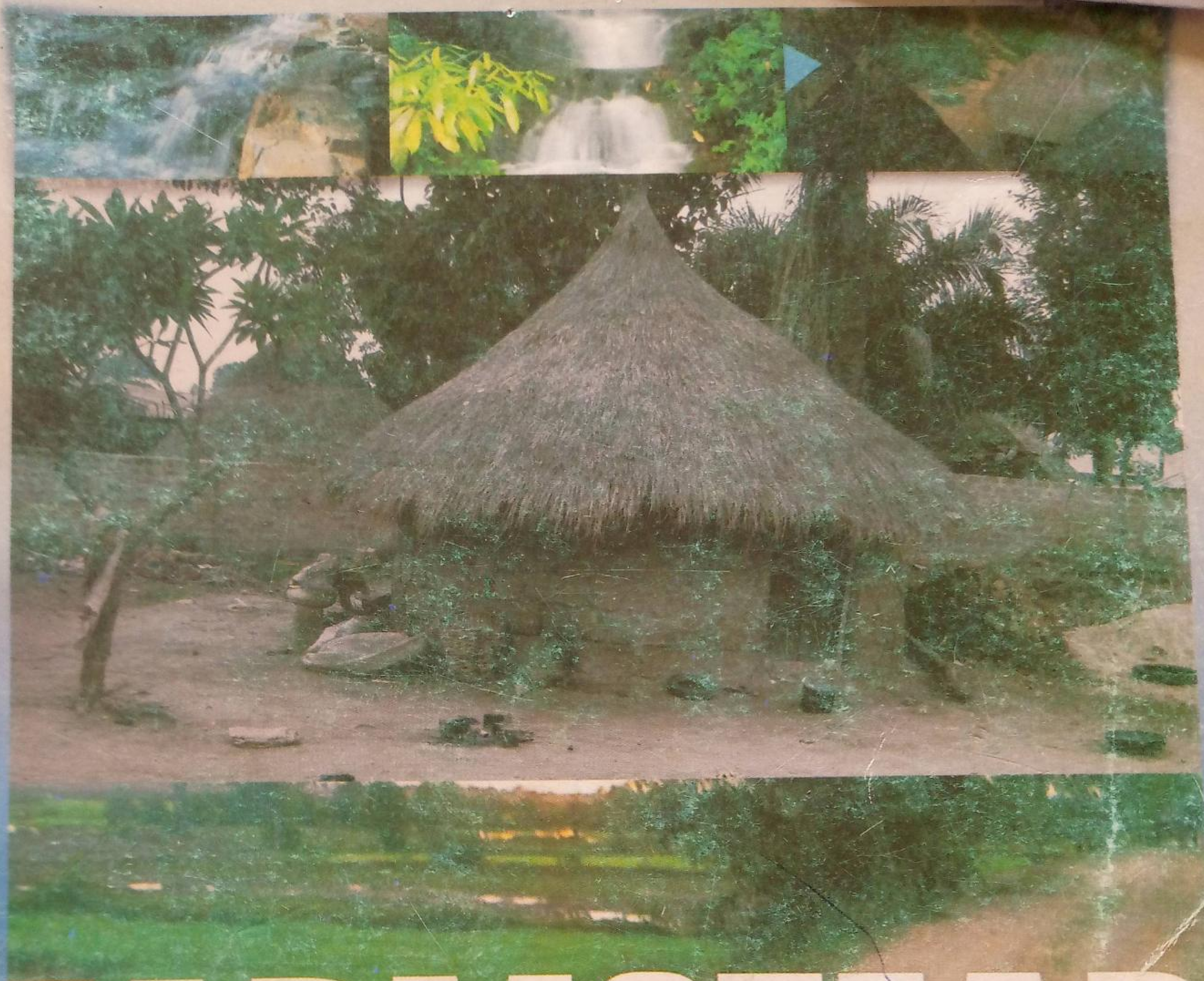

FARMSTEAD INFRASTRUCTURES

B. A. ALABADAN

CHAPTER 10

WATER SUPPLY

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10.1 Planning water source works

10.1.1 Introduction

Water, along with food, is one of the essentials of life. Water supply system capable of supplying a sufficient quantity of potable water is a necessity for a modern city. Also, in the farmstead, potable and sufficient water supply is a major concern in this regard.

The success of any water project aiming at improved water supply both in quantity and quality must be performed with the full participation of the entire population of the community.

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While relatively small quantities will sustain human life, much more is needed for cooking, personal hygiene, laundry and cleaning, livestock and perhaps for irrigation.

Of utmost importance is the need for the understanding of water use which varies from city to city depending on the climate, environmental concern, population, industrialization, and other factors. Water uses can be divided into groups like municipal, industrial, and commercial water uses.

The mention of municipal water use involves domestic use of water which denotes the water used in private residences, apartment houses, which could either be for drinking, bathing, lawn sprinkling, sanitary, and other household purposes. Talking of the industrial and commercial water uses, this involves the water used by commercial establishments and industries. Public water use include the water required for use in parks, civic buildings, schools, hospitals, churches, street washing, etc.

10.1.2 Water demand

The first step in the design of a water supply project is the determination of water demand or the quantity of water that will be required for various purposes with the provision for the estimated requirements of the future. Types of water demand include; domestic, commercial and industrial demand, demand for public or civic uses, fire demand, loss and waste of water and demand for the farmstead.

a. Domestic water demand

This includes the water which is required for use in private residences and apartment houses for cooking, bathing, drinking, washing of clothes and plates. The amount of water in this category depends on the living conditions of the consumers.

b. Commercial or industrial Water Demand

This includes the water demand of commercial and other establishments such as offices, hospitals, hotels, restaurants, cinema halls, schools etc. On an average, for a farm with moderate commercial activities, about 20 to 25% of the total water consumption is generally made in the design of water supply for these uses.

c. Demand for civic or public use

This includes the quantity of water for public utility purposes such as watering of parks and gardens, sprinkling of water on dusty roads and for decorative features like farm fountains. A provision of usually 5 to 10% of total consumption is made to meet this demand.

d. Fire Demand

This is the quantity of water required for fire-fighting purposes. Fire may break out and may lead to severe damage if not controlled. Therefore, a big or a medium sized farm should make provision for water for fire fighting. There are empirical formulae that are used to determine the quantity of water needed for this purpose;

I) Kuichling's Formula, $Q = 5663\sqrt{p}$

(ii) Buston's Formula; $Q = 2650\sqrt{p}$

(iii) John R. Freeman's Formula; $Q = 946\left(\frac{p}{5} + 10\right)$

where, Q = quantity of water needed
P = population in thousands

e. Loss and waste of water

The water in this category is sometimes termed as water unaccounted for. This includes the water lost due to leakage in mains, valves and other fittings, worn or damaged meters. A provision of 30-40% is always made for this but could be brought down to as low as 10-15% of total water consumption.

f. Types of water for the farmstead

Clean water for use in the home
Reasonably clean water for livestock
Water for irrigation.

10.1.3 Factors influencing water use

Among the factors affecting water use are

a. Climate

When the temperature is high, the water use is expected to be high. In extremely cold climates, water may be wasted at faucets to prevent the freezing of pipes.

b. Population

Water use is both influenced by the size of the city and the economic status of the customers. The per capita use of water is much lower in poor and scantily populated areas than in wealthy and densely populated communities.

c. Environmental concern

Increased public concern about excessive use of resources has led to the development of devices that can be employed to reduce the quantity of water used in residences. Table 10.1 below gives the amount of water used by conventional devices.

