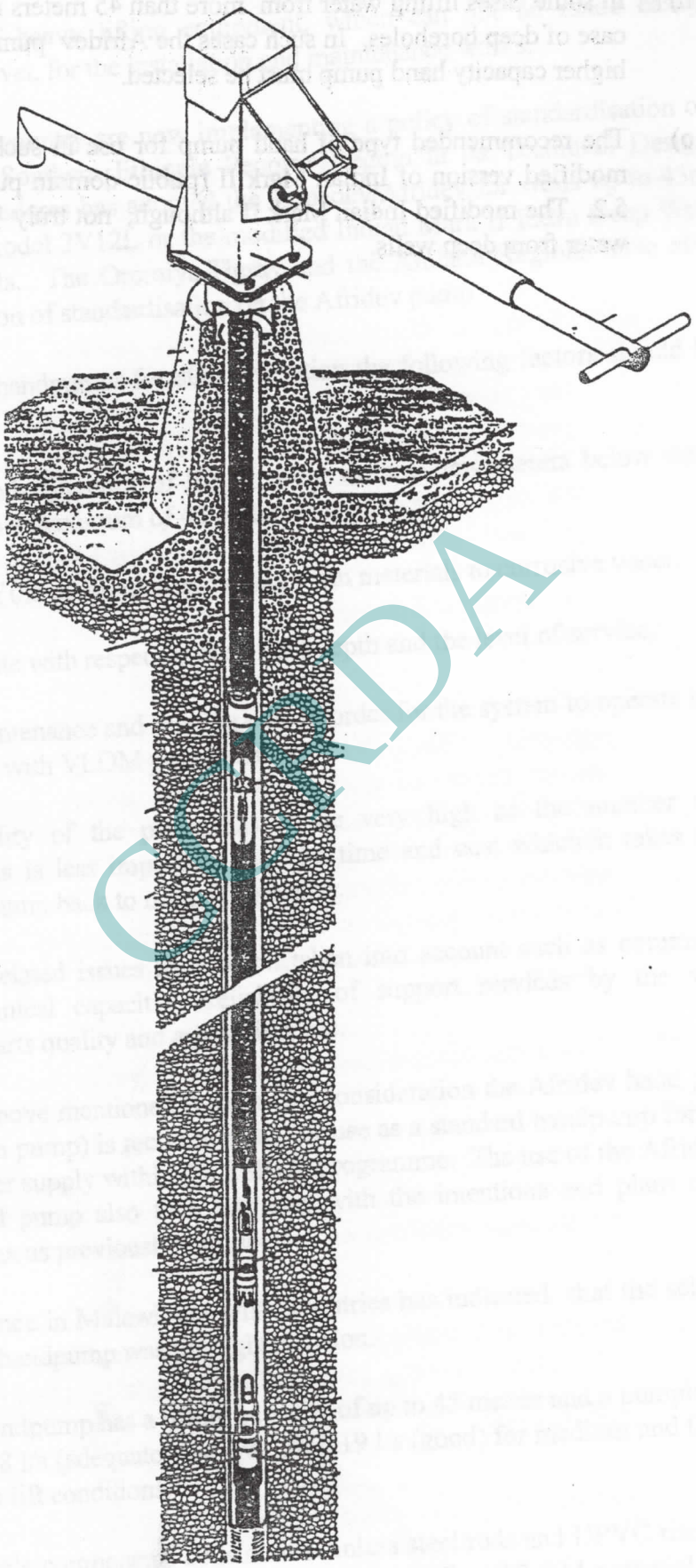
m) All the downhole components consist of stainless steel rods and UPVC riser pipes which are resistant to corrosion. The pump has excellent VLOM potential as it is easy to repair. The pump is illustrated in Fig. 5.1.

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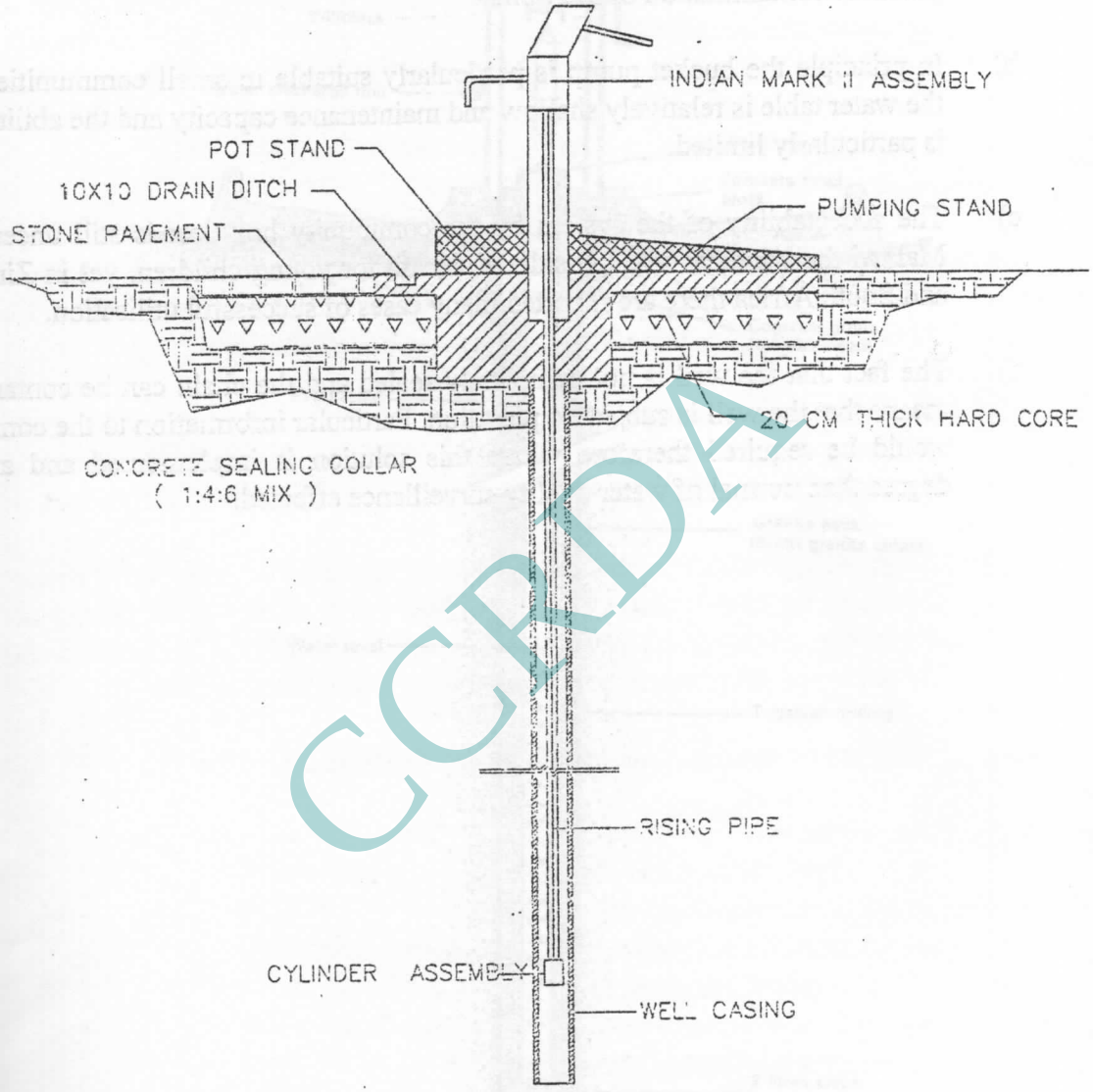
n) In some cases lifting water from more than 45 meters might be necessary as in the case of deep boreholes. In such cases the Afridev pump becomes unsuitable and a higher capacity hand pump must be selected.

o) The recommended type of hand pump for use in such kind of deep wells is the modified version of Indian Mark II (public domain pump) type as shown in Fig. 5.2. The modified Indian Mark II although, not truly VLOM, is capable of lifting water from deep wells.

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ESRDF	ETHIOPIAN SOCIAL REHABILITATION AND DEVELOPMENT FUND HAND BOOK FOR RURAL WATER SUPPLY AND SANITATION		
Title: HAND PUMP INSTALLED ON A BOREHOLE		Scale -----	Date	FIG.No 5.2
CARL BRO INTERNATIONAL in association with MCE METAFERIA CONSULTING ENGINEERS P.L.C				

5.2 BUCKET PUMPS

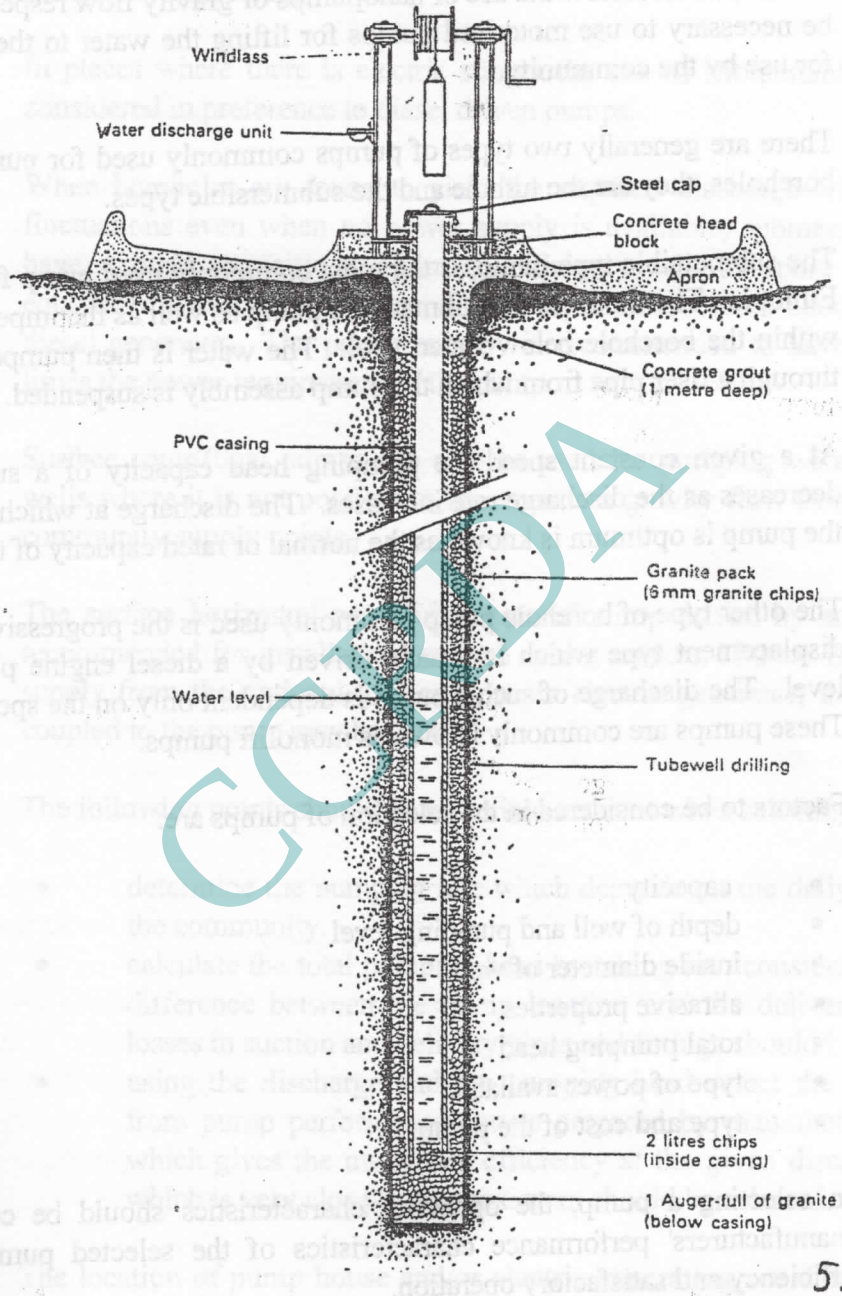
a) A simple technology utilising the principles of the traditional method of withdrawing water from a well has been developed in southern Africa. The bucket pump uses a narrow, deep bucket and windlass as illustrated in Fig 5.3 to minimise potential contamination of the well.

b) In principle the bucket pump is particularly suitable in small communities where the water table is relatively shallow and maintenance capacity and the ability to pay is particularly limited.

c) The acceptability of the system by the community however is still uncertain. In Malawi the windlass was considered unsafe for young children, yet in Zimbabwe and South Africa there are reported many cases of successful utilisation.

d) The fact that the well is not completely sealed and the chain can be contaminated means that the well is subject to pollution. Particular information to the community would be required therefore where this solution is implemented and a higher degree than normal of water quality surveillance effected.

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Windlass
Water discharge unit
Steel cap
Concrete head block
Apron
Concrete grout (1 metre deep)
PVC casing
Granite pack (6 mm granite chips)
Water level
Tubewell drilling
2 litres chips (inside casing)
1 Auger-full of granite chips (below casing)

5.3

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5.3 MOTORISED PUMPS

a) Where the depth of the borehole or location of spring (together with the level of service) do not allow the use of handpumps or gravity flow respectively then it will be necessary to use motorised pumps for lifting the water to the convenient point for use by the community.

b) There are generally two types of pumps commonly used for pumping water from boreholes, they are the turbine and the submersible types.

c) The submersible type pump, is the most commonly used pump for this purpose in Ethiopia. The motor of the submersible pump as well as the impeller unit is placed within the borehole below water level. The water is then pumped to the surface through a riser pipe from which the pump assembly is suspended.

d) At a given constant speed the pumping head capacity of a submersible pump decreases as the discharge rate increases. The discharge at which the efficiency of the pump is optimum is known as the normal or rated capacity of the pump.

e) The other type of borehole pump commonly used is the progressive cavity positive displacement type which is usually driven by a diesel engine placed at ground level. The discharge of such a pump is dependent only on the speed of the engine. These pumps are commonly known as monolift pumps.

f) Factors to be considered in the selection of pumps are:

- capacity
- depth of well and pumping level
- inside diameter of well
- abrasive properties
- total pumping head
- type of power available
- type and cost of the pump.

g) In selecting a pump, the operating characteristics should be compared to the manufacturers' performance characteristics of the selected pump for optimum efficiency and satisfactory operation.

h) The following procedure can be used for selection of motorised pumps for boreholes.

- from the pumping test information, the yield of the borehole (recommended range of pumping rate), static and dynamic water levels and recommended pump setting position should be determined.
- calculate the total pumping head which comprises of static and dynamic heads.

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- from manufacturer's performance curves select the pump with the highest efficiency with the given characteristics.

i) If the borehole yield is unreliable, the required discharge is small and if there is no electric power supply grid in the area the use of diesel driven monolift pump should be considered.

j) In places where there is electric supply the use of submersible pump should be considered in preference to diesel driven pumps.

k) When boreholes are found to yield the required discharge without considerable fluctuations even when no power supply is available, submersible pumps which have a rated capacity at optimum efficiency will be more efficient than the equivalent diesel driven pump. The pump in these cases should be driven by a diesel generator. The power supply is recommended to have a capacity of 1.5 times the power requirement of the pump.

l) Surface centrifugal pumps can also be used for pumping water from spring wet wells where it is not possible to incorporate a gravity flow from the spring to the community supply points.

