

Ponds

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Surface-water sources, such as ponds, are sensitive to surface pollution, particularly bacteriological pollution. However, they should not be neglected as a source of drinking water, because usually there is a great demand for surface water in contexts where no other water source exists (e.g. where groundwater is difficult to exploit, due to the depth of the aquifer or high salinity), and in contexts where maintenance is not likely (i.e. on transit routes in some pastoral areas).

1 Types of pond

Two types of ponds exist: impluvium ponds and run-off ponds. Impluvium ponds are used in places where precipitation is high (humid tropical areas, e.g. South East Asia). These ponds do not have a catchment basin, but collect the rainwater that falls directly onto their surface. Water quality thus depends on the sanitary conditions of the pond (cleanness, presence of animals etc.). In this case, adequate design and construction (including the installation of features such as appropriate water-drawing structures), and water-point management can lead to satisfactory water quality, and the water can be used for domestic and drinking purposes.

Where precipitation is low, in the so-called arid and semi arid lands (ASAL) such as the Sahel, the Horn of Africa, the Kalahari etc., the ponds are located in low-lying areas and collect run-off water (see Chapter 3 and Figure 19.2). Given all the opportunities for contamination during run-off, water quality is poor. On the other hand these ponds are mostly used in areas populated by pastoral communities and are mainly used for animal consumption. This also increases the risks of water contamination. In these pastoral areas, ponds may be used by different clans or communities and are usually isolated from permanent settlements. Water-supply management cannot, therefore, be done on a regular basis and any sophisticated installations should be built only after analysing operation and maintenance constraints.

In any case, the risk of water contamination remains high and treatment before consumption (by boiling, filtering etc.) is the best way to guarantee access to safe drinking water.

The inhabitants generally know how to build or rehabilitate ponds or rainwater reservoirs, but to optimise them and ensure longer service life, certain rules and construction parameters must be observed.

2 Community impluvium ponds: the example of Myanmar

2.1 Feasibility study

The feasibility study deals essentially with the nature of the subsoil, which must be impermeable (tests and observation on site, digging trial holes), and also with rainfall and evaporation, in order to size the pond on the basis of demand.

The availability of land for these ponds is sometimes low when land pressure is high (agricultural land, ownership problems etc.).

2.2 Technical recommendations

The work entails various elements shown in Figures 19.1. The pond itself is an excavation carried out in impermeable ground. The embankments which surround it are built with the excavated material. They protect the pond from run-off and limit access. The overflows allow excess rainwater to be drained off, and therefore ensure the protection of the structure. The pavement and drain protect