Table 10.1 Water requirements for conventional household devices

Device	Wastewater flow (litre/capita/day)
Bathrub faucet	30
Clothes washing machine	34
Kitchen-sink faucet	27
Lavatory faucet	11
Shower head	45
Toilet	95
TOTAL	242

d. Cost of water

If the rates at which water is supplied are high, lesser quantity may be consumed by the people and vice-versa. This will also bring water wastage down considerably

e. Method of charging

In the metered method of water supply, consumers tend to be careful about how they use water since it is "pay as you use." But in an unmetered system, consumers will be tempted to use water more liberally resulting in a lot of wastage of water.

f. Quality of water

If the quality of supplied water is good, it will be consumed more because the consumers will consider it safe for use. WHO (1993) in Appendix 3 contain the standard for drinking water.

In determining the volume of clean water, the location and convenience are significant factors. From Table 10.1, it is obvious that people adapt their need to supply. People tend to consume more water when the source is very close to the house or at home and less when the source is far away from home. The advantages of close source of water to the house can be seen in improved sanitary conditions for healthier and clean environment.

Table 10.2 Domestic water consumption per person

Water source	Consumption/person (litres/day)
Several kilometers away	2- 4
Up to 1 kilometer away	4-8
Water next to house	10-40
Water in home for WC, tap & shower	- -
water in home for WC, bath, kitchen & laundry	100-250

10.2 Farm reservoirs and dams

10.2.1 Modern water supply systems

Among the elements that constitute a modern water supply systems are:

1. Sources of water supply
2. Available storage facilities
3. Transmission to treatment facilities, if there is any need
4. Treatment facilities
5. Distribution facilities

10.2.2 The sources of water supply

a. The water cycle

The discussion on water supply scheme will not be complete without mentioning the origin of all water bodies. Hydrological cycle, as shown in the plate 10.1 below is the general name given to the series of processes whereby water is evaporated from oceans and all other water bodies in the likes of lakes and river through the process of evaporation. This water having evaporated from the water surfaces are transferred as vapour over continents and precipitated as rain, hail, dew, or snow.

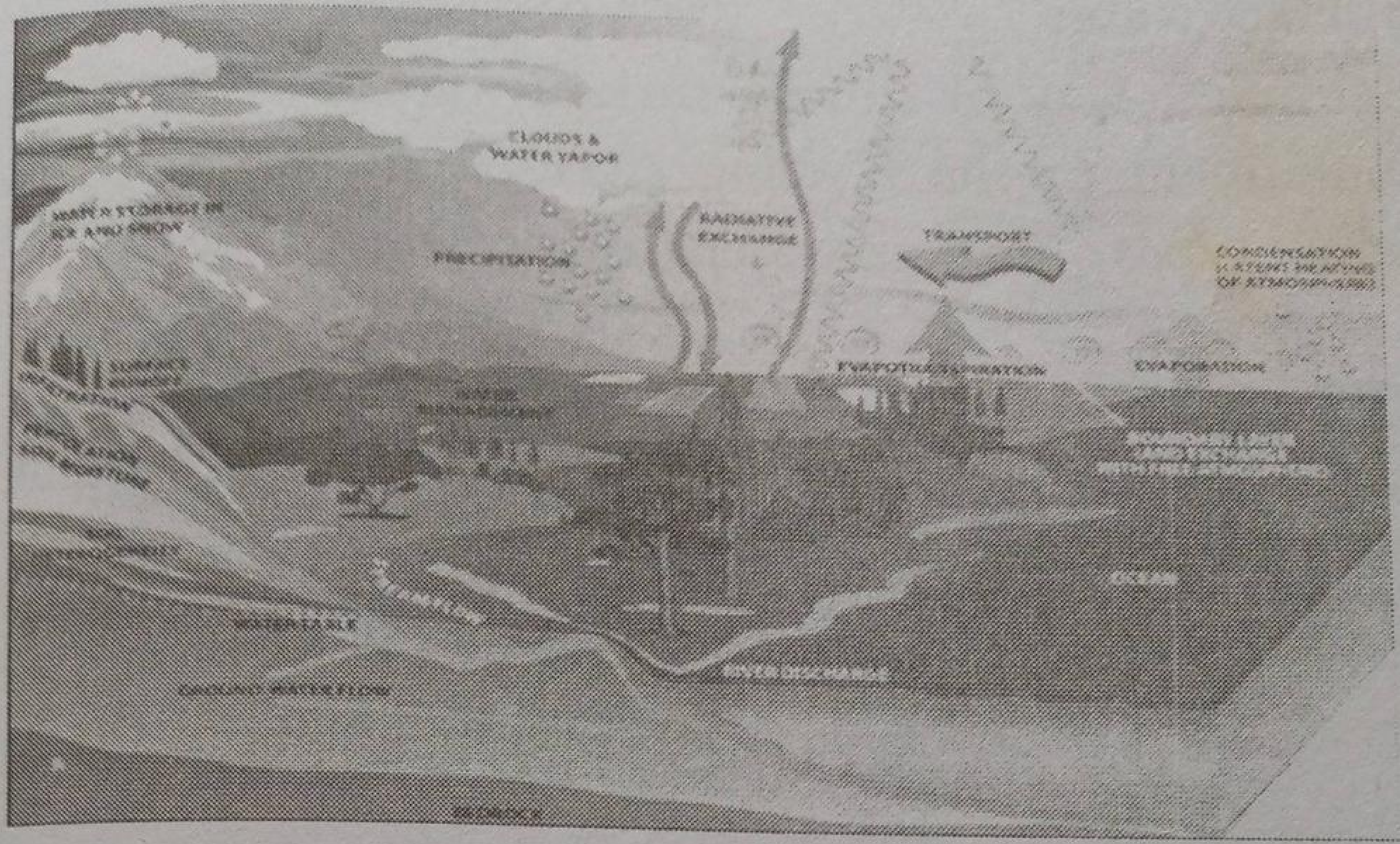

Plate 10.1 Hydrologic cycle above

This water finds its way back to lakes and oceans as overland flow, streamflow, underground percolating flow, or a combination of these through the processes of infiltration and percolation. The intensity of rainfall plays major roles in the hydrologic cycle explained above.

With the mentioned processes above, the water needs to be stored or reserved during the period of high flow in such a way that during the period of low flow there will be enough for the consumption of the masses and in the case of livestock farming, for the animals. As the rainfall gets to the earth surface, part of the rainfall enters the ground through the process called infiltration. And when the soil mass reaches the field capacity, the water instead of been infiltrated into the soil mass becomes what is termed runoff, also called overflow.

With this, the rainfall that gets to the earth surface could be categorized into Surface water and Groundwater.

b. Surface water

The simplest way of storing surface water for use is through impoundment of the flowing river, as shown in Plate 10.2. Different types of surface water are discussed below.