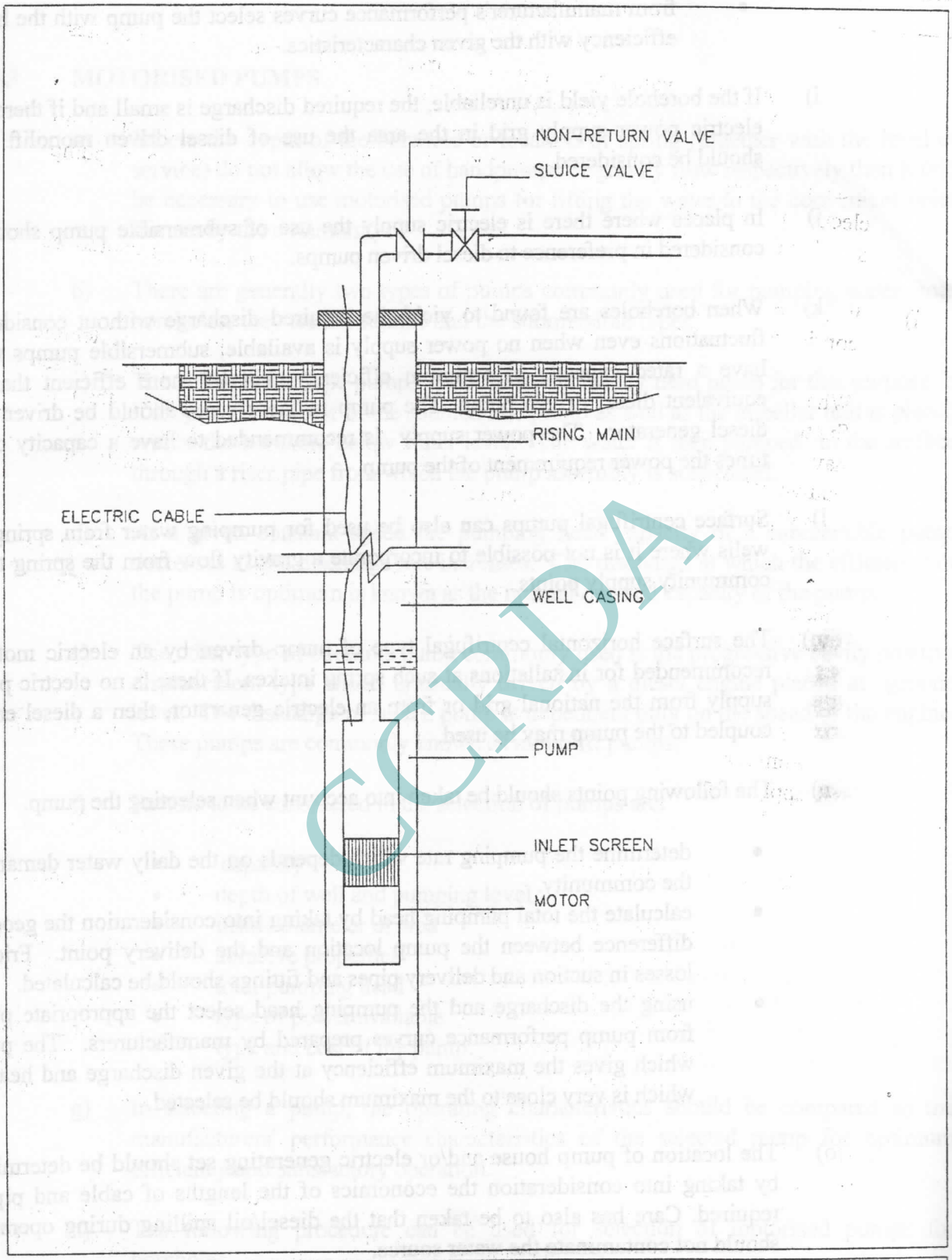
m) The surface horizontal centrifugal type of pump driven by an electric motor is recommended for installations at such spring intakes. If there is no electric power supply from the national grid or from an electric generator, then a diesel engine coupled to the pump may be used.

n) The following points should be taken into account when selecting the pump.

- determine the pumping rate which depends on the daily water demand of the community.
- calculate the total pumping head by taking into consideration the geodetic difference between the pump location and the delivery point. Friction losses in suction and delivery pipes and fittings should be calculated.
- using the discharge and the pumping head select the appropriate pump from pump performance curves prepared by manufacturers. The pump which gives the maximum efficiency at the given discharge and head or which is very close to the maximum should be selected.

o) The location of pump house and/or electric generating set should be determined by taking into consideration the economics of the lengths of cable and piping required. Care has also to be taken that the diesel/oil spilling during operation should not contaminate the water source.

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Title: SUBMERSIBLE PUMP		Scale: -----	Date:	FIG.No: 5.4
CARL BRO INTERNATIONAL in association with MCE METAFERIA CONSULTING ENGINEERS P.L.C			

5.4 SOLAR AND WIND PUMPS

5.4.1 General

Solar and wind pumps are attractive forms of water lifting devices due to their zero energy costs and other environmental benefits. They are more costly and sophisticated to install than conventional diesel or diesel generator driven pumps and have suffered from reliability and efficiency problems in the development of models suitable for remote rural water supply systems. However improvements in these latter characteristics in recent years now make them a viable alternative to be considered at least on a pilot basis.

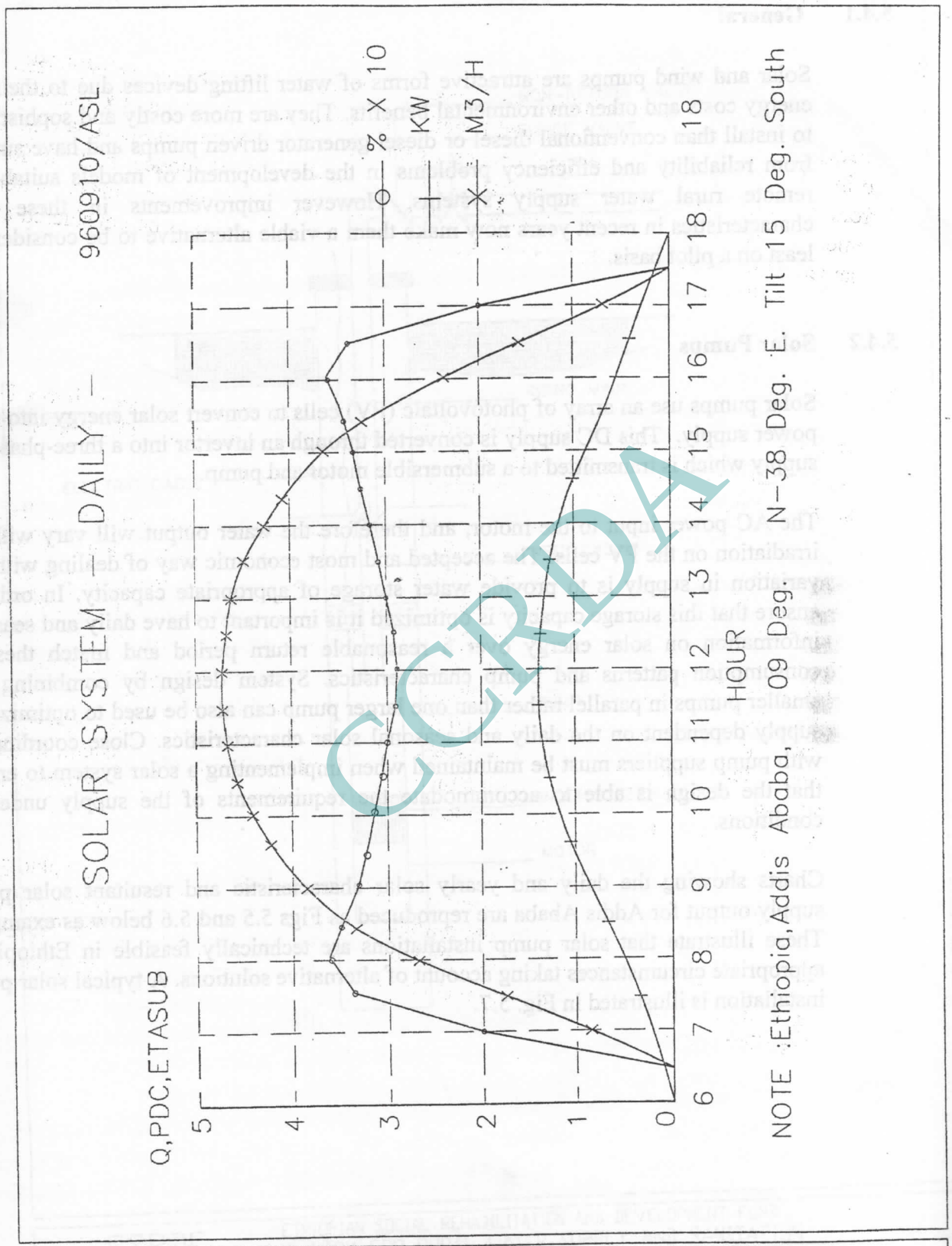
5.4.2 Solar Pumps

Solar pumps use an array of photovoltaic (PV) cells to convert solar energy into a DC power supply. This DC supply is converted through an invertor into a three-phase AC supply which is transmitted to a submersible motor and pump.

The AC power input to the motor, and therefore the water output will vary with the irradiation on the PV cells. The accepted and most economic way of dealing with this variation in supply is to provide water storage of appropriate capacity. In order to ensure that this storage capacity is optimized it is important to have daily and seasonal information on solar energy over a reasonable return period and match these to consumption patterns and pump characteristics. System design by combining two smaller pumps in parallel rather than one larger pump can also be used to optimize the supply dependent on the daily and seasonal solar characteristics. Close coordination with pump suppliers must be maintained when implementing a solar system to ensure that the design is able to accommodate the requirements of the supply under all conditions.

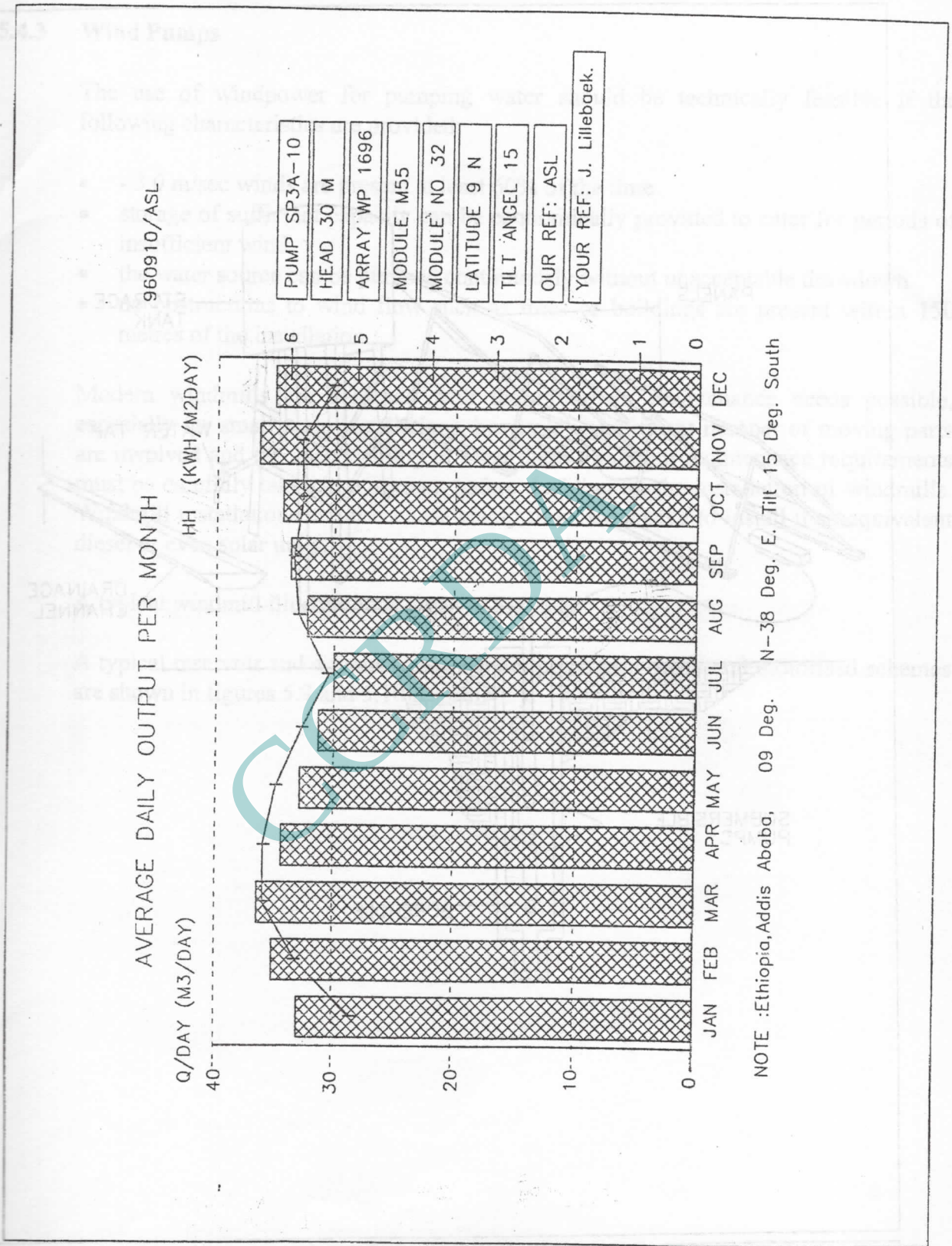
Charts showing the daily and yearly solar characteristic and resultant solar pump supply output for Addis Ababa are reproduced as Figs 5.5 and 5.6 below as examples. These illustrate that solar pump installations are technically feasible in Ethiopia in appropriate circumstances taking account of alternative solutions. A typical solar pump installation is illustrated in Fig. 5.7.

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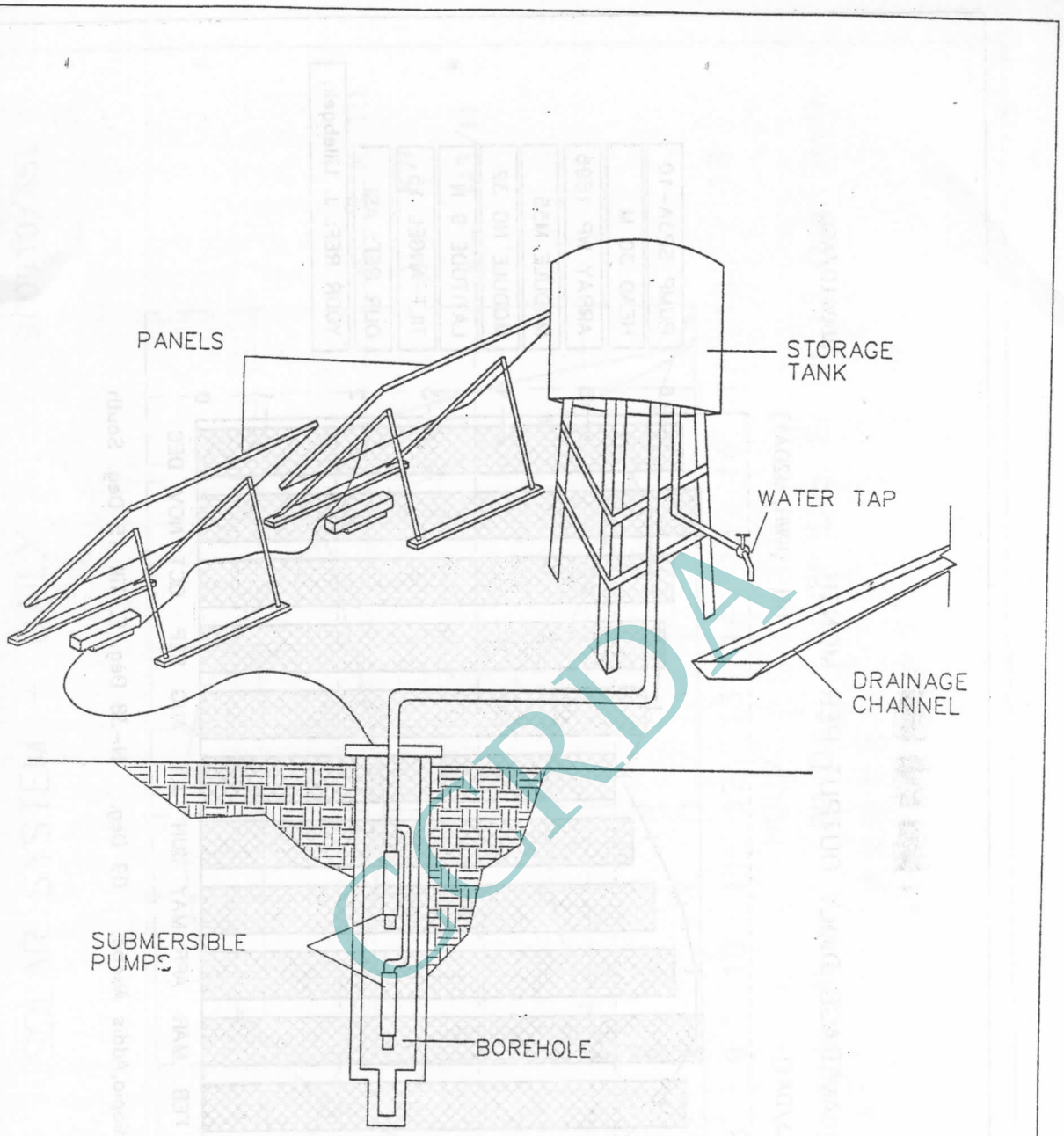
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ESRDF	ETHIOPIAN SOCIAL REHABILITATION AND DEVELOPMENT FUND HAND BOOK FOR RURAL WATER SUPPLY AND SANITATION		
Title: SOLAR SYSTEM -DAILY-	Scale: -----	Date:	FIG.No: 5.5
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Title: AVERAGE DAILY OUTPUT PER MONTH		Scale: -----	Date:	FIG.No: 5.6
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ESRDF	ETHIOPIAN SOCIAL REHABILITATION AND DEVELOPMENT FUND HAND BOOK FOR RURAL WATER SUPPLY AND SANITATION		
Title: SOLAR PUMP	Scale: -----	Date:	FIG.No: 5.7
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5.4.3 Wind Pumps

The use of windpower for pumping water should be technically feasible if the following characteristics are provided:

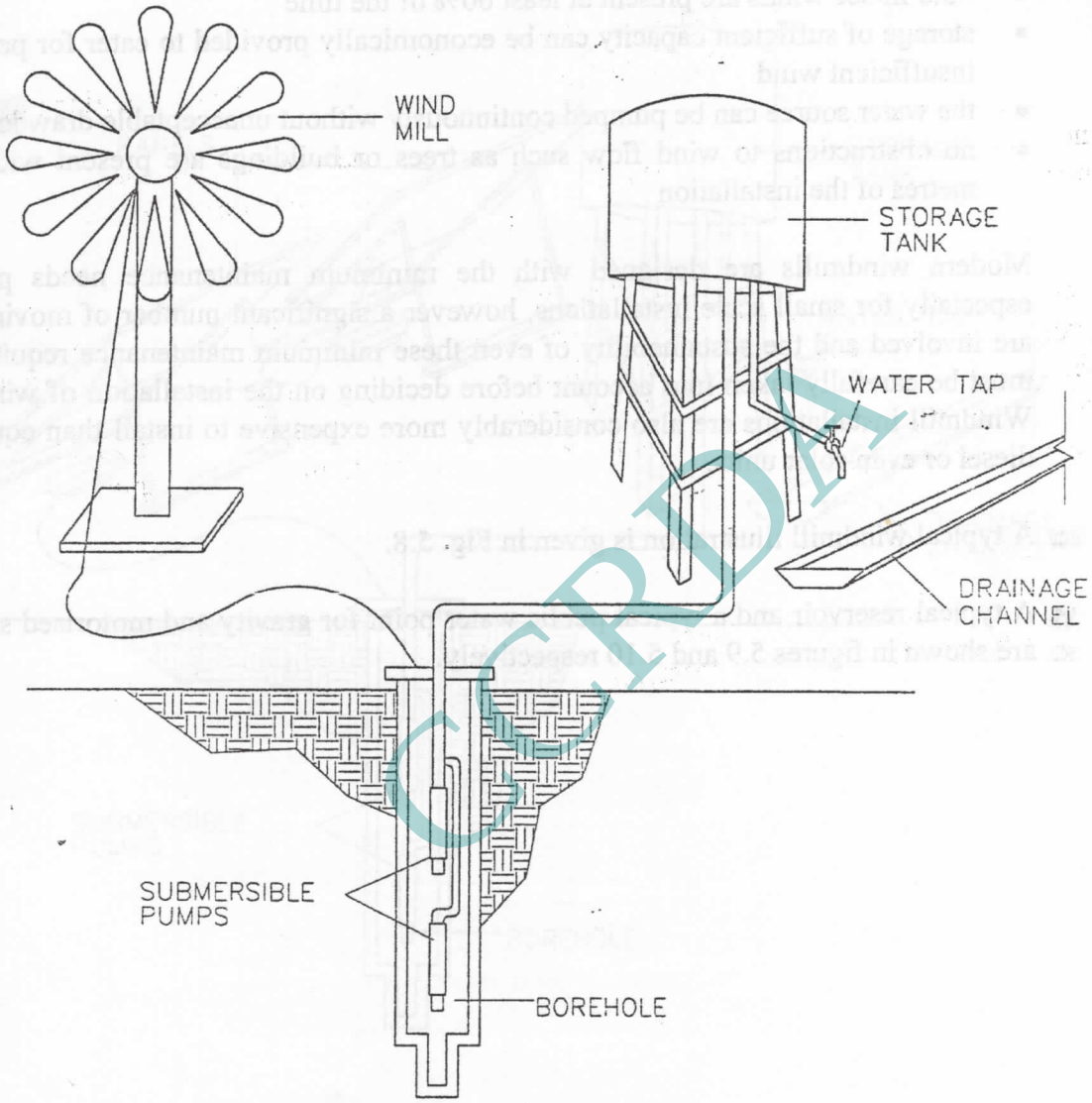
- - 3.0 m/sec winds are present at least 60% of the time
- storage of sufficient capacity can be economically provided to cater for periods of insufficient wind
- the water source can be pumped continuously without unacceptable drawdown
- no obstructions to wind flow such as trees or buildings are present within 150 metres of the installation

Modern windmills are designed with the minimum maintenance needs possible, especially for small scale installations, however a significant number of moving parts are involved and the sustainability of even these minimum maintenance requirements must be carefully taken into account before deciding on the installation of windmills. Windmill installations are also considerably more expensive to install than equivalent diesel or even solar units.

A typical windmill illustration is given in Fig. 5.8.

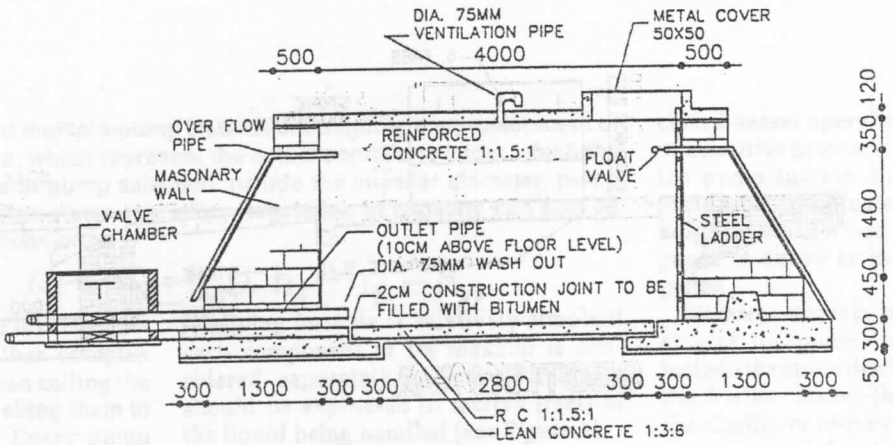
A typical reservoir and a typical public water point for gravity and motorised schemes are shown in figures 5.9 and 5.10 respectively.

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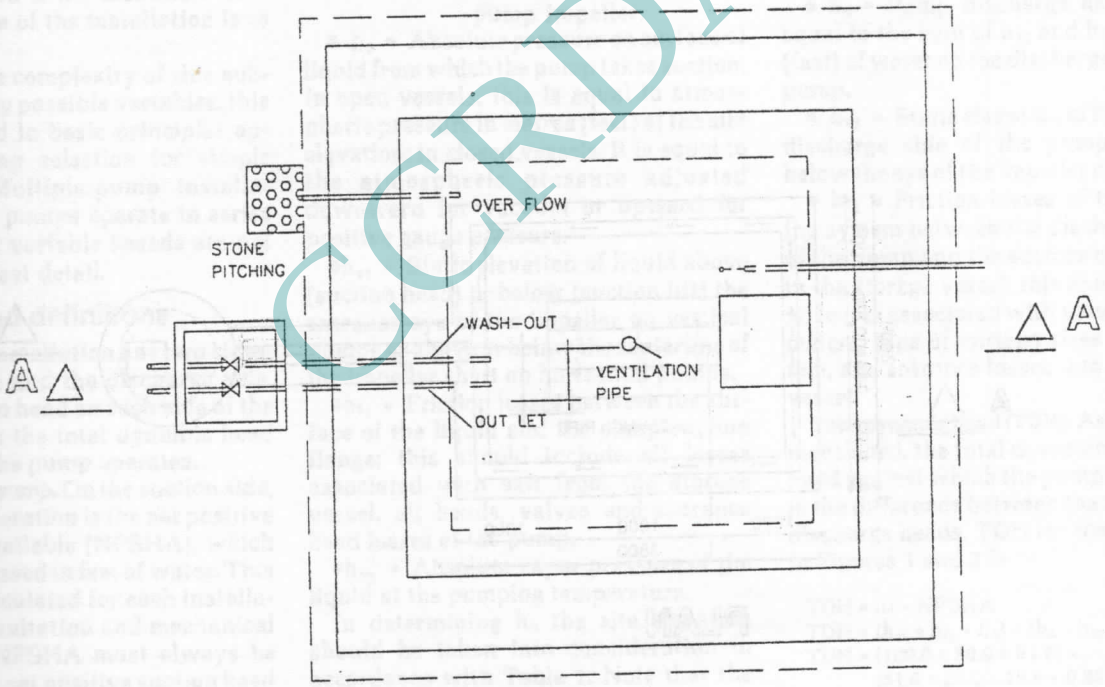


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Title WIND PUMP		Scale -----	Date
CARL BRO INTERNATIONAL in association with MCE METAFERIA CONSULTING ENGINEERS P.L.C			FIG.No 5.8



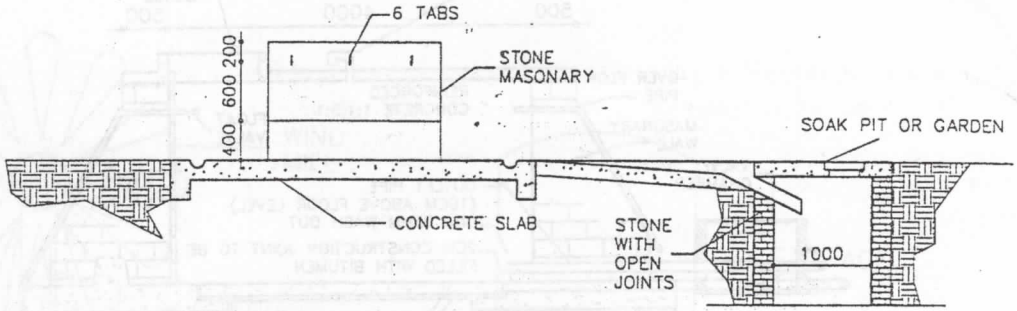
SECTION A-A



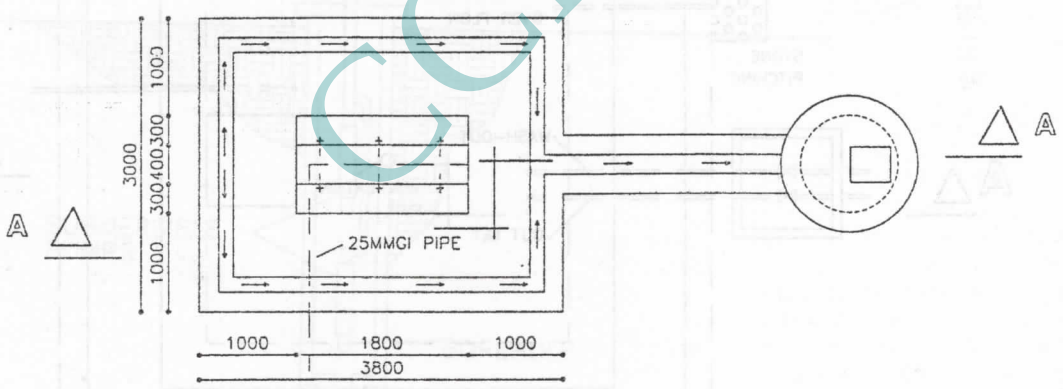
PLAN

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ESRDF	ETHIOPIAN SOCIAL REHABILITATION AND DEVELOPMENT FUND HAND BOOK FOR RURAL WATER SUPPLY AND SANITATION		
Title: WATER RESERVOIR, 25MQ		Scale -----	Date	FIG.No 5.9
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SECTION A-A



PLAN

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Title: PUBLIC WATER POINT FOR GRAVITY AND MOTORIZED SCHEMES	Scale: -----	Date:	FIG.No: 5.10
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Using pump curves and valving techniques for efficient pumping

Charles W. Hilsdon

Pump selection in single- and multiple-pump installations involves the development of accurate system head curves, which represent the actual conditions under which the pump will operate. Variables in pump selection include the impeller diameter, pump speed, and parallel- and series-pump operation. Regulation of capacity can also be affected by certain valving techniques.

CORRECTION * $NPSHA = h_a \pm h_s - h_{f_1} - h_{vp}$

Proper selection of pumps for efficiently handling water is a rather complex matter and involves more than calling the nearest supply house and asking them to pull a pump off the shelf. Every pump installation is different. Each important installation should be individually evaluated by someone qualified and experienced in the field if the maximum efficiency and value of the installation is to be realized.

Because of the complexity of this subject and the many possible variables, this article is limited to basic principles applicable to pump selection for simple installations. Multiple-pump installations where the pumps operate in series or parallel or at variable speeds are not covered in as great detail.

Basic data and definitions

Every pump installation has two sides: the suction side and the discharge side. The difference in head on each side of the pump results in the total dynamic head against which the pump operates.

Suction side of pump. On the suction side, the basic consideration is the net positive suction head available (NPSHA), which is usually expressed in feet of water. This value can be calculated for each installation; to avoid cavitation and mechanical problems, the NPSHA must always be greater than the net positive suction head required (NPSHR) for the particular pump.

The NPSHR for any given pump must be obtained from the manufacturer's published data. Inherent in the design of a pump, the NPSHR includes such factors as the impeller eye diameter, the number and shape of the vanes, and the shape of the suction passage. The NPSHR varies among different makes of pumps, different pumps of the same make, and with the capacity and speed of any one pump.

Insufficient NPSHA leads to reduced efficiency and capacity and to reduced pump life caused by vibration, cavitation erosion, vapor lock, and the possibility that the pump could run dry.

Calculation of the NPSHA by the following formula is relatively simple if each component of its makeup is considered separately. All measurements should be expressed in metres (feet) of the liquid being handled (see Figure 1).

* • NPSHA = $h_a \pm h_{f_1} - h_{vp}$
  = Net positive suction head head available at the entrance eye of the pump impeller.

• h_a = Absolute pressure on surface of liquid from which the pump takes suction. In open vessels, this is equal to atmospheric pressure in metres (feet) at the site elevation; in closed vessels, it is equal to the atmospheric pressure adjusted downward for vacuum or upward for positive gauge pressure.

• h_{s_1} = Static elevation of liquid above (suction head) or below (suction lift) the entrance eye of the impeller on vertical pumps or above or below the centerline of the impeller shaft on horizontal pumps.

• h_{f_1} = Friction losses between the surface of the liquid and the pump suction flange; this should include all losses associated with exit from the storage vessel, all bends, valves and entrance head losses at the pump.

• h_{vp} = Absolute vapor pressure of the liquid at the pumping temperature.

In determining h_a the site elevation should be taken into consideration in accordance with Table 1. Note that the atmospheric pressure decreases about 0.3 m (1 ft) for each 305 m (1000 ft) increase in elevation.

The value for h_a should be physically measured; h_f should be determined by utilizing appropriate head loss data or gauge measurements if convenient.

For h_{vp} Table 2 may be used. The vapor pressure is small when the water is cold; at 100°C (212°F) (or boiling) the vapor pressure is greater than the sea-level atmospheric pressure. This causes the water vapor to escape to the atmosphere.

Figure 1 provides two examples for determining the NPSHA for a simplified open-vessel pump installation. Variations include an open vessel with the water level below the pump centerline or a closed vessel operating under a vacuum or a positive pressure. If a gauge is used at the pump suction, the NPSHA calculations must be adjusted for velocity head and for the vertical distance that the gauge is above or below the pump impeller.

Discharge side of pump. On the discharge side of the pump basic considerations include the static discharge head (h_{s_2}) and the friction losses (h_{f_2}) associated with the pipeline or conveying system between the pump and the storage vessel.

The following definitions are illustrated in Figure 2, together with an example of head on the discharge side of the pump.

• h_d = Pump discharge head; this is equal to the sum of h_{s_2} and h_{f_2} in metres (feet) of water on the discharge side of the pump.

• h_{s_2} = Static elevation of liquid on the discharge side of the pump above or below the eye of the impeller of the pump.

• h_{f_2} = Friction losses of the conveying system between the discharge flange of the pump and the surface of the liquid in the storage vessel; this should include all losses associated with valves, fittings, meters, pipe of various sizes in the system, and entrance losses into the storage vessel.

Total dynamic head (TDH). As previously mentioned, the total dynamic head is the head against which the pump operates. It is the difference between the suction and discharge heads. TDH for the first pump in Figures 1 and 2 is

$$TDH = h_d - NPSHA$$
$$TDH = (h_{s_2} + h_{f_2} + h_a) - (h_a + h_{s_1} - h_{f_1} - h_{vp})$$
$$TDH = (100.0 + 50.0 + 31.6) - (31.6 + 20.0 - 10.0 - 0.89)$$
$$TDH = (181.6) - (40.71) = 42.94 \text{ m } (140.89 \text{ ft})$$

It should be noted that in the final analysis for TDH, where the vessels on the suction and discharge side of the pump are open to the atmosphere or subjected to the same gauge pressure, the value of h_a is balanced out and the value for the vapor pressure h_{vp} can generally be ignored if the water temperature is below about 29°C (85°F).