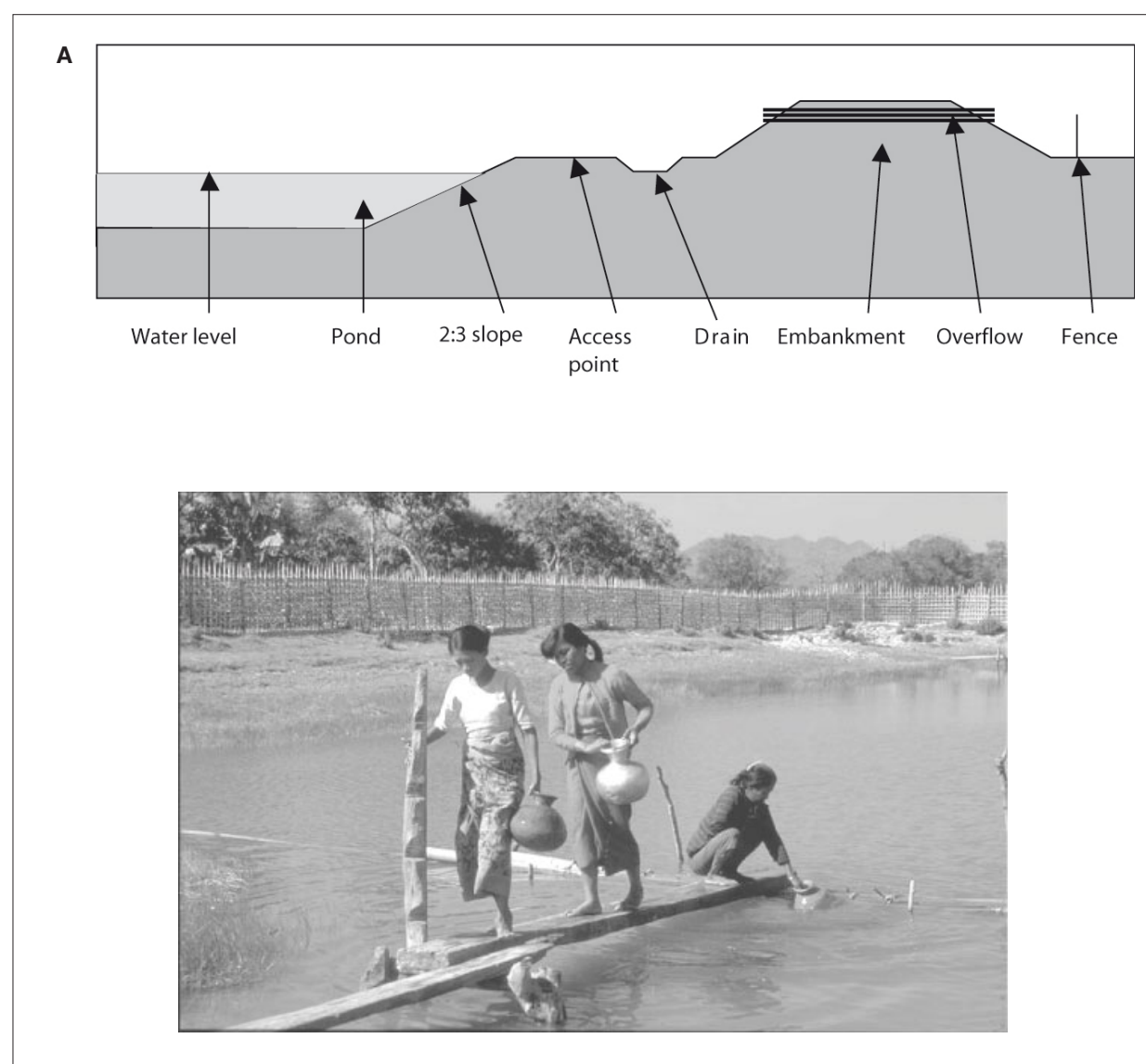


Figure 19.1: Community pond (ACF, Myanmar, 1996).

A: construction plan. B: water-collection system.

the pond against run-off from the embankments. The fence and the water-abstraction area, which is set on a floating pontoon, help to protect the water against pollution. The pontoon allows people to draw water from not too close to the banks, where water is clearer and cleaner.

All slopes (embankments, excavations) are 66% (2 height units per 3 width units). The surface area of the whole pond system is therefore much higher than just the surface of the pond, see Figure 19.1A.

Before commencing excavations, the ground is set out to mark the various parts of the structure (embankments, overflows, protection fences), and indicate excavation levels.

Stabilisation of the embankments is carried out as digging advances, by successive layers, with a manual rammer or compactor. The ground is wetted slightly to ensure compaction; insufficient compaction can result in the failure of the structure when it is first filled with water.

When building large ponds, adequate compaction of the ground is checked with a manual dynamic penetrometer (an instrument which measures the depth of penetration of a standard needle or cone into the material under standardised conditions of loading and time).

As the excavation advances, samples are taken every 50 cm to verify that the ground still contains sufficient clay, and corresponds with the feasibility study results, based on a precise geological section of the first few metres plus permeability tests. In the absence of impermeable subsoil, it is possible to compact clay laid on the base of the pond (0.5 m) or to install a waterproof membrane, which is expensive and more difficult to install.

The embankments are covered with soil, and grass is planted to prevent erosion: perennial, ground-covering, shallow-rooted species should be used. Bushes and small shrubs are not suitable, because their roots encourage water infiltration. An effective and suitably large overflow is located at the appropriate side (at least 1 m below the top of the embankments). The downstream section, where the water flows, is lined with stones and is concreted for the first metres.

Finally, to improve the quality of the drinking water, some simple measures are needed, such as a protective fence made of wood or bamboo or, even better, a fast-growing hedge to prevent access by animals.

Water is generally drawn directly using a jar or bucket, which has the advantage of being very rapid. In order to prevent people from drawing water at the edge of the pond, access pontoons (fixed or floating), which are easy to make, should be provided. Some systems provide protection, especially the installation of a handpump in a well supplied by a drain from the pond (see Section 4.1), or directly in the pond itself: proper use of this type of system depends a lot on local customs.

2.3 Design example

This design example concerns a village in the Mangdaw region of Myanmar which has 500 inhabitants. Two boreholes drilled here proved to be negative (saline water), and the inhabitants asked ACF to help them to improve their rainwater-storage pond, a traditional water source in the region.