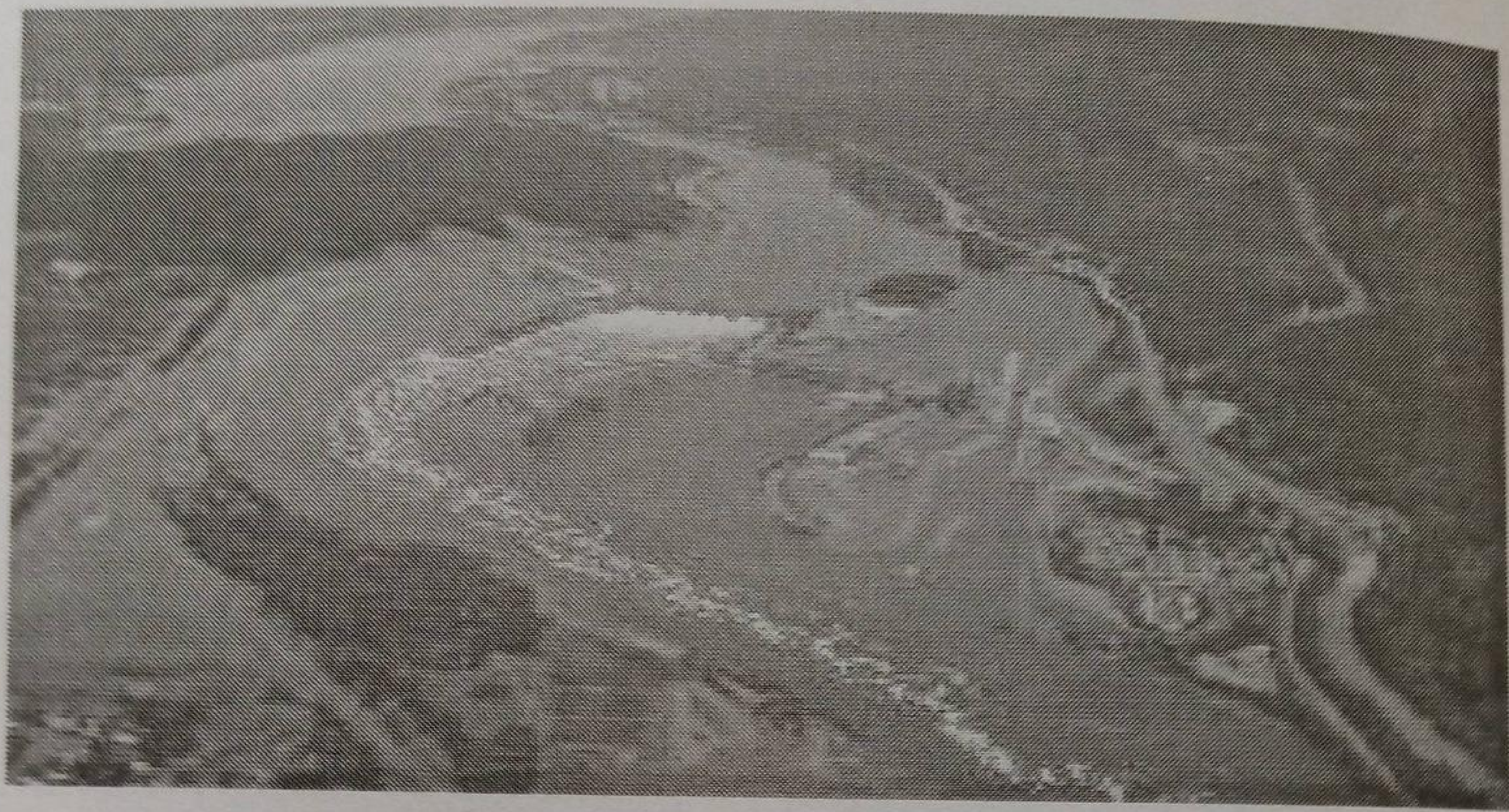

Plate 10.2 Surface water

i. Dam

This is achieved by constructing an obstruction across the flowing river. The size of the dam to be put in place determines the capacity of the reservoir required and the quantity of water being supplied from the dam. There are different types of dams based on their modes of construction, the materials used in construction, and the shape of the dams. The common types in use are gravity, buttress, arch and earth dams.

Gravity dam

This is a dam that resists the pressure from the water, called hydrostatic, by its self weight and it is constructed with mass concrete as shown in Plate 10.3. The soil on which to erect the foundation must have been tested to confirm the suitability of the soil to withstand the load of the dam. Failure of the gravity dam may occur at the foundation plane or at any higher level in the dam. It is of good construction practice to step the foundation of a dam to increase resistance to sliding.

Plate 10.3 A gravity dam

Buttress dam

This dam consists of a sloping membrane which transmits the water load to a series of buttresses at right angles to the axis of the dam. The dam usually requires only one-third to one-half as much concrete as gravity dams of similar height but are not necessarily less expensive because of the increased form-work and reinforcing steel required. Plate 10.4 showed an example of the dam

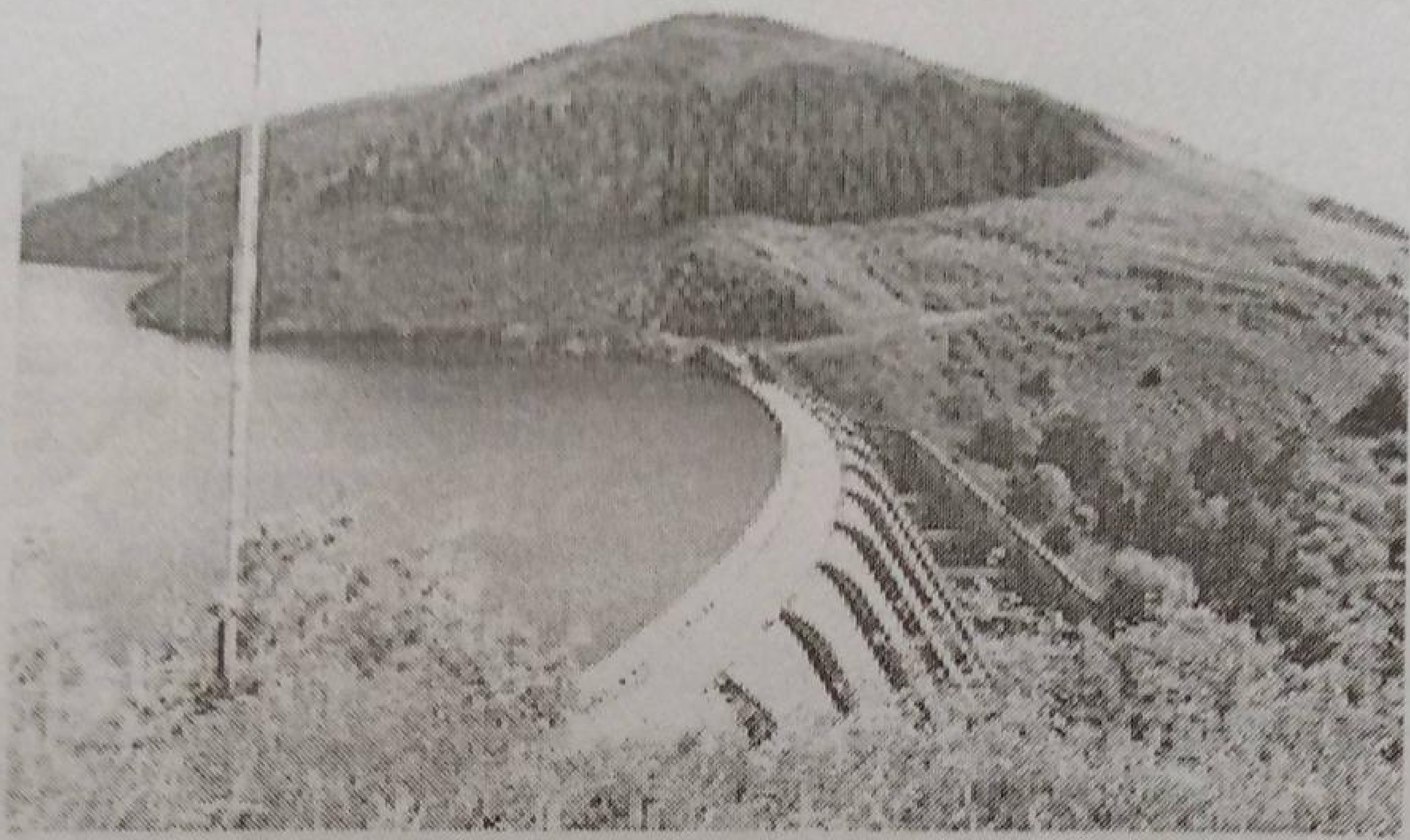

Plate 10.4 Arch-Buttress dam

Arch dam

The dam as shown in Plate 10.5 is a type curved in plan and carries most of the water load horizontally to the abutments by arch action. The arch could be a single one or have multiple arches depending on the length of the whole dam. The construction of the arch dam is done using reinforced concrete members.