System head curve

The TDH previously derived constitutes only one point on the system head curve. This one point will be beneficial in determining the approximate pump size

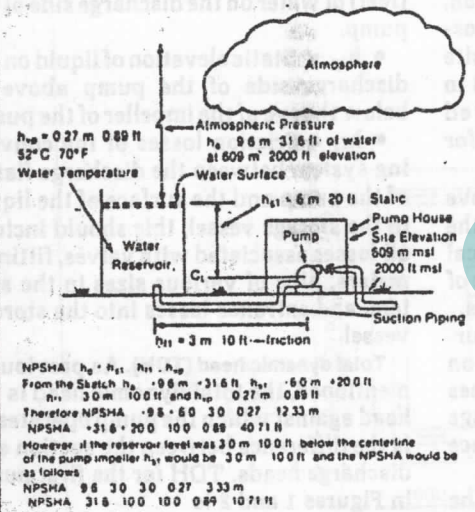
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TABLE 1
Correction of h_a to site elevation

Site Elevation Above Mean Sea Level		Atmospheric Pressure at 29°C (85°F)	
m	ft	m of water	ft of water
0	0	10.3	33.9
305	1000	10.0	32.9
610	2000	9.6	31.6
914	3000	9.3	30.5
1219	4000	8.9	29.3
1524	5000	8.6	28.3
1828	6000	8.3	27.3
2133	7000	8.0	26.3
2438	8000	7.7	25.3
2743	9000	7.4	24.4
3048	10 000	7.2	23.5

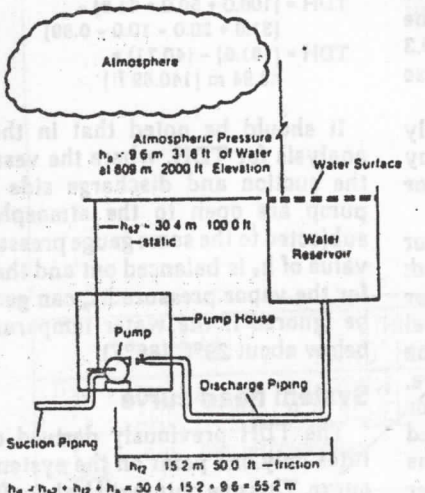
TABLE 2
Vapor pressure values for water

Temperature		Vapor Pressure	
°C	°F	m of water	ft of water
4	40	0.08	0.27
10	50	0.12	0.40
15	60	0.18	0.59
21	70	0.27	0.89
28	80	0.37	1.20
32	90	0.49	1.61
38	100	0.67	2.19
100	212	10.79	35.4



NPSHA $h_a + h_{s1} - h_{f1} - h_{vp}$
From the Sketch h_a = 9.6 m = 31.6 ft h_{s1} = 6.0 m = 20.0 ft
h_{f1} = 3.0 m 10.0 ft and h_{vp} = 0.27 m 0.89 ft
Therefore NPSHA = 9.6 + 6.0 − 3.0 − 0.27 = 12.33 m
NPSHA = 31.6 + 20.0 − 10.0 − 0.89 = 40.71 ft
However, if the reservoir level was 3.0 m 10.0 ft below the centerline of the pump impeller h_{s1} would be −3.0 m −10.0 ft and the NPSHA would be as follows
NPSHA = 9.6 − 3.0 − 3.0 − 0.27 = 3.33 m
NPSHA = 31.6 − 10.0 − 10.0 − 0.89 = 10.71 ft

Figure 1. Calculations for determining NPSHA for simplified open-vessel installation



$h_d = h_{s2} + h_{f2} + h_a = 30.4 + 15.2 + 9.6 = 55.2$ m
$h_d = 100.0 + 50.0 + 31.6 = 181.6$ ft

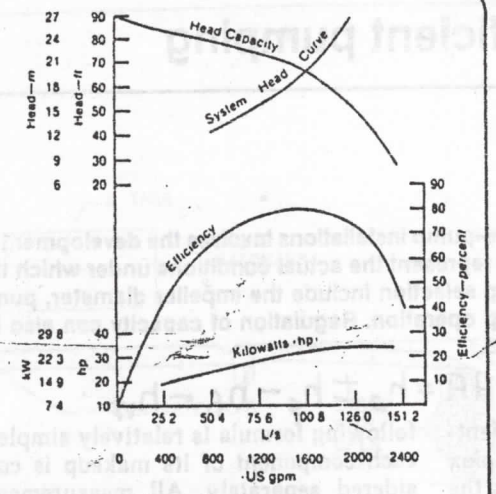


Figure 3. Pump curve 1

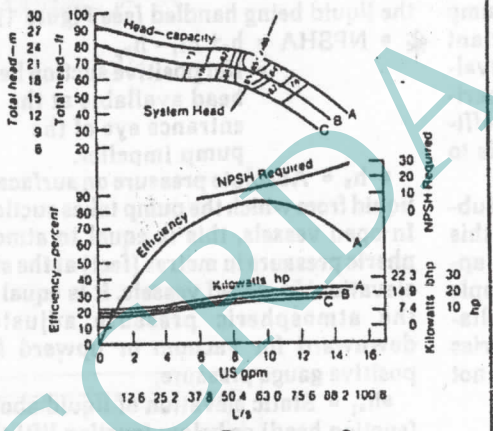


Figure 4. Pump curve 2

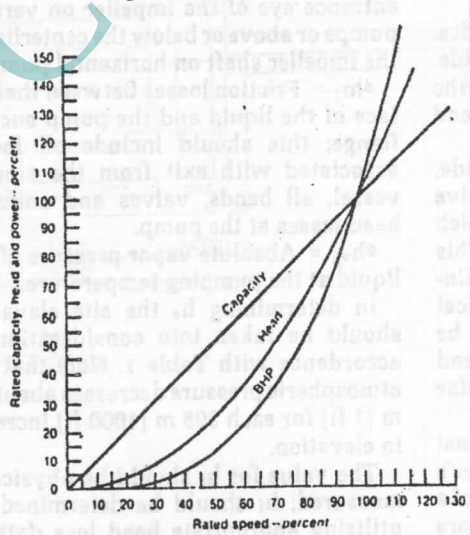
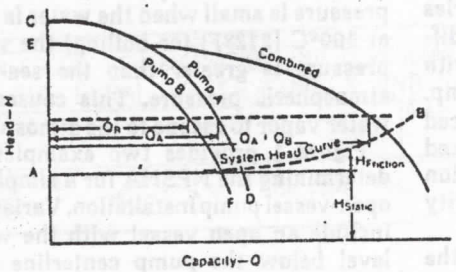


Figure 5. Pump curve 3: the effect of speed change on centrifugal pumps



and horsepower required; however, in order to fully evaluate the installation, a system head curve must be developed.

The curve may be developed by determining the TDH at various capacities above and below the normal operating condition. This curve should further be expanded to take into consideration the effect of variation in water surface levels of the storage vessels on the suction and discharge sides of the pump. The system head curve should also be modified to take into consideration any capacity regulation devices that may be necessary for the installation.

The importance of developing an accurate system head curve or a set of system head curves cannot be overemphasized. These curves represent the conditions under which the pump will operate. With these curves, one can study various published pump curves and determine which available pump is best suited for the job.

Pump curve 1. Pump curve 1 (Figure 3) is a typical single-stage constant-speed pump curve on which a simple system head curve has been superimposed. The system head curve in this case was developed by plotting the TDH at three different capacities; namely, 12-m TDH at 50 L/s, 20-m TDH at 101 L/s, and 27-m TDH at 126 L/s (40-ft TDH at 800 gpm, 65-ft TDH at 1600 gpm, and 90-ft TDH at 2000 gpm).

This pump curve shows the characteristic curves for this particular pump; namely, the head capacity curve, the efficiency curve, and the horsepower curve. Examination of the curves will show that the system head curve intersects the head capacity curve at the point of maximum efficiency. Therefore, the pump can be expected to deliver 101 L/s at 20-m TDH (1600 gpm at 65-ft TDH) at 81 percent efficiency and will require about 33 hp. In this case a standard 40-hp motor would be used.

Pump curve 2. Pump curve 2 (Figure 4) shows the effect of varying the impeller diameter at a constant speed and also shows NPSHR. For example, with impeller C, the pump could be expected to deliver 58 L/s at 17-m TDH (920 gpm at 56-ft TDH) at 85 percent efficiency and would require a 15-hp motor. The NPSHR is about 4 m (13 ft). With an A impeller the pump would deliver about 63 L/s at 22-m TDH (1000 gpm at 73-ft TDH) at 82 percent efficiency. It would require a 20 hp motor and about 4.6 m (15 ft) NPSH.

This case illustrates the flexibility one should consider in selecting a pump, especially in situations where the system head can change. For example, it might be advantageous to install this pump with a C impeller and a 25-hp motor, and later change to an A impeller for greater

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Effect of changing speed. In the previous examples, pumps operating at constant speeds were discussed. Curve 3 (Figure 5) shows the effect of varying the speed on a centrifugal pump in accordance with affinity laws.

In theory, the capacity varies directly with the ratio of the two speeds; the head varies as the square of the ratio of the two speeds; and the horsepower varies as the cube of the ratio of the two speeds. For example, at 100 percent of rated speed, the capacity, head, and horsepower is 100 percent of the rated performance. At 50 percent of rated speed, the capacity is 50 percent of rated capacity; the head is 25 percent of rated head; and the horsepower required is about 13 percent of rated horsepower.

To further illustrate the effect of a 50 percent reduction in speed on a centrifugal pump, consider the pump previously shown by pump curve 2 with the A impeller. This pump, when operating at 1760 rpm, is rated at 63 L/s at 22-m TDH (1000 gpm at 73-ft TDH) and requires a 30-hp motor. If the speed is reduced to 50 percent or 880 rpm, the resulting theoretical capacity, head, and horsepower would be approximately:

$$\text{New capacity} = \left(\frac{880\ \text{rpm}}{1760\ \text{rpm}}\right) \times 63\ \text{L/s}$$

(1000 gpm) = 31.5 L/s (500 gpm) = 50 percent of rated capacity

$$\text{New head} = \left(\frac{880\ \text{rpm}}{1760\ \text{rpm}}\right)^2 \times 22\ \text{m (73 ft)} =$$

5.5 m (18.3 ft) = 25 percent of rated head

$$\text{New horsepower} = \left(\frac{880\ \text{rpm}}{1760\ \text{rpm}}\right)^3 \times 22\ \text{hp} =$$

2.75 hp = 13 percent of rated hp

An increase in impeller speed generally results in a small increase in efficiency; however, within the speed range that most water works pumps operate, the change in efficiency can generally be considered insignificant.

Although variable-speed pumps in most cases are quite expensive, they are sometimes necessary because of varying system requirements. Thus their use should not be ignored.

Parallel and series pump operation

In installations where the system requirements cover a wide range of capacities and heads, two or more pumps may be arranged for parallel or series operation. This allows the operator to meet system requirements in the most economical manner.

In parallel operation, near maximum efficiency can usually be obtained by operating those pumps needed to meet the demand. The pump characteristics should be

similar and generally have steep head capacity curves.

An additional advantage of a multiple-pump installation is the flexibility of being able to take some of the pumps out of service for maintenance, while the others meet the demands of the system.

Curve 4 (Figure 6) shows the effect of operating centrifugal pumps in parallel. In this illustration, the system head curve A-B starts at the static head H and rises with increased flow. Pump A operating alone is represented by curve CD, and pump B alone by curve EF. Pump B begins delivery when the discharge head of pump A falls below the shutoff head of pump B. This is represented by point E on the curve. The combined delivery at a given head is equal to the sum of the individual capacities of the two pumps at that head. The combined head capacity curve shown is developed by plotting the summations of the capacities of the two pumps at respective heads.

Curve 5 (Figure 7) shows the effect of series operation of centrifugal pumps. Study of this curve reveals that the combined head for any flow is equal to the sum of the individual heads at that flow.

An approximate and general rule of thumb for parallel centrifugal pump operation is that capacities can be added; for series operation, the heads can be added. Combined horsepower and efficiency curves can be derived in a similar manner with the aid of formulas available in any good hydraulic handbook.

It must be emphasized that each pump and each installation is usually different. The pumps should be considered in various combinations with the actual combined curves derived in each case for the results to be reliable.

Capacity regulation: valving techniques

In many installations, it is not possible to exactly match system curves to pump characteristics at all times. Therefore, a means for varying the system head curve may be necessary. Capacity variation can be accomplished by changing the head on the pump or speed of the pump. For example, at times the head against which the pump operates may be so low as to cause a capacity increase great enough to overload the motor or cause excessive cavitation. By throttling a valve in the discharge line, the head will be increased so that the system head curve will intersect the head capacity curve at a smaller capacity, thus keeping the motor within operating limits.

Discharge throttling results in lower efficiency and power is lost at the throttled valve. This loss in efficiency may be important in larger installations and may make more costly methods of modulation more attractive. Throttling the suction might possibly result in less power or

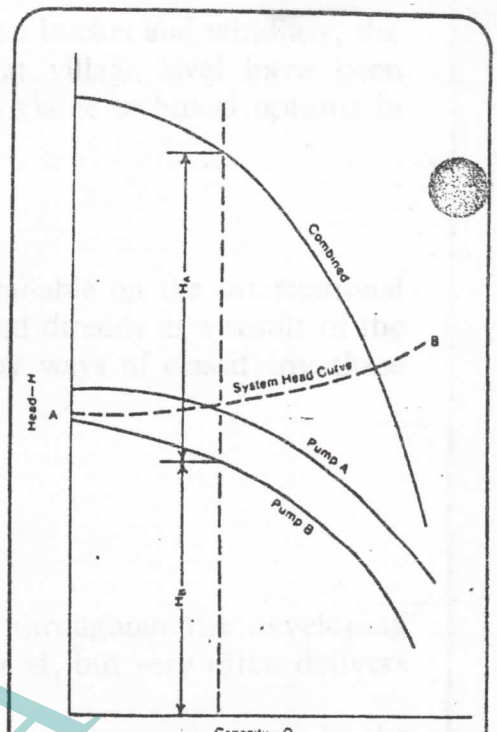


Figure 7. Pump curve 5: centrifugal pumps operating in series

efficiency loss compared with discharge throttling, provided sufficient NPSH is available.

Bypass regulation is another means of keeping the pump within operating limits. It is normally used to help prevent overheating the pump where very low capacities are encountered.

Speed regulation, adjustable vanes ahead of the impeller, and introduction of air into the pump suction are still other possible means to regulate capacity. These methods are generally so complex and expensive that their use is of little practical value except in installations large enough to justify model installation.

Avoiding problems

Pumping problems can usually be avoided by good design, good pump selection, and good installation and operating practices. Some guidelines to follow are:

- Keep the suction head on the impeller as high as possible.
- Avoid high water temperatures.
- Use as large a suction pipe as possible.
- Avoid unnecessary fittings on suction, and keep it as short as possible.
- Select a pump with the lowest NPSH requirements.
- Keep pump discharge head near the most efficient point on the head capacity curve by throttling, changing the impeller diameter, or changing the speed or size of discharge line.

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this reason 'upgraded wells' and a modernised bucket and windlass, the 'Bucket Pump', which are maintainable at village level have been endorsed by the Zimbabwe Government as viable technical options in the current rural water supply programme.

Types of handpump

Many hundreds of handpumps are now available on the international market, and many new designs have emerged directly as a result of the international water decade. There are many ways of classifying these into groups including the following:

1. Bucket type pumps
2. Direct action reciprocating pumps
3. Lever action reciprocating pumps
4. Rotary pumps

The first category is the most common throughout the developing world. It is very traditional, easily maintained, but very often delivers water of low quality.

Of the reciprocating pump types, the direct action pumps may be the most useful for shallow wells, but are currently less common than the lever operated pumps which can lift water from much greater depths, and thus are more versatile. In recent years PVC has been used more and more to replace steel as an engineering material. PVC does not corrode and can easily be cut and joined, and thus lends itself to simple maintenance procedures. It can however easily be broken, the inherent strength deteriorating over the years. Many more recently designed direct action pumps use a high content of PVC. The most rugged handpumps are still lever action types.

Rotary handpumps are dominated by the Mono Pump, of which there are two basic hand-driven types, the direct drive and the gearbox drive. The direct drive unit is made in Zimbabwe.