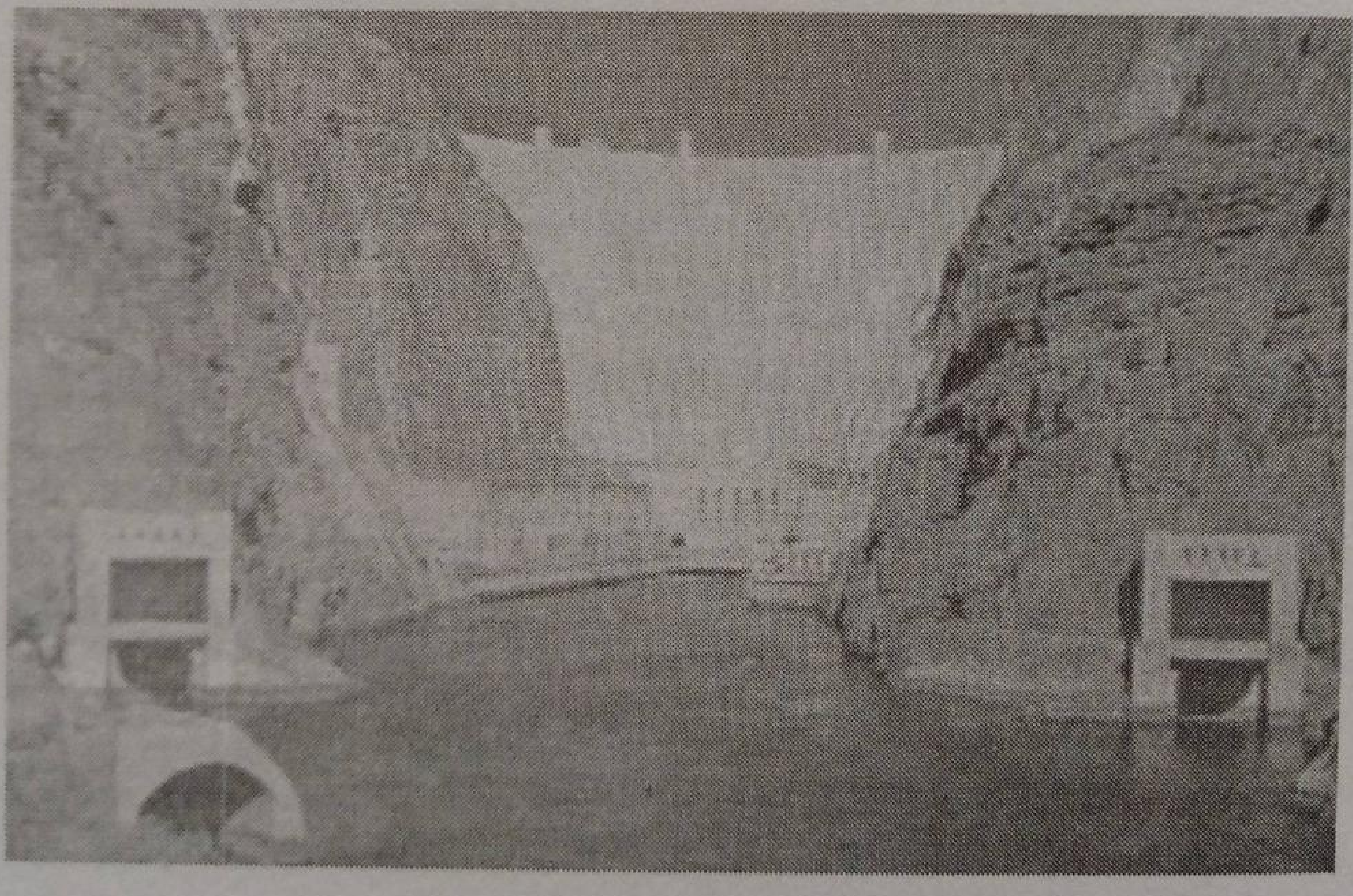

Plate 10.5 An arch dam

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Earth dams

This is a common form of dam where the earth materials are used in its construction. This is achieved by scooping the earth materials with a minimum of processing by using earth-moving equipment.

As compared with the reinforced concrete type of the dam like those mentioned above, the use of earth-moving equipment have resulted in decreased cost for earth moving as compared with an increase in cost of concrete as a result of increased wage and material cost. The embankment is homogenous essentially throughout, with only a blanket of impervious material placed on the upstream face. An example of this type of dam is shown in Plate 10.6 below.