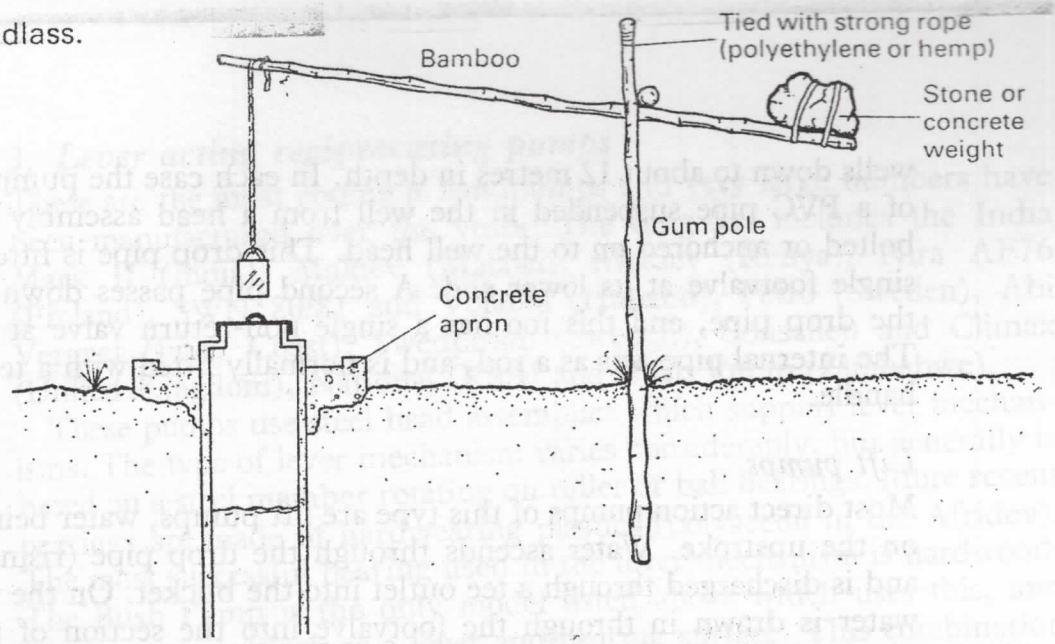
Description of the pump types

1. Bucket type pumps

This is often not considered as a pump at all by some organisations, and has for too long been ignored as a meaningful method of upgrading water supplies in Developing Countries. However, the evidence in favour of its use is very considerable, and there are positive signs that it is increasingly acceptable as a tool for upgrading poorly protected supplies.

Most bucket type pumps use a bucket and rope, or a bucket, rope and windlass. A combination of bucket, chain and windlass is the most hygienic. In some countries the bucket is pulled with a pulley wheel, which provides a mechanical advantage but may have little hygienic value. The 'shaduf' is a bucket and rope attached to a counterbalanced pole, and one of the earliest hygienic methods of raising water which dates back to 2500 BC. It is still used today in the Middle East. Elsewhere in Africa and the Middle East, the windlass is widely used as a means of raising the bucket and rope. This offers a mechanical advantage, but has the additional advantage of hygienically storing the

The bucket and windlass.



The shaduf: a successful method of lifting water from shallow wells.

chain or rope and preventing its contamination on the ground.

Bucket and windlass mechanisms are very common in Central Africa and there are tens of thousands operating successfully in Zimbabwe alone. However, most are placed on wide diameter wells which are poorly protected in other ways and have inadequate sanitary seals and headworks.

Contamination of the well can take place through many routes, notably through the chain and base of the bucket, if these make contact with the ground. When there is no raised collar, waste water can run back into the well, and during the rainy season this possibility increases. When the well is lined, fitted with a raised collar, a lid, surrounding concrete apron and water run-off, water quality can be enhanced considerably (see 'upgraded well'), and this makes the concept of a bucket and windlass more acceptable as a technical option.

This process has been taken one step further in Zimbabwe, where the concept has been modernised in the form of the 'Bucket Pump'. Primarily using the same techniques found in traditional practice, this pump employs a tubular bucket with a valve at its base. This passes up and down a static PVC casing, which is best placed in a tubewell. The bucket is raised and lowered within the casing and delivers water at a rate which varies between 5 and 10 litres per minute. The singular advantage of this system is that the water produced is substantially better in bacteriological quality than that taken out of most wide diameter wells.

2. *Direct action reciprocating pumps*

These are becoming more common in many rural programmes in several parts of the world. They include the Tara Pump (Bangladesh), Mark V (Malawi), Madzi (Malawi), Blair (Zimbabwe), Nsimbi (Zimbabwe), Rower (Bangladesh), Waterloo (IDREC), Wavin (Netherlands), Nira AF 85 (Finland), Ethiopia BP50 (Ethiopia), and many others.

Most are made with PVC components below ground level and steel components above ground level and are used exclusively on shallow

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wells down to about 12 metres in depth. In each case the pump consists of a PVC pipe suspended in the well from a head assembly which is bolted or anchored on to the well head. This drop pipe is fitted with a single footvalve at its lower end. A second pipe passes down through the drop pipe, and this too has a single non-return valve at its base. The internal pipe acts as a rod, and is normally fitted with a tee-shaped handle.

Lift pumps

Most direct action pumps of this type are lift pumps, water being raised on the upstroke. Water ascends through the drop pipe (rising main), and is discharged through a tee outlet into the bucket. On the upstroke water is drawn in through the footvalve into the section of the drop pipe which acts as a cylinder. On the downstroke, the footvalve closes and the piston valve opens and passes through the water held in the cylinder. On the upstroke the piston valve closes and water is raised above this and discharged at the outlet again. Many direct action pumps using the lift principle have hollow pushrods which are buoyant, which makes pumping easier. Neoprene seals are often used in combination with the PVC pipe. The water delivery rate usually lies between 15 and 30 litres per minute.



Blair Pump.



Nsimbi Pump.

Force pumps

One type of direct action pump uses the force pump principle — th Blair Pump and its derivatives made in Malawi, Papua New Guinea ar the Philippines. In this case the piston valve is linked to the pump ro which is hollow and acts as a water spout and handle combined. On th upstroke water is drawn into the lower end of the cylinder through th footvalve. On the downstroke, the footvalve closes and water is forc through the open piston valve, through the hollow pushrod to th surface and out of the 'walking stick' handle. This configuration us less parts than other direct action pumps and is therefore simpler a cheaper to make. The delivery rate varies between 15 and 20 litres p minute.

3. *Lever acting reciprocating pumps*

These are the most common handpumps and very large numbers have been manufactured over the years. The long list includes the India Mark II (India), Maldev (Malawi), Afridev (Kenya), Nira AF76 (Finland), SWN 80/81 and Volanta (Holland), Petro (Sweden), Abi Vergnet (Ivory Coast), Swedpump (Sweden), Consallen and Climax (United Kingdom), National (RSA) and Bush Pump (Zimbabwe).

These pumps use steel head assemblies which support lever mechanisms. The type of lever mechanism varies considerably, but generally is based on a steel member rotating on roller or ball bearings. More recent bearings are made of hardwearing plastics (polyacetal in the Afridev). The most successful bearing used in the lever mechanism is hardwood. The Bush Pump is the only model listed above which uses this, and employs a teak block as a lever and bearing surface. This combination has made the Bush Pump one of the most successful handpumps used in the Developing World.

In almost all cases pump rods are made of mild or stainless steel, although fibreglass rods are used in the USA. The drop pipes (rising mains) are made of galvanised or black iron or PVC. Polyethylene is used in some cases. Most cylinders are made of brass, although some are made of stainless steel. Both 50 mm and 75 mm cylinders are used. Lever acting pumps are certainly more complex than direct action pumps, and thus are generally more difficult to maintain. They are more robust however, and are essential for all deep well and heavy duty settings. The Zimbabwe Bush Pump has been in service for over fifty years and is still the handpump of choice in Zimbabwe (1989). There are very few lever acting handpumps that could compete with it in terms of simplicity and endurance.



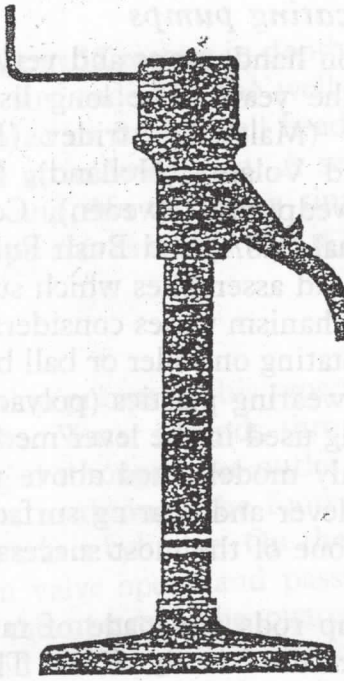
Bush Pump.

4. *Rotary pumps*

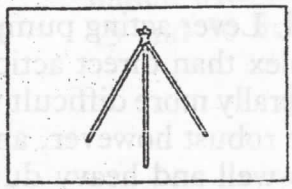
These are less familiar in rural development schemes but are being used more, as their low maintenance requirements are becoming more well known. They are simple and elegant in concept, but in practice their delivery rate is low, and may actually be more difficult to maintain than more conventional reciprocating pumps, although this will happen less frequently. The Monolift (United Kingdom) is becoming more commonly used in some countries together with the Moyno IV (USA) and the Direct Action Mono Handpump (RSA & Zimbabwe).

All these pumps use a rotor/stator system, with a steel helical rotor which turns within a helical rubber or elastomerical stator. The pump rods rotate. The delivery rate for handpumps varies from 8–16 litres per minute. The rotor system is robust and may operate for many years without attention. Motorised mono pumps are commonly used on boreholes and may operate for ten years or more without servicing.

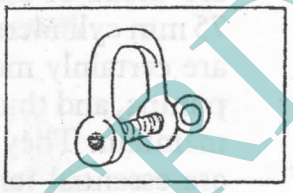
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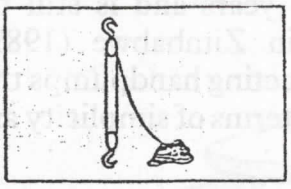
A. Equipment required to install Mono Pump



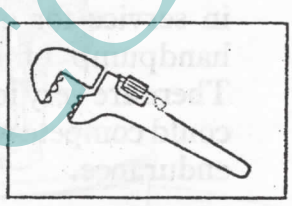
1. Sheer legs, minimum lift 4½ m



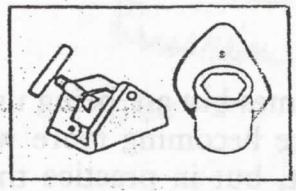
4. 2 'D' shackle



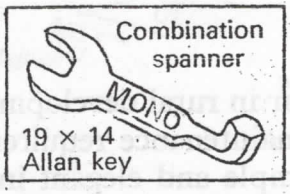
2. 1 ton chain or rope blocks



5. 2 pipe wrenches

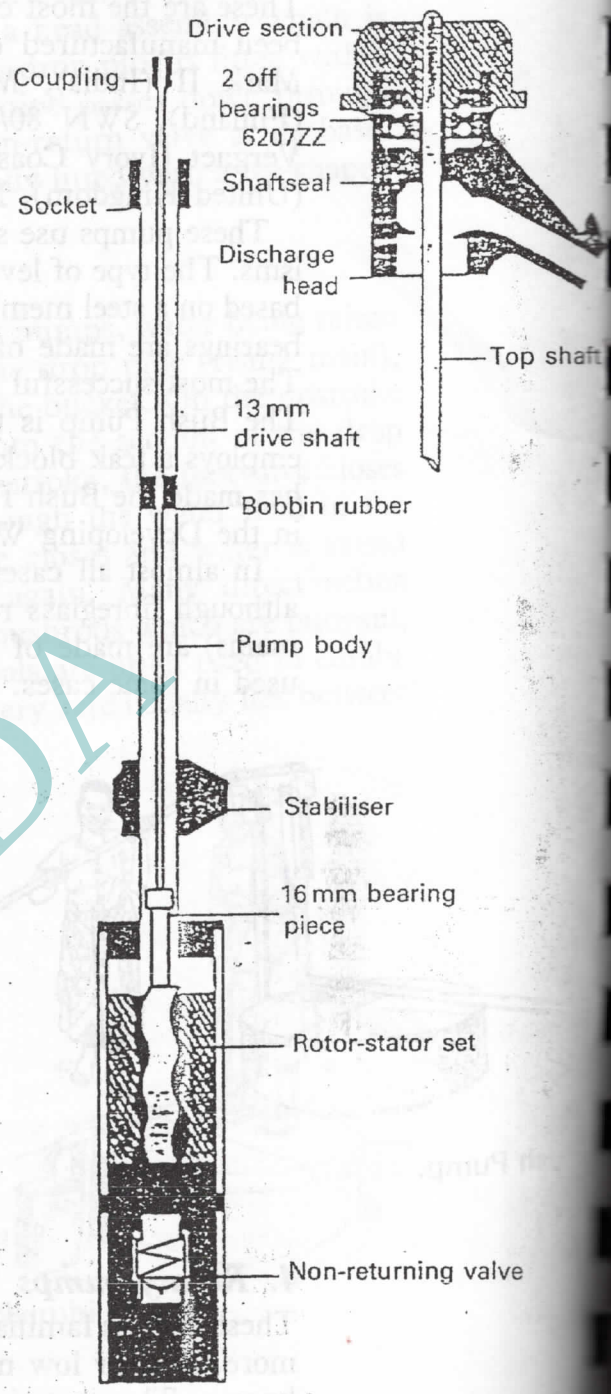


3. 2 Pipe clamps or 1 pipe clamp and 1 socket swivel



6. 19 mm open end spanner 14 mm Allan key

B. Parts list



The mono direct drive handpump.

Handpumps used in Zimbabwe

The handpump was chosen many decades ago as the most pr method of delivering potable water to community water points rural areas of Zimbabwe. This method of raising water from the underground reservoir still applies today. Water tapped from ade protected wells and boreholes is generally fit for drinking with

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need for artificial treatment, and this is seen as a big advantage. However, the proportion of water sources which are adquately protected is low. The results of two studies (1983 Demographic Socio-Economic Study and 1984 National Socio-Economic Study) show that 35% of households in the communal lands have access to protected sources of water during the wet season and 42% during the dry season. In brief, two thirds of the households do not have all year round access to a safe water supply. Wells are the most common source of water and about 75% of these are used throughout the year, although few are adequately protected. Boreholes are the most common improved sources of water in the communal lands, and many of these are used by large numbers of households. Since about 25% of wells dry up every year, the reliance on existing wells drops during the dry season, whilst the reliance on boreholes increases.

Although at least ten different types of handpump have been used in Zimbabwe, only four of these, the Bucket Pump, Blair Pump, Nsimbi Pump and Bush Pump, have been used in large numbers.

Zimbabwe's most successful handpump, known as the Bush Pump, has been used successfully for over fifty years in the rural areas, and remains the pump of choice for all heavily used community water points. All four pumps have been adapted for the range of conditions normally found in the communal lands, and are known to operate well when built and installed correctly, and when a suitable maintenance system is established. However, without maintenance the pumps can fail and remain out of order for months. It is therefore the maintenance system, rather than the pump itself which determines whether a handpump programme will be successful in the long term, assuming, of course, that technical faults in the pump itself have been reduced as far as possible.

With the basic consideration of maintenance in mind, the National Action Committee of the Zimbabwe Government made a recommendation in 1987 to standardise the handpumps used in the rural programme. Only two options were chosen by the committee, the Bush Pump and the Bucket Pump, with all other options being phased out of the programme for community settings. It was further recommended that just one design of Bush Pump be used in future, being a hybrid which combined the best features of a number of earlier Bush Pumps.

Specific situations were recommended for the use of these two pump options. The Bush Pump is to be used in all deep and heavy duty settings where the number of users is greater than ten families (60 persons). The Bucket pump is to be used in shallow and light duty settings where the number of users is less than ten families (60 persons). With the Bucket Pump, full village participation is expected in maintenance.

In addition, the committee recommended that the upgrading of traditional and family wells be encouraged, especially where these were perennial and in regular use. These were regarded as an important national resource which could no longer be ignored. Future programmes may include a large proportion of family based Upgraded wells with a correspondingly smaller proportion of community based Bucket Pumps.

The logic of the decision is clear enough. In the first instance, Bush

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Pumps are well known, have a successful history in heavy duty settings and a maintenance system which is already established for them (by the DDF). Bucket Pumps can be managed by the user communities with little assistance from outside and when properly placed, they can deliver water of an acceptable quality. Whilst their delivery rate is low, they serve small communities well and maintenance costs are low. Traditional wells are common, and already represent a considerable national investment in labour. They are used daily by a considerable proportion of the total rural population, and thus the upgrading of these resources was considered vital.

Regarding the PVC bodied pumps, the Blair and the Nsimbi, these have both been installed in relatively large numbers (about 1000 of each), but without a national programme established to maintain them. In addition, whilst both are relatively simple in design and low in cost, there is little if any available evidence to show that local management by the user community has been successful without considerable assistance, both technical and in the supply of spare parts, from outside. In addition both pumps have a high content of PVC and a limited lifespan of perhaps five years in a communal setting. The committee felt that large investments for hardware should be made in buying pumps which were durable and where the 'backbone life' could be considered in decades rather than in years. In this regard, many Bush Pumps are known to provide service for twenty or thirty years and represent a good capital investment. PVC pumps are best placed in family or extended family settings, where they can provide good service for many years and thus represent a good investment.

This section provides detailed information on all four types of handpump still in use in Zimbabwe, namely the Bucket, Blair, Nsimbi and Bush Pumps. In addition pumps of all these types can be hand fabricated in local workshops in most parts of the world, and a description of hand built models is included.