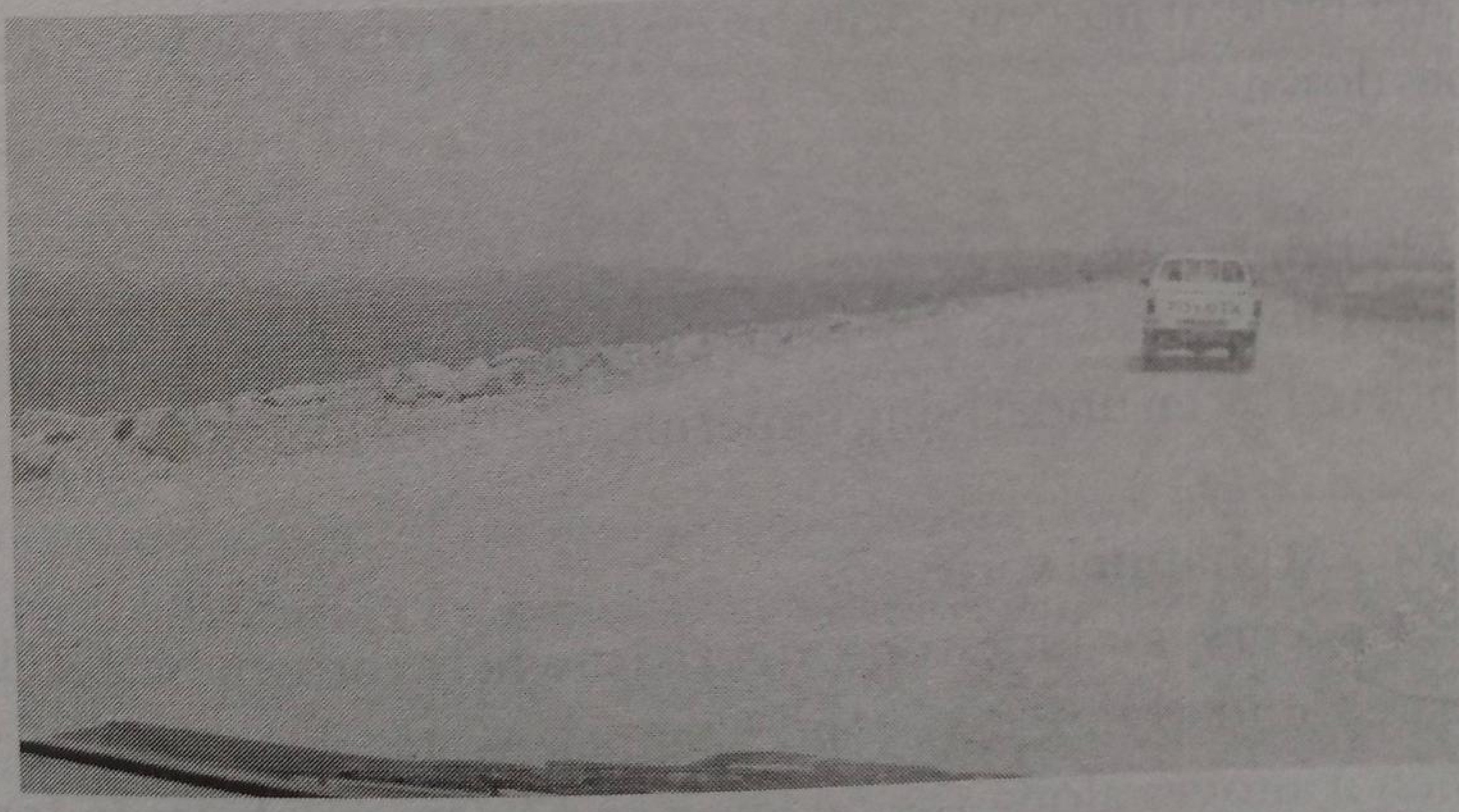

Plate 10.6 The crest of Gurara earth dam, Nigeria

ii. Rivers

In low-lying areas water is mainly drawn from rivers and stored in reservoirs to provide against seasonal variations in supply and demand.

iii. Lakes/ponds /springs

In upland areas, water is usually stored in natural or man-made lakes fed by run-off from the surrounding higher ground. Spring is defined as a large discharge of water from an aquifer concentrated in a small area. Majority of springs are ephemeral but some are in some cases perennial.

The common types of spring are

Valley spring

This develops in a valley side where topography intercepts the water table. It however dries up eventually when the water table goes down.

Stratum spring

This is liable to form where downward flow of groundwater is hindered by an underlying impermeable layer like shale.

Solution channel spring

This occurs in limestone districts where brown water has created underlying caves and channel. Water dissolves $CaCO_3$ when it moves along the bedding and fractures planes to form caves and channels.

Fault spring

This occurs where permeable beds like water bearing limestone are faulted against impermeable beds like shale.

Thermal spring

This is common in area of volcanic activities where there are geothermal fields. The escape of hot water is mainly controlled by fracture systems in the volcanic rocks

iv. Piped water

Most urban and rural areas are served by a supply of water piped from the supplier main.

v. Reservoir/ponds/stock tanks

The adequate water supply will not be feasible if there is full dependence on the stream or river as the only source of water supply to either the city for water consumption or the farms for animals. There are periods in a year where the stream flow expected is very low and also the period of high flow. There is therefore need to store excess water during the period of high flow in order to prevent drought during the period of low flow. This is where the issue of reservoir comes in.

The major types of reservoir are storage and distribution reservoirs. Because of the varying demand for water during the day, many cities find it necessary to provide distribution reservoir within water supply system. The main function of the reservoir is to stabilize the flow of water by regulating a varying supply in a natural stream or demand by the consumers. For the community water supply, water is stored or reserved before sending it to the water-treatment plant for purification and for onward pumping to the community.

On the farms, where the main function of reserved water is for the purpose of the livestock, farmers and irrigation, the stock tanks or ponds may conserve the intermittent flow from small creeks or rivers close to the farm. Also, the need for water treatment plant in the farm should be of great importance, perhaps, not only for the hygiene of the animals but also for the work force in the farm.

c. Groundwater

This refers to subsurface water occupying the zone of saturation, from which wells and springs are fed. In a strict sense, the term applies only to water below the water table. One of the major ways of accessing the groundwater storage is through wells dug to either confined or unconfined aquifer.

I. Well

A well is a shaft sunk or excavated below the level of ground water or into sub-soil water bearing strata. The shaft that is usually circular is lined with brick, stone or pre-cast concrete section to maintain the sides of the well. The terms boreholes, dug well and tube well described the manner in which water is reached.

Wells can be mainly divided into two classes: Dug wells or open wells and Bored or drilled wells or tube wells

A dug well is a hole dug with a diameter large enough to allow a man to work and usually to a maximum of 30 meters. A tube well is a perforated pipe with a pointed end, which is either hammed or jetted into the ground. When a well is less than 7m deep, it is a shallow well while a deep well is more than 7m deep. A borehole well is drilled with a cable or rotary drill. It has smaller diameter and 200 meters or more in depth. Springs break where water level in a permeable stratum is above the level of the junction of a permeable and an impermeable stratum.

Open wells are comparatively of bigger diameter and is suitable for discharges up to 0.005 m^3/sec. Tube wells or bored wells are long pipe sunk into the ground with a strainer which allows water to pass through but prevents sand from coming in. An example of the tube well shown in Fig. 10.1 below draws water either from an unconfined aquifer of unlimited extent, or from one or more confined aquifer layers

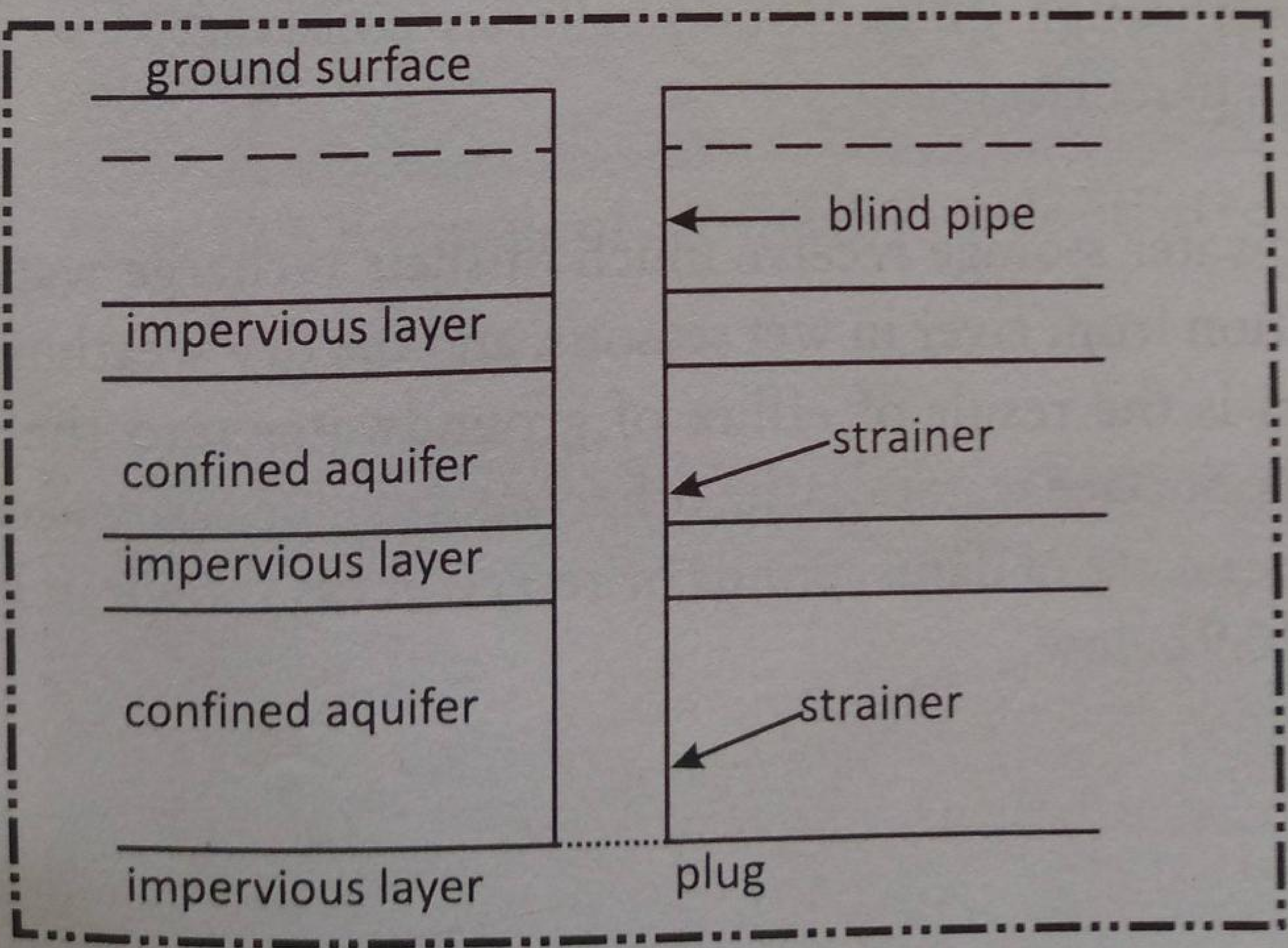

Fig. 10.1 Strainer type of tube well

10.2.3 Available storage facilities

With the sources of water described above, the perennial rivers or streams are capable of giving a constant supply of water at demand to the masses either during the period of high flow or low flow. But in the case of river or stream that depend largely on the peak flow when the rainfall is at the peak, the need for storage facilities is needed to enhance the continuous availability of water. This is when dams, ponds or farm dams for farms play major roles in the area of effective water supply for both human and animal consumption.

In the study of water supply either for the consumption by mankind, livestock or for irrigation, what are of paramount importance are the processes involved in accessing this water. In some regions, water supplies are drawn wholly or in part from groundwater either by means of boreholes, wash-bores and wells or through underground galleries constructed so as to intercept percolating flows.

Groundwater storage receive much of their recharge water by percolation from river in wet seasons, and the dry weather flow of rivers is the result of efflux of groundwater into the river channels. Surface water on the other hand can be easily accessed through the use of dams, ponds or reservoirs as shown in Plates 10.7 to 10.9 below.