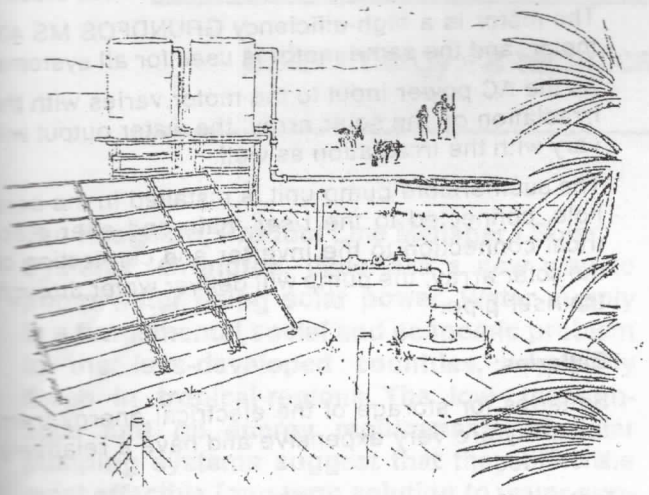
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Table 5. Recommended settings for 'handpumps'.

PUMP SYSTEM	DEPTH RANGE	MAX NO. USERS	IDEAL SETTING
Bucket/Windlass on well	1 – 15 metre	20	Family
Bucket Pump	1 – 15 metre	60	Small community
Bush Pump	1 – 100 metre	250	Large community
Blair Pump	1 – 12 metre	60	Family/small community
Nsimbi Pump	1 – 12 metre	60	Family/small community

NOTE: The bucket and windlass, Bucket Pump and Bush Pump are used in Government sponsored programmes. The Bush Pump is used most.

Solar Pumping Systems

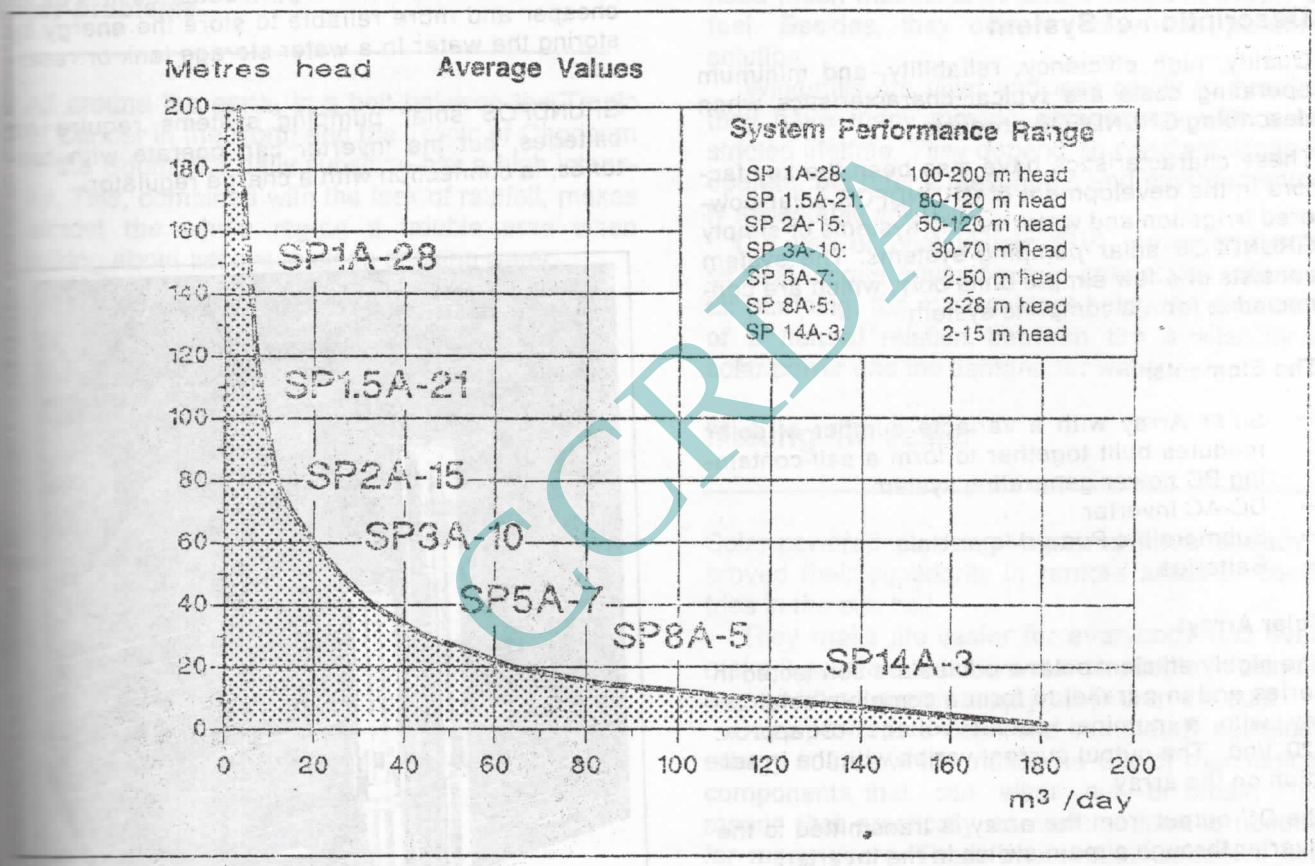


General Data and Survey Capacity Diagram

The curve shows the capacity of a 1800 Wp system. The shaded area applies to lower Wp values.

The curve is based on:

- Irradiation on a tilted surface
  H_T = 6 kWh/m² day
- Irradiation on a horizontal surface
  H_H = 5.5 kWh/m² day (473 cal/cm² day)
- An average ambient temperature of 30°C
- 20° northern latitude
- A tilt angle of 20°



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...fications

GRUNDFOS solar pumping systems are specially ...igned for water supply and irrigation in remote ... where no reliable electricity supply is avail... Features like extremely long life and mini... maintenance are key factors with these ...ping systems.

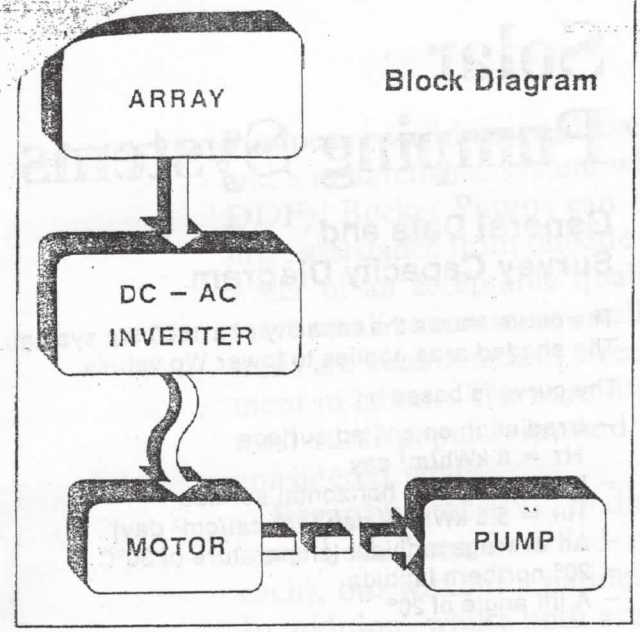
The only moving part of the system is GRUNDFOS' well-known submersible pump/motor unit made entirely of stainless steel. There are several unique advantages of using photovoltaic power in connection with water pumping.

Primarily, there is a natural relation between the availability of solar power and the water requirement. The water requirement grows during periods of hot weather when the sun shines most brightly and the output of the solar array is at a maximum. Conversely, the water requirement will decrease when the weather is cool and the sunlight is less intense.

The water can be pumped during the day and stored. Water is then available at night and during cloudy periods.

The possibility of storing the pumped water eliminates the need for batteries in the system.

GRUNDFOS®



Block Diagram

Description of System

Quality, high efficiency, reliability, and minimum operating costs are typical characteristics when describing GRUNDFOS products.

These characteristics have also been the key factors in the development of GRUNDFOS solar-powered irrigation and water supply systems or simply GRUNDFOS solar pumping systems. The system consists of a few simple units only, which are connected to form a complete system.

The Elements:

- Solar Array with a variable number of solar modules built together to form a self-containing DC power generating system
- DC-AC Inverter
- Submersible Pump/Motor Unit
- Batteries

Solar Array:

The highly efficient solar modules are connected in series and in parallel to form a complete solar array with a nominal output voltage of approx. 120 Vdc. The output current varies with the irradiation on the array.

The DC output from the array is transmitted to the inverter through a main switch in the inverter.

DC-AC Inverter:

The GRUNDFOS inverter converts the DC power from the solar array into three-phase AC power which is transmitted to the submersible motor.

The AC output voltage and frequency vary continuously as a function of the irradiation.

The construction and mode of operation of the GRUNDFOS inverter are unique, i.e. the system utilizes the power output of the solar DC generating system to an absolute maximum.

Submersible Pump/Motor Unit:

The submersible pump is close-coupled underneath the pump so that the motor and the pump form a complete unit. All vital parts of both motor and pump are manufactured from stainless steel.

The motor is a high-efficiency GRUNDFOS MS 402 motor, and the same motor is used for all systems.

As the AC power input to the motor varies with the irradiation on the solar array, the water output will vary with the irradiation as well.

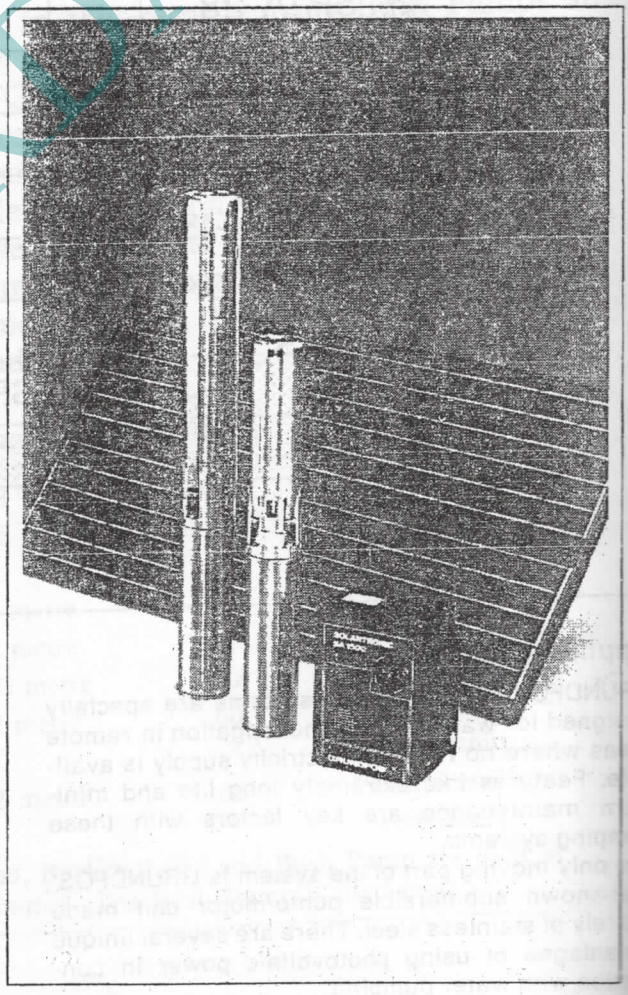
The submersible pump unit is installed in the bore hole, connected to the riser main and after electrical connection to the inverter and connection of the solar array, the pump will deliver water through the riser pipe.

Batteries:

Batteries for storage of the electrical energy from the array are very expensive and have a relatively short life.

Instead of storing the energy in batteries, it is much cheaper and more reliable to store the energy by storing the water in a water storage tank or reservoir.

GRUNDFOS solar pumping systems require no batteries, but the inverter can operate with batteries, in connection with a charge regulator.



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GRUNDFOS®

Unique advantages with solar-driven water pumps

Solar energy - a technical and economical alternative

Jan Heegaard, Product Line Manager - Solar Systems, Grundfos, describes a new way to pump water using solar power. **Water supply is a fundamental social and economic problem in the less-developed countries, especially those in tropical regions. The low maintenance and nil energy requirements of solar pumping systems suggest that they offer the most effective long-term solution to water supply problems**

All around the earth, in a belt between the Tropic of Cancer in the North and the Tropic of Capricorn in the South, the daily sunshine has a high intensity. This, combined with the lack of rainfall, makes almost the whole region a trouble area when talking about access to clean drinking water.

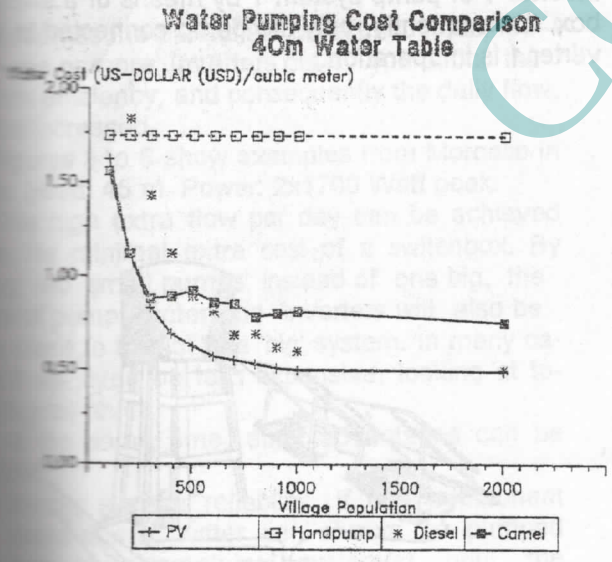


Figure 1

As most of the developing countries in the world are placed in this geographical belt, this article concentrates on this area.

Traditionally, water was taken from big open wells, and history has proved that this is the least healthy of all kinds of water supply systems.

Hand pumps were introduced and they make a possible alternative if the water quantity needed is limited. However, hand pumps require the constant presence of people to operate the pumps.

Diesel or diesel generator driven pumps are relatively inexpensive and simple to install, but need much maintenance and a constant supply of fuel. Besides, they offer a noisy and polluting solution.

Windmills are quiet and less costly to run, but they have many moving components with a restricted lifetime. They depend on constant winds to operate, but offer a reasonable and environmentally acceptable solution.

The use of photovoltaic (PV) power presents several unique advantages in connection with water pumping, the most evident being the existence of a natural relation between the availability of solar power and the demand for water.

Making life easier

Solar-powered pumping systems have already proved their superiority in remote areas of countries in the sun belt.

They make life easier for everybody and even make it possible to bring water to people in remote areas with no energy supply other than the sun!

Solar power is a clean and completely noiseless energy source which makes no use of mechanical components that can wear out or break. This means that practically no maintenance is needed for many years. These photovoltaic modules can be connected directly to the highly reliable submersible pumps which are optimised to work at high efficiencies and at the same time designed for a long life without maintenance.

Several independent organisations and institutions have made technical and economic comparisons which speak very much in favour of solar pumping systems. One was made in Mali for a comparison of diesel, animal and hand-driven systems with solar pumping systems. (See figure 1.). Technically, the solar concept proves to be the most reliable solution and, in the lower flow areas, where a reasonable pressure is needed, also the most economical solution.

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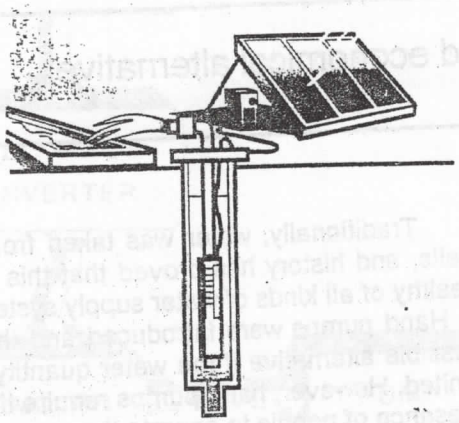


Figure 2

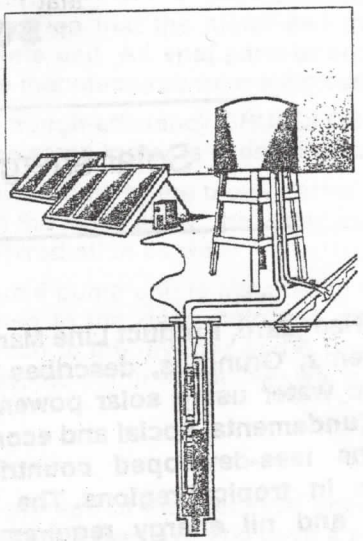


Figure 3

For small and large systems

Of course, the comparison depends on the efficiency of the PV system chosen - and consequently on its price - but even small PV systems will supply the electricity required to drive a submersible pump capable of delivering water to a farm or a small community.

PV pump installations may even be improved by applying some non-traditional thinking in connection with the layout of the entire PV system.

By making better use of the energy supplied by the PV modules, i.e. installing high-efficiency pumping systems, we will reduce the cost per m^3 of water supplied. Also, the system reliability can be further improved by thinking in alternative ways - and this is a very important factor in remote areas of developing countries, where help and service may be days away.

Grundfos provide the pumps

Grundfos, the world-wide pump manufacturer, is today the world's largest supplier of middle-size pumps for solar-driven installations. Since the introduction of the system in 1982, Grundfos has delivered pumps to more than 3,000 units.

The long time working with solar-driven systems has given Grundfos considerable experience in these fields, with consequent benefits for the humanitarian organisations. Grundfos has delivered pumps for solar-driven drinking water supply almost all over the world.

From the pump side, there are many opportunities for influencing and optimising the fine results which PV pumps have already proven. One is parallel coupling of two or more pumps.

Parallel coupling: double the flow

Parallel coupling can be made in two ways. One is the mechanical connection of two or more pumps to the same riser pipe (see figures 2 and 3 above).

In such an installation, two pumps would almost double the flow supplied by one pump.

But things become really interesting when the above concept is combined with a parallel connection of the PV modules (see figure 4 below).

In the morning, all solar arrays are connected to inverter 1 of pump system 1 by means of a switch-box. Consequently, only the pump connected to inverter 1 is in operation.

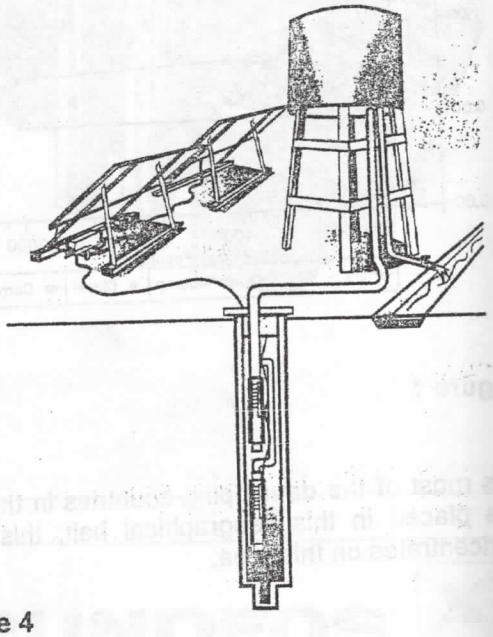


Figure 4

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the radiation is so strong that pump system 1 is running at its maximum, the software in inverter 1 sends a signal to the switchbox to interrupt the parallel connection of the solar arrays. Inverter 1 is now connected to array 1 and inverter 2 to array 2, and the pump connected to inverter 2 starts operating.

When the irradiation is decreasing, e.g. in the evening, in cloudy or misty weather, inverter 2 is cut out and the solar arrays will go back to parallel connection, i.e. only pump system 1 is in operation.

This solution ensures an optimised system efficiency. It gives a higher daily flow compared to the traditional system consisting of one large pump with motor and inverter. The energy of the PV modules is simply better utilised than with a middle-sized pump and motor.

Flow depends on the weather

Many factors have an influence on how much extra daily flow can be obtained - from a few per cent to more than 100% extra flow! Amongst other things, the flow increase will depend on the time of the year and on how fast the sun rises in the morning and sets in the evening.

For instance, in coastal areas with many clouds, the parallel connection will ensure a larger flow increase than on an average solar day.

The further we get from the Equator, the more extra flow will be obtained. If the radiation is reduced because of fog, this will also ensure a larger flow increase in comparison with an average solar day.

Moreover, as the panels are parallel-coupled, putting one or more inverters out of operation, the system efficiency, and consequently the daily flow, will be increased.

Figures 5 to 6 show examples from Morocco in West Sahara. Head: 45 m. Power: 2x1700 Watt peak.

This high extra flow per day can be achieved with the minimal extra cost of a switchbox. By using two small pumps instead of one big, the cost of pump, motor and inverters will also be reduced to that of one 'big' system. In many cases it will even be less expensive, looking at total price level.

At the same time, other advantages can be gained:

Higher system reliability. If one component breaks down, water can always be pumped from the remaining system(s) until the component is repaired - a feature of vital importance in remote areas of the third world.

Simplified spare parts stocking.

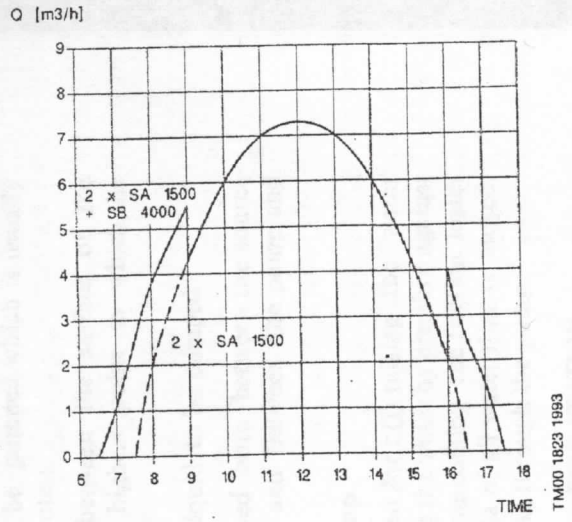


Figure 5. Average solar day with no clouds

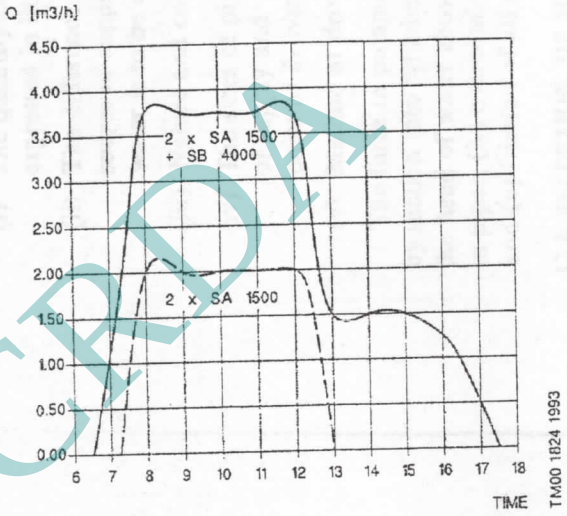


Figure 6. Theoretical example of a cloudy day

A solution for the environment

Such systems can be used everywhere in the world where the sun is plentiful and a traditional energy supply is difficult or impossible to install. And when increasing the system efficiency by means of parallel coupling, the potential geographical regions are further enlarged to the North and to the South of the Tropics.

When bearing in mind the ever-increasing global pollution, one must not ignore this environmentally sound way of providing living beings' most basic need: **WATER**.

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CHAPTER 12.

WATER PUMPING MACHINERY

12.1. NECESSITY OF PUMPING

Pumping is usually required to raise water at one or more points in the system and very rarely only a few cities in the mountainous or sub-mountainous regions can supply water to consumers entirely under gravity. The pumping is, therefore, necessary for the areas where gravity flow is not possible. It is also resorted to, when it is desired to increase the pressures in the pipelines or when water is to be raised from lower to higher levels. The pumping is resorted to for the following purposes, *viz* :

(i) To pump raw water from a source to the purification works which is termed as "raw water pumping" ;

(ii) To pump purified water to an elevated tank or high level reservoir which is termed as "pure water pumping" ;

(iii) To pump directly into the distribution mains ;

(iv) To pump well water into overhead tanks in one or two stages, *i e*, pumping from the well to the ground level in first stage and then from ground level to elevated tanks in the second stage ; and

(v) To pump for improving pressures (boosting) in distribution system at high points.

The pumping machinery is actually one of the most important adjuncts of the waterworks and the breakdown of pumping machinery may mean water famine. Hence, it is of utmost importance that the pumping machinery should be reliable and of standard make.

Where by chance both the systems, *i e*, gravity as well as pumping system are possible, a comparative study should be thoroughly made. In case finally the supply by pumping is decided, the following main factors should be considered.

(i) Reliability

The waterworks engineer should ensure that the whole plant is reliable. It should run continuously for long periods without stoppages for cleaning, repairs, oiling, breakdowns, etc.

(ii) Efficiency

The quantity of water should be raised with a minimum consumption of fuel and in this condition the plant will be called an efficient one.

(iii) Maintenance

The pumping machinery and plant should be so chosen that it is not complicated and the cost of maintenance is small.

12.2. CONSIDERATIONS FOR INSTALLING PUMPS

The following are the most important points in installing the pumps :

(i) The quantity of water to be pumped which is usually expressed in litres per minute ;

(ii) The difference in levels between the surface of the source of supply and the highest point to which the water is to be delivered ;

(iii) Nature and condition of liquid to be pumped ;

(iv) The sizes of pipes to be used both between the source of supply and the pump and between the pump and point of delivery ; and

(v) Method of driving the pump.

The force in pumping is required for : (i) raising the water by suction into cylinder, (ii) raising the water by pressure against the head of water above it, (iii) overcoming the friction losses in pipes, (iv) overcoming the inertia of all water that is moved, and (v) friction of all water passing through the pump.

12.3. SELECTION OF SITE FOR PUMPING STATION

The selection of site for a pumping station should be in

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view of the following :

(i) It should be above all the sources of contamination in the vicinity of the town on the upstream side (if the source is a river or big lake).

(ii) It should be above the highest flood level (HFL).

(iii) It should be so selected that future growth and expansion may be possible.

(iv) In case of rivers the site for the pumping station should be such that the pumping machinery may draw up the water sufficiently to meet the peak demand during the busiest hour of the day. For this, the dry weather flow in the summer season, the likely changes in the water course and meandering, etc should be properly considered.

Note : If the site is not properly selected, there will be scarcity of water. In some of the important towns like Delhi, etc, the difficulty has been felt because the site was not proper.

12.4. TYPES OF PUMPS

The following types of pumps have been generally used for pumping the water :

(i) Displacement pumps ;

(ii) Centrifugal or screw type pumps (velocity pumps) ;

(iii) Air lift pumps (buoyancy pumps) ; and

(iv) Miscellaneous pumps.

12.4.1. Displacement pumps

This class includes a piston or a plunger which alternately draws water into a cylinder on the intake stroke and forces the same out in the discharge stroke. It is called "reciprocating type pump". Another type of the displacement pump is "rotary type pump".

The reciprocating pumps may be single-acting or double-acting. A single-acting pump draws water into the cylinder in one stroke and discharges in the return stroke as shown in Fig 12.1 and gives an intermittent supply. The piston works

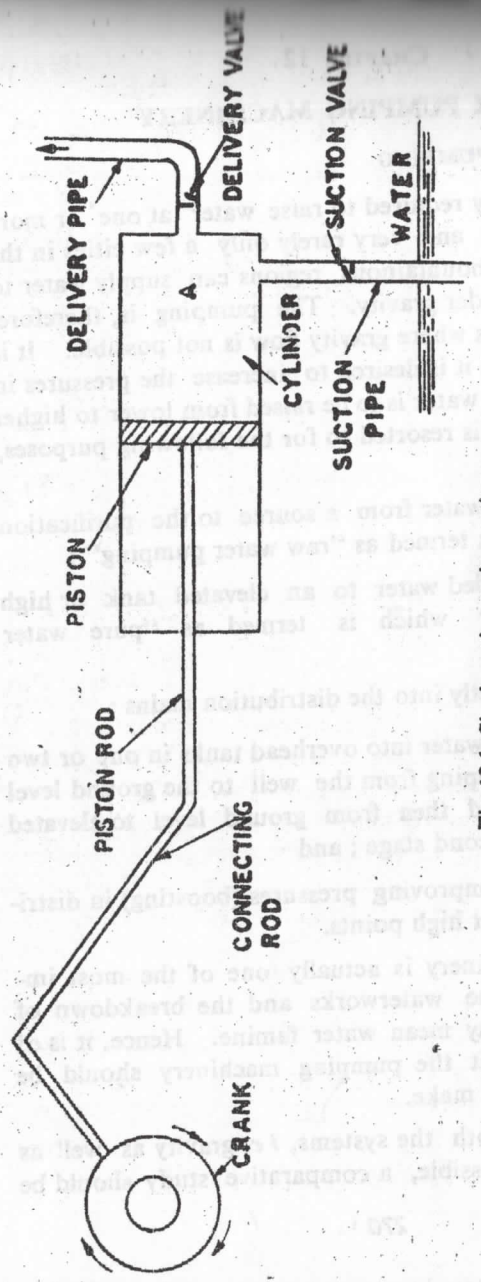


Fig 12.1. Single-acting reciprocating pump

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inside a cylinder by some power. In one stroke, the water is sucked in, the suction valve remains open and the delivery valve remains closed, while in the next stroke, the delivery valve remains open and suction valve remains closed and water is delivered up. Since in only one stroke out of two the water is delivered, a pulsating flow is produced which is a great disadvantage.

In case of double-acting reciprocating pumps, the pulsating flow is greatly reduced because there are two suction and two delivery valves in the same cylinder and the water is delivered in every stroke. Even then it is seen that there is still some variation in flow and therefore double-acting duplex or triplex pumps (*i e*, the pumps with 2 sets of piston and cylinder or 3 sets of piston and cylinder) are used.

An air chamber is placed in the discharge piping close to the pump to counteract the shocks and water hammer caused by pulsating flow.

12.4.1.1. Pump valves

These are the integral and most important parts of the reciprocating pumps and are placed in entrance and exit passages so as to allow water to flow in only one direction, *i e*, (i) the valve should afford an un-obstructed flow of water in one direction, and (ii) the valve should entirely close the passage and prevent the return of water in the contrary direction ; usually they are heavy enough to close by their own weight.

Advantages

The reciprocating pumps are suitable for high heads and fluctuating loads and give greater efficiency (up to 90%) than centrifugal pumps for high lifts. Their efficiency decreases rapidly below a head of 30 m where the centrifugal pumps are suited and are more efficient.

Disadvantages

The disadvantages of reciprocating pumps are : (i) pulsating flow, (ii) high initial cost, (iii) non-suitability for sandy waters, (iv) possibility of damage due to sudden stoppages

caused by any obstruction or closed valve, (v) complicated, (vi) more heavy and requiring larger floor area, and (vii) more noisy.

The "rotary pumps" have two rotating pistons or gears which mesh together and draw water into the chamber and force it practically continuously into the discharge pipe. These are small sized pumps and particularly suitable for small discharges and moderate heads.

Advantages

The advantages of rotary pumps are : (i) uniform rate of discharge, (ii) simplicity in operation, (iii) handling of any type of liquid (free from grit, etc) from lightest to heaviest irrespective of viscosity or volatility, (iv) requiring no valves, and (v) self-priming.

Disadvantages

The disadvantages of rotary pumps are : (i) their high initial cost, and (ii) less durability.

12.4.2. Centrifugal pumps

The centrifugal pump essentially consists of a circular casing with an impeller (which has a number of spiral vanes)

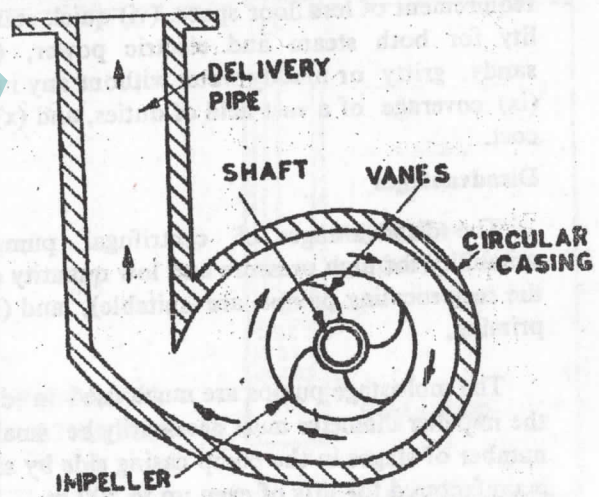


Fig 12.2. Centrifugal pump

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inside it keyed on a shaft which is driven by some power. When the shaft or impeller rotates at high speed, the centrifugal force is produced by rotation of vanes which force the water up into the delivery pipe as shown in Fig 12.2.

The impeller is usually run by electric motor. Various types of centrifugal pumps are available of which the "volute centrifugal pump" and "turbine pump" are common and most important.

Sometimes a multistage centrifugal pump is used (when the head is more than 90 m). In this case, the pump comprises of several impellers on one shaft to generate a greater head than that can be obtained from a single-stage pump.

The centrifugal pump cannot be started unless it is initially full of water and, therefore, it becomes necessary for the pump to remain submerged in the source of water or alternatively the pump can be provided with a foot-valve at the bottom of the suction pipe so that the water may remain in the pipe and does not go down.

Advantages

The advantages of centrifugal pumps are : (i) high dependability and durability, (ii) low initial cost, (iii) compactness, (iv) simplicity in construction and operation, (v) lightness and requirement of less floor space, (vi) quick starting, (vii) suitability for both steam and electric power, (viii) handling of sandy, gritty or muddy water without any injury to the pump, (ix) coverage of a vast field of duties, and (x) less maintenance cost.