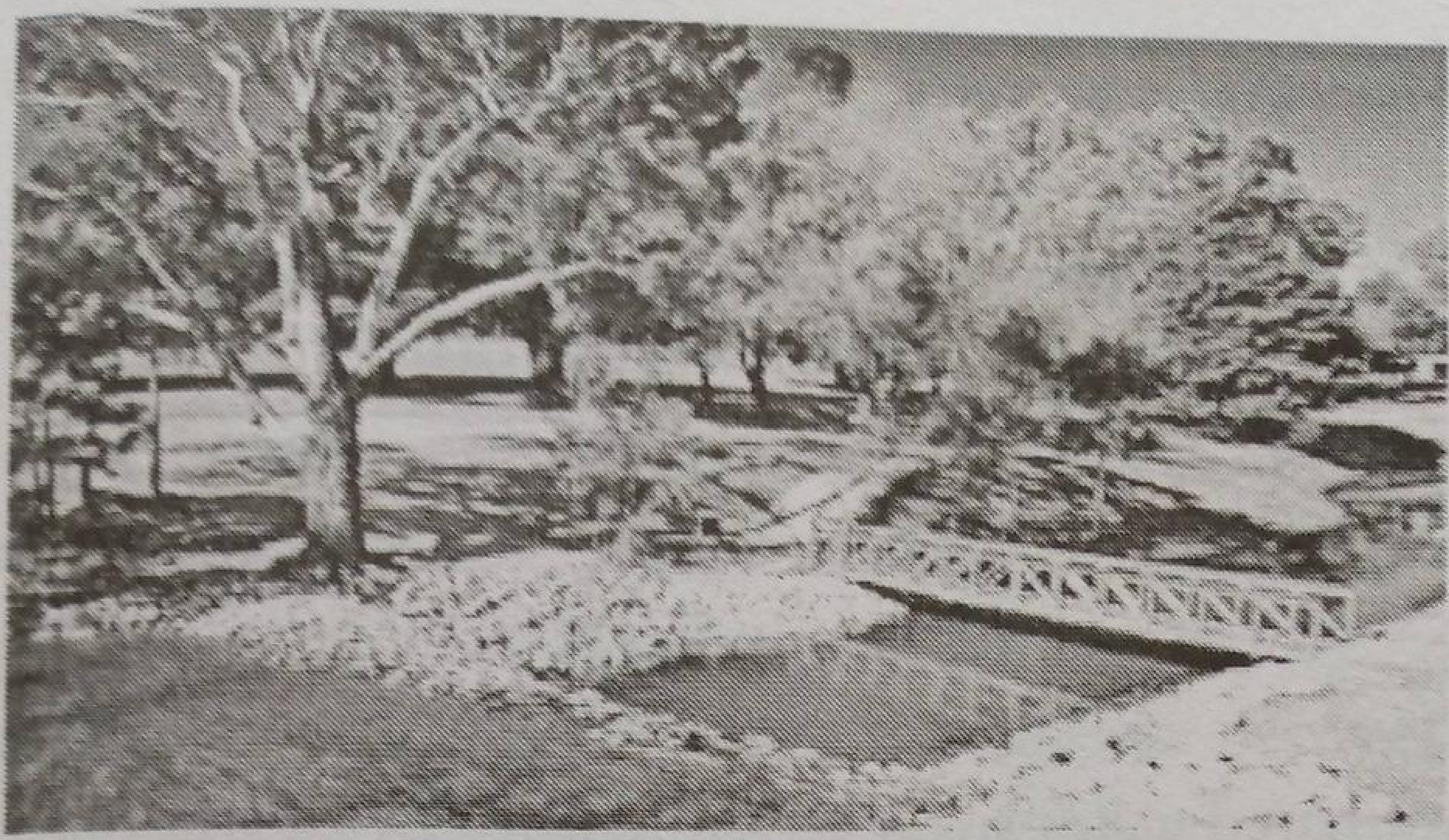

Plate 10.7 Example of off-stream farm pond

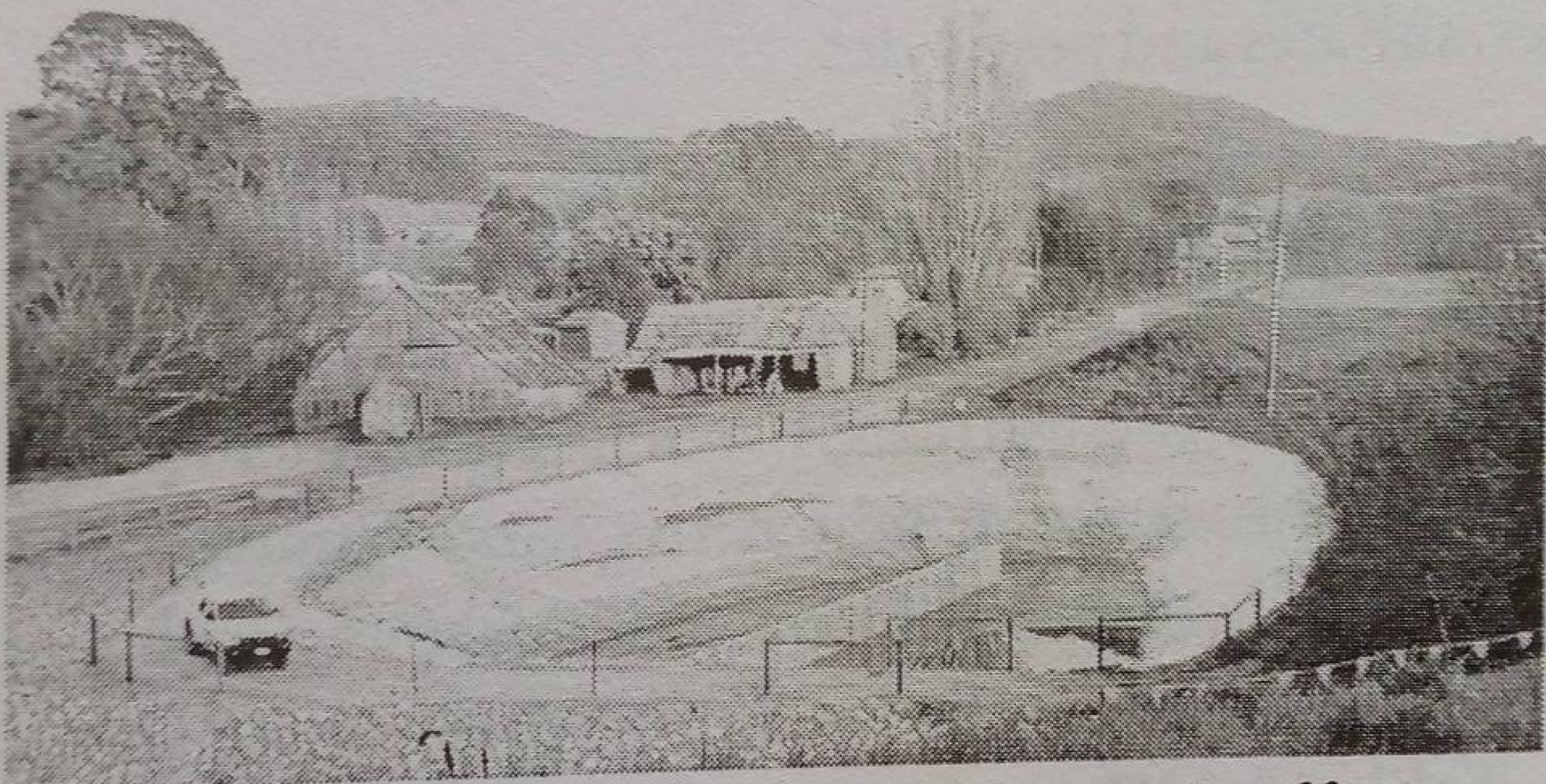

Plate 10.8 Example of artificially made off-stream dam

Plate 10.9 Farm pond

10.3 Livestock water supply

Water from the ponds as mentioned in the previous section needs to pass through proper treatments before being sent for the consumption of the animals. Safe water supply is essential for healthy livestock and poultry. Contaminated water can affect growth, reproduction, and productivity of animals as well as safety of animal products for human consumption. Contaminated water supplies for livestock can also contaminate human drinking water. For these reasons, farm water supplies should be protected against contamination from bacteria, nitrates, sulfates and pesticides.

10.3.1 Quantity of water required by livestock

Table 10.3 gives the estimated water requirements for various classes of livestock from which the total requirement can be determined. Chickens, Pigeons and Turkeys can live on used water from the house

Table 10.3 Water requirements for livestock

Type and number	Daily need (litres)	Total (litres)
Upgraded dairy cows	x70	=
Upgraded beef cows	x50	=
Local cattle	x20	=
Sheep	x5	=
Goats	x3	=
Poultry		
Dipping	$x\frac{3}{7}$	=
Ducks and geese	x1	=
Biogas		$= \frac{100}{7}$

10.4 Sources of Contamination

10.4.1 Coliform

These are organisms found in the gastrointestinal tract of livestock, humans and birds. While these bacteria may not be harmful, their presence often indicates that other disease-causing bacteria may also be present. The main source of coliform bacteria is animal waste. Where large numbers of animals are concentrated near shallow or poorly protected wells or ponds, bacterial contamination can occur during heavy rainfall.

10.4.2 Blue-green algae

Toxic blue-green algae can contaminate surface drinking water supplies. In livestock, blue-green algae poisoning causes muscle tremors, diarrhea, lack of coordination, collapse, labored breathing, liver damage, and death. Algae grow and multiply because of favorable nutrient and temperature conditions.

10.4.3 Nitrates

Nitrates by themselves are not very toxic. However, in the rumen of cows or sheep, microorganisms change nitrates to nitrites, which are quite toxic. Nitrites are further acted upon by microorganisms and converted into protein. In cows or sheep that consume large amounts of nitrates in short periods of time, however, nitrites accumulate faster than they can be built into protein. These excess nitrites are absorbed into the bloodstream.

There the nitrites react with the hemoglobin (the red oxygen-carrying pigment of the blood) to form methemoglobin, which prevents the blood from carrying oxygen. If a large portion of the hemoglobin has been converted to methemoglobin, the animal shows symptoms of asphyxiation including labored breathing, a blue muzzle, a bluish tint to the whites of the eyes, trembling, a lack of coordination, inability to stand, and often death.

Some sources of nitrates in groundwater include nitrogen fertilizers, animal manure or wastes, crop residues, human wastes, and industrial wastes. Since nitrates are soluble and move with percolating water, groundwater pumped from a well may contain nitrates even if their source is from a considerable distance.

10.4.4 Sulphate

Sulphates appear in water when they are dissolved as water moves down through soil and rock formations. Human activities have little effect on the concentration of sulphates or other dissolved minerals in groundwater supplies.

10.4.5 Pesticides

Many pesticides are readily broken down and eliminated by livestock with no obvious ill effects, but there is a possibility that some could be excreted in milk or accumulate in meat. Fish are more sensitive to pesticides than are livestock or poultry.

Pesticides can enter a surface water or groundwater supply from runoff, drift, rainfall, direct application, accidental spills, faulty storage facilities, and faulty waste disposal techniques. Of the pesticides currently in use, the organophosphates are the most dangerous for livestock.

8.4.6 Salinity

The damage of high saline water depends more on the total amount of minerals present rather than on any specific one. The ions most commonly involved in high saline waters are calcium, magnesium, sodium, bicarbonate, chloride, and sulphate. Usually chlorides are less harmful than sulfates. Magnesium chloride appears to be more injurious than calcium or sodium salts.

High saline waters can be located where there is saline intrusion in the water. Table 10.3 gives the National Resources Council recommendations on saline waters for horses and other animals.

10.4.7 Iron

There is no evidence to show that iron will cause any problems in livestock or poultry. According to Report Number 26 of the Council for Agricultural Science and Technology, "Under usual conditions, water supplies only a small percentage of the iron available to animals. Because iron from natural sources is absorbed with efficiency less that 10 percent, the iron in water should not pose a hazard to animals. Under these circumstances, a 'no limit' recommendation is reasonable. High doses of the

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more available forms of iron, however, are toxic."

Table 10.4 Saline water for livestock

Total soluble salts	Comments
Less than 1,000	These waters have a relatively low level of salinity and should present no serious burden to any class of livestock.
1,000 to 2,999	These waters should be satisfactory for all classes of livestock; they may cause temporary and mild diarrhea in livestock not accustomed to them, but they should not affect their health or performance.
3,000 to 4,999	These waters should be satisfactory for livestock; they may cause temporary diarrhea or be refused at first by livestock not accustomed to them.
5,000 to 6,999	These waters can be used with reasonable safety for dairy and beef cattle, sheep, swine, and horses. Water approaching the upper levels of these limits should be avoided for pregnant or lactating animals.
7,000 to 10,000	These waters are probably unfit for swine; considerable risk may exist in using them for pregnant or lactating cows, horses, sheep, the young of the species, or for any animal subjected to heavy heat stress or water loss. In general, their use should be avoided, although older ruminants, horses, and even swine may subsist on them for long periods of time under conditions of low stress.
More than 10,000	The risks with these highly saline waters are so great that they cannot be recommended for use under any conditions.