Disadvantages

The disadvantages of centrifugal pumps are : (i) non-suitability for high pressure and low quantity duties (for which the reciprocating pumps are suitable), and (ii) requirement of priming.

The multistage pumps are much used in deep wells where the impeller diameter must necessarily be small. By placing a number of stages in the pump casing side by side, they can be manufactured for lifts of even up to 300 m.

When placing an order to purchase a centrifugal pump, (i) the head against which it must operate, (ii) the discharge required, and (iii) the variation of head, etc are accurately specified. The size of the centrifugal pump is designated by the diameter in cm of the discharge pipe. The suction pipe is 6-13 mm bigger than the delivery pipes up to 25-75 mm. For the size of the pump equal to 10 cm and above, the suction and delivery pipes are equal in size.

According to IS : 1520-1960, while placing an order for horizontal centrifugal pumps to handle clear, cold and fresh water (*i e*, water having 50 ppm maximum turbidity on silica scale, 500 ppm maximum chlorides, 3 000 ppm maximum total solids, 6.5-8.5 pH value, 1.004 maximum specific gravity and 30°C temperature), the purchaser should furnish to supplier the information regarding : (i) installation site, (ii) number of pumps required, (iii) spare parts required, (iv) type of drive (electric motor/engine), (v) optional fittings required, (vi) pump operating conditions (*i e*, capacity and total head), (vii) pipes and fittings (length and size of suction pipe ; number and size of bends, tees, valves and other fittings on suction pipe ; length and size of delivery pipe ; number and size of bends, tees, valves and other fittings on delivery pipe ; material and condition of pipes and fittings ; and sketch of pipeline), (viii) drive arrangement (direct through coupling, flat/V-belt, gearbox, propeller or splicer shaft, and hydraulic/magnetic coupling), (ix) drive data (electric drive—type of current frequency, voltage, preferred speed and rating ; and engine drive—preferred speed direction of rotation and rating), (x) details of prime mover if existing, (xi) site conditions (height above mean sea level, maximum and minimum temperatures during the year, humidity, nature of atmosphere, details of quality of water, water free from sand or not, and water corrosive or not), and (xii) any other information or requirement.

As regards the general requirements, the size of the suction end of a double suction pump should be preferably one size larger than that of the delivery end to offset the increased loss in the double suction bend incorporated in the pump. The typical sizes used are : 100/75, 125/100, 150/125, 200/150,

shall be provided on the delivery side. A priming connection should be provided. The base plate which accommodates pump and the prime mover, when provided, should be rigid and stable so that alignment is not affected. The impeller should be properly balanced along with any other unmachined rotating parts on proper balancing equipment so as not to cause any vibration. The shaft should be finished to close tolerance at the impeller, coupling, pulley and bearing diameters ; and the impeller, pulley and shaft sleeves should be firmly secured to the shaft by keys and/or nuts. The bearings may be ball, roller or sleeve bearings. The prime mover should be capable to provide a power which is more than the maximum power required by the pump.

12.4.3. Air lift pumps

The air lift pumps have some unique features which are not possessed by any other types of pumps. An air lift pump with sufficient capacity can draw more water from the deep well than any other type of pump. The pump is operated by compressed air. The air lift pumps are used to lift water from deep open wells up to 60 m and sometimes even up to 150 m. The principle of working is that by mixing the water with air in the discharge, the density of mixture is less than that of the water itself. As such the pressure of the column of air and water in the bottom of reduction pipe or delivery tube is less than that of the solid water outside in the well and an upward flow is created.

The details of the pump are shown in Fig 12.3.

The pump is lowered into the water and the compressed air is passed through a rubber tube worked by a small motor. The air pipe is $\frac{1}{6}$-$\frac{1}{7}$ of the delivery tube in cross-section. A stop valve is provided at the main supply pipe, a foot valve and strainer is provided at the suction pipe.

Advantages

The advantages of air lift pump are : (i) it can produce large volume of water from a well of small diameter ; (ii) it can draw sandy, gritty and muddy water and sewage ; (iii) it is

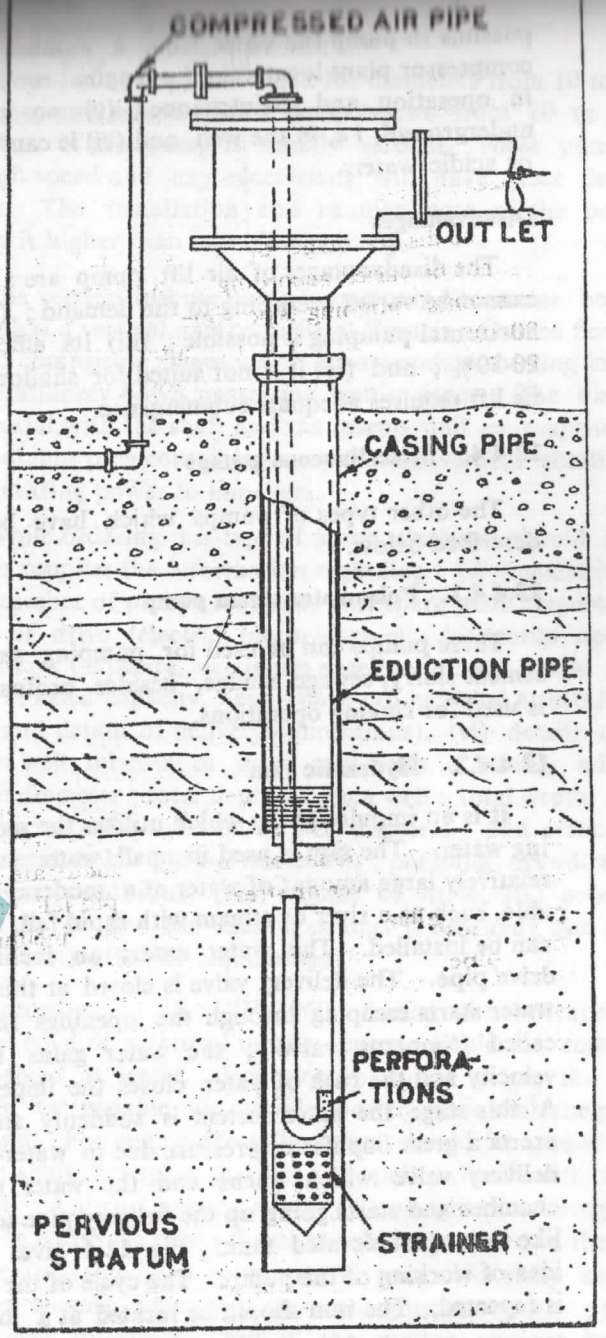


Fig 12.3. Air lift pump

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possible to pump the water from a number of wells by one compressor plant located in the engine room ; (iv) it is easy in operation and maintenance ; (v) no working parts are underground, *i e*, in the well, and (vi) it can draw the alkaline or acidic waters.

Disadvantages

The disadvantages of air lift pump are : (i) its discharge cannot be varied according to the demand ; (ii) only a limited horizontal pumping is possible ; (iii) its efficiency is low, *i e*, 20-30% ; and (iv) it is not suited for shallow depths because its lift requires adequate submergence.

12.4.4. Miscellaneous pumps

The other types of pumps which have been used are as described below.

12.4.4.1. Pulsometer steam pump

These pumps can be used for pumping semi-liquids, mud, cement slurry, sewage, sludge, besides ordinary pumping. It is used for sinking operations.

12.4.4.2. Hydraulic ram

It is an impulse pump which utilizes the momentum of falling water. The ram is used in small water supplies where a relatively large amount of water at a moderate head is available, such as a river or stream with rapid fall, where the pump can be installed. The water enters an inclined pipe called drive pipe. The delivery valve is closed at this stage but the water starts escaping through the openings in another valve called "impetus valve" ; the water gains more and more velocity and the rush of water closes the impetus valve fully. At this stage, the water current is suddenly stopped and this exerts a great impulse or pressure due to water-hammer on the delivery valve which opens and the water enters the air chamber and starts going up the delivery pipe to its destination like that of an elevated tank. Fig 12.4 gives completely the idea of working of the pump. The cycle of the whole process is repeated. The ram should be located at a lower level than

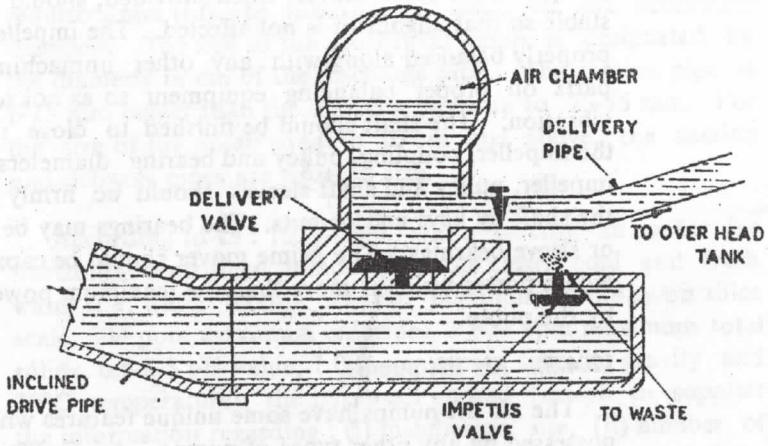


Fig 12.4. Hydraulic ram

the source of water so that a natural fall is obtained to develop the velocity at the impetus valve.

Advantages

The advantages of a hydraulic ram are : (i) it is quite efficient for lifts up to 30 m ; (ii) its running cost is not much ; (iii) no fuel is needed ; (iv) once the ram is started, it needs little attention ; and (v) it is durable and reliable.

Disadvantages

The disadvantages of a hydraulic ram are : (i) the water which goes out of the impetus valve is wasted considerably ; and (ii) noise of operation.

12.4.4.3. Bore-hole pumps

These are used where the ground water level is very low. The bore-hole pump is lowered in the main tubewell pipe itsel while the motor is located at ground level which drives a vertical shaft extending down to the pump. The vertical spindle turbine pump is invariably adopted nowadays. The bowls of the bore-hole pumps should be kept at a sufficiently low level so that they remain submerged below water under working conditions. If the submergence is not possible, the foot valve should remain submerged. These pumps are electrically driven.

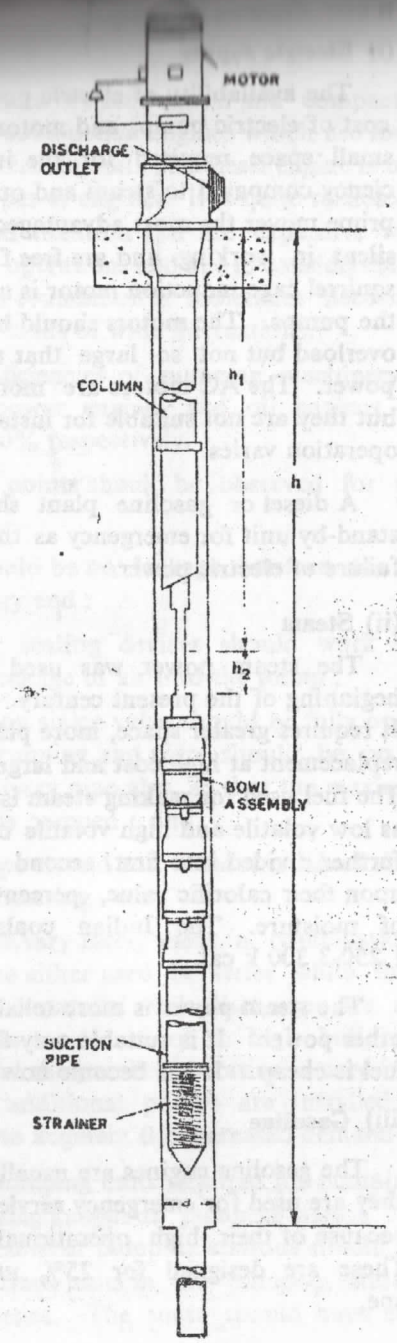


Fig 12.5. Vertical spindle turbine pump

The bore-hole pumps are made for diameters from 10 to 35 cm and the usual length of the pump varies from 20 to 60 cm. The bore of the pump is strictly vertical. These pumps run at high speed and any eccentricity will have great damaging effect. The installation and running cost of the bore-hole pump is higher than an ordinary pump.

The vertical turbine pump (commonly known as bore-hole pump) is a vertical axis centrifugal Francis or mixed flow type pump comprising stages which accommodate rotating impellers and stationery bowls possessing guide vanes. The discharge is coaxial with the shaft and the pump unit is suspended by the column pipe containing a system of vertical shafting for transmitting power to impellers.

While ordering this type of pump, the user should furnish to the supplier the information regarding : (i) installation site, (ii) number of pumps required, (iii) spare parts required, (iv) type of drive (electric motor/engine), (v) pump operating conditions (capacity, maximum speed, and head below ground level at rated capacity, head above ground level at rated capacity, and details of delivery connections), (vi) details of well (open well, tubewell or open well with a boring; minimum inside diameter ; total depth of open well : total depth of top housing pipe for tubewell h ; well slantness ; and static water level depth below ground surface h_1 ; pumping drawdown h_2) ; (vii) site conditions, (viii) details of drive, (ix) accessories (whether or not the suction strainer is required), and (x) any other information or requirement.

According to IS : 1710-1960, during the operation, the lowest bowl of a vertical turbine pump should be completely submerged in water. For electric motor drive, the motor should be capable to provide power more than the pump's demand. For engine drive, the power should be applied to the pump shaft through a gear head or pulley head with flat or V-belt. A thrust bearing to carry the weight of rotating parts and the hydraulic down-thrust should be provided in the driver or the discharge head as an integral part. Normally an open ended suction pipe will serve the purpose with properly developed tubewells. But if the suction strainer becomes

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necessary, it may be either provided separately or integral with the suction pipe. The strainer should have a net area of openings equal to at least three times the suction pipe area.

12.5. SUCTION LIFT

The suction lift should be avoided as far as possible. If the suction cannot be avoided, the arrangements for priming the pumps should be made or vacuum pumps should be installed to exhaust air from the suction lines. Only the potable water should be used for priming. To avoid the air pockets, the suction lines should be as short and straight as possible with a continuous upward slope from the foot valve to the pump. Also, the suction pipe should be larger than the discharge pipe of the pump.

The pumps lift water by creating a partial vacuum which permits the atmospheric pressure to force the water up in the suction pipe. Thus, theoretically, the suction lift is equal to the atmospheric pressure head, *i e*, 760 mm of mercury which is equivalent to 760×13.6 mm or 10.336 m of water at mean sea level where 13.6 is the relative density of mercury. However, there are many losses due to friction, etc and this head cannot be obtained in practice because the perfect vacuum can never be produced. Allowable suction is about 6 m and the pump should not be placed more than 6 m higher than the source of supply. In case of centrifugal pumps, it may be 4.5 m. The following relationship may be used for working out the suction lift :

$$H = A - V_p - V_h - H_f \qquad (12.1.)$$

where H is the suction lift, A the atmospheric pressure, V_p the vapour pressure of water, V_h the velocity head in suction pipe and H_f the friction head in pipe.

12.6. POWER REQUIRED FOR WORKING PUMPS

The power required for pumping should be so selected that it is most reliable and least expensive. The reliability is the most important factor The choice of power should suit the pumping unit which has been selected as most suitable for the duty to be performed. The choice of the prime mover should be amongst the following :

(i) Electric supply

The availability of electric power at cheap rates, a low first cost of electric pumps and motors and other equipment, the small space required for the installation, high operating efficiency compared to steam and other fuels, etc have made this prime mover the most advantageous. The electric motors are silent in working and are free from nuisance of smoke. The squirrel cage induction motor is most widely used for driving the pumps. The motors should be large enough to avoid the overload but not so large that they unnecessarily waste the power. The AC motors are more efficient than DC motors but they are not suitable for installations in which the space of operation varies.

A diesel or gasoline plant should be invariably kept as stand-by unit for emergency as there is always possibility of failure of electric power.

(ii) Steam

The steam power was used in pumping plants till the beginning of the present century in majority of installations. It requires greater space, more plants and accessories requiring replacement at high cost and larger number of operating staff. The fuel used for making steam is "coal" (which is classified as low volatile and high volatile coal). Each type of coal is further divided into first, second and third grades depending upon their calorific value, percentage of ash and percentage of moisture. The Indian coals have calorific value from 1 250-3 300 k cal.

The steam power is more reliable and fool-proof than any other power. It is suitable only for large plants located where fuel is cheap. It has become now almost out of date.

(iii) Gasoline

The gasoline engines are usually used as stand-by units or they are used for emergency service with electric power motors because of their high operational costs and low first costs. These are designed for 25% more capacity than the desired one.

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