10.5 Water Testing

When water is suspected of causing health problems in livestock, an accurate diagnosis is crucial. A laboratory examination of both the animals and the water supply may be necessary to adequately diagnose the problem. A veterinarian may need to determine the actual disease. Since water is often blamed for problems caused by production or disease, temporarily changing to a known safe water supply is a useful test to determine if the water supply is causing the health problems.

10.5.1 Water borne diseases

These are diseases that are transmitted through contaminated water. They are normally caused by the presence of micro-biological parameters in water. However, absence of such parameters as pathogenic bacteria, viruses etc would not guarantee that the water is safe. The prevention of water borne diseases is therefore left to many precautions to be taken from the source of raw water to the ultimate consumer. Below are some of the water borne diseases:

a. Diseases caused by bacteria

i. Typhoid	Caused by *Salmolenna typhi*
ii. Paratyphoid	Caused by *Salmolenna paratyphi*
iii. Cholera	Caused by *Vibrio cholerae*
iv. Bacillary dysentery	Caused by *Shigella dysenterial*
v. Diarrhoea	Caused by *Escherichia coli*

b. Diseases caused by viruses

i. Infectious hepatitis	Caused by Hepatitis A virus

ii. Infectious gastroenteritis — Caused by Norwalk-type virus

ii. Poliomyelitis — Caused by Polio viruses

c. Diseases caused by protozoa

I. Amoebiasis or amoebic dysentery — Caused by *Entamoeba hystolytica*

ii. Giardiasis — Caused by *Giardia lambia*

iii. Criptosporidiosis — Caused by *Cryptosporodium*

10.6 Worked example

Water system problem

It is necessary to design the water system for domestic and stock watering for a family of five who keep 3 zebu cows and 10 goats. The water will be pumped from a dug well that is 3m below and 5m away from where the pump will be located. The pump will need to discharge into the storage tank at a minimum pressure of 300 kPa. The discharge from the tank between cut-out and cut-in pressure should be approximately $^1/_{12}$ of daily water consumption so that the pump will operate no more than 12 times per day. Water will be discharged from the tank at a distance of 50m to a single tap and the head loss at a flow of 1 l/s should not exceed 10% of the average pressure. The pump dealer has advised that his pumps are approximately 75% efficient in terms of power demand and the electric motors are 85% efficient.

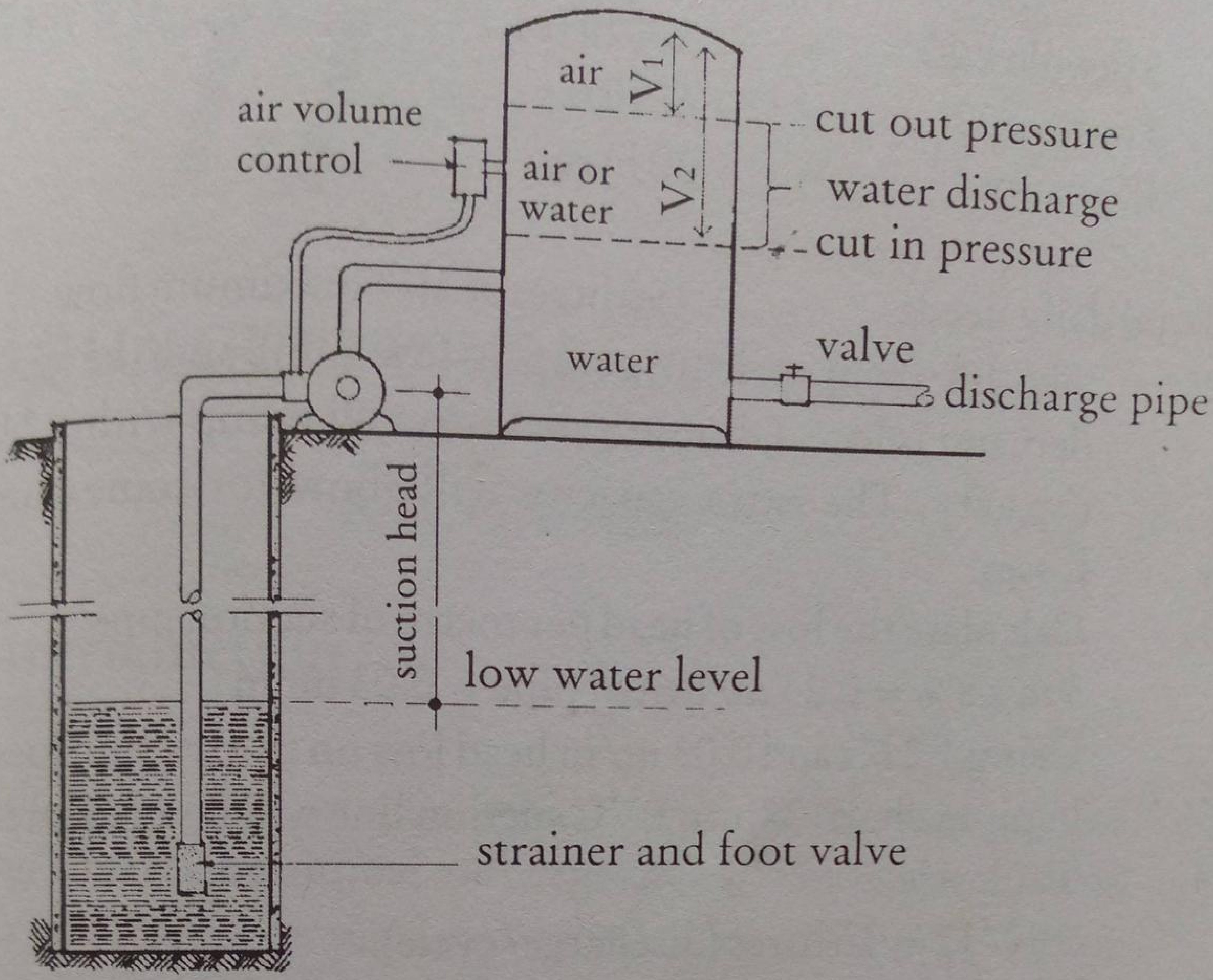

Fig. 10.2 Hydro pneumatic water system

Determine

1. Total daily water consumption (max flow is 1 l/s)
2. A suitable type and capacity of pump
3. An adequate tank size

Solution

1. From Table 10.2 a single water tap supply indicates 10 – 20 litres per day person. Choose 20 litres.

From Table 10.3 local cattle require 20l/day and goats 3l/day.

5 people x 20	=	100 litres
3 cows x 20	=	60 litres
10 goats x 3	=	30 litres

Total daily needs 190 litres at 1l/s maximum flow

2. The lift from well to pump is low (3m) and the water demand is low. Choose a shallow-well pump with 1.2 l/s capacity. The extra capacity will allow for some pump losses.
3. Calculate the loss of head per metre of suction pipe
   3 m x 8% = 0.24 m/8 m of pipe = 0.03 m/m
   Using 1.2 l/s and 0.03 m/m head loss on the friction losses in pipes chart, 38mm PVC suction line will be adequate.
4. Tank size
   190/12 = 16 litres (discharge/cycle)
   Choose a pressure range of 200 to 300 kPa with atmospheric pressure of 100 kPa.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Assuming $T_1 = T_2, V_2 = V_1 + 16$

$$400V_1 = 300(V_1+16)$$
$$100V_1 = 4800$$
$$V_1 = 48\text{litres}$$

$V_2 = 48 + 16 = 64$ litres

$V_2 = ½$ of the tank size

Therefore, Approximate tank size = 2 x 64 = 128 litres