In order to work out the volume of the pond, it is best to use average monthly data on precipitation and evaporation, and then compare the cumulative demand with the annual volume of recoverable rain (see Chapter 10A). As monthly data was not available for the region, annual estimates were used. Average annual rainfall was taken as 4 000 mm, and the average annual temperature as 25 °C (see Annex 6). Evaporation from the water body could not be calculated exactly, because no direct measurements had been made (e.g. with an evaporation tank, or evaporation meter) and the usual formulae (Lugeon's formula, Meyer's formula, calorific balance etc.) are difficult to use because they require a large number of parameters. Use of the simple Turc's and Coutagne's formulae given in Annex 6 is reserved for the calculation of flow loss in a catchment basin. Therefore, strictly speaking, they should not be used to calculate the evaporation from a water body. As an indication, Coutagne's formula gives an annual real evapotranspiration rate (RET) of 1.1 m, whereas Turc's gives 1.6 m; rough estimates of the average annual evaporation from free surface water given in the literature (Réménieras) indicate values of 1.5 to 3 m for humid tropical regions. The 1.5 m value was therefore assumed.

The amount of useful water available for refilling the pond is therefore:

$$4.0 - 1.5 = 2.5 \text{ m/year, or } 2.5 \text{ m}^3 \text{ per m}^2 \text{ of surface area.}$$

Water demand of the inhabitants is assumed to be 30 l/person/day over a period of 7 months in the year. In practice, the inhabitants use jars to recover the rainwater that falls on their roofs during the rainy season (5 months). Even when rainfall stops for a few days, people go to the pond without affecting the water reserve given that any water taken is replaced by rain immediately after.

Therefore, in one year, total demand is:

$$0.03 \times 500 \times 365 \times 7/12 = 3\,200 \text{ m}^3$$

To cover demand, the minimum area of the pond can therefore be calculated considering the useful rainfall per square metre:

$$3\,200/2.5 = 1\,280 \text{ m}^2$$

Ponds have a trapezoidal design (see Figure 19.1) and the volume is calculated through the following formula:

$$V = (l-h/p)(w-h/p)h \quad \text{Formula (1)}$$

where V = pond volume (m^3), l = pond length (m), w = pond width (m), h = water height (m), p = bank slope (vertical/horizontal) (non-dimensional).

The pond is 40 m long (l), 25 m wide (w) and 1.3 m deep (h). According to the nature of the soil, the slope of the banks in the area is usually 2/3.

The pond surface is $40 \times 25 = 1\,000 \text{ m}^2$ and its volume is 1.140 m^3 (see formula (1)), which is clearly inferior to population needs and justifies an increase in the pond size.

As the surface area is inferior to the minimum of $1\,280 \text{ m}^2$ required, it must be increased to collect the necessary volume of rainwater. In order to maximise the increase in volume respective to the increase in surface area, the width of the pond should be increased, rather than its length. Therefore, the maximum volume of the pond corresponding to a surface area of $1\,280 \text{ m}^2$ is obtained with $l = 40$ and $w = 32$.

To increase the volume of the pond, the best solution is to increase the depth, in order to limit losses by evaporation (which are proportional to the surface area) and also because of the problems of access to land. Soil drilling showed that a clay cap is present down to 3.3 m, so the depth was set at 3 m, which allows 30 cm of clay to be kept above the permeable formation.

The volume calculated with formula (1) is then:

$$V = (40 - (3/2 \times 3)) \times (32 - (3/2 \times 3)) \times 3 = 2\,930 \text{ m}^3$$

If the volume is inferior to the expected volume, the surface area must be increased. Increasing the width up to 35 m, V becomes $3\,250 \text{ m}^3$, which corresponds to the needs identified. The pond will be 40 m long, 35 m wide and 3 m deep.

Overflows are installed to drain off rainwater in case the pond has been under-dimensioned, which is quite possible because several estimations are included in its design.

2.4 Human and financial resources

Generally, building village ponds is very labour-intensive, but labour can be provided by villagers through voluntary community participation or remuneration in food for work or cash for work. A food security analysis (particularly food availability and accessibility) should determine the appropriate form of participation. To carry out the excavation and compacting, people are organised in groups of 9, each group with a leader. Presence is recorded daily and payment is based on the excavated volume, but the number of working days is also taken into account, considering that certain formations are harder to

Table 19.I: Example of costs for of a pond excavated manually (ACF, Myanmar, 2003).

Excavation volume	2 950 – 1 150 = 1 800 m ³
Number of person-days to excavate the pond	1 470
Number of people on the site	70
Number of working days	21
Cost of excavation / m ³	0.7 €
Cost of labour	0.7 x 1 800 = 1 260 €
Cost of pontoons	200 €
TOTAL COST	1 460 € *

* The cost is modified according to the number of working days

dig. This system is appropriate to local culture and customs, as fraud is unheard in these communities (Table 19.I).

Ponds and reservoirs can also be made more quickly using mechanical shovels and a bulldozer. However, hire of excavation machines, if they are locally available, is generally expensive (several hundred euros per day). Digging by hand or by machine should be studied and the most appropriate solution chosen depending on the local context. Creating a pond in a village by hand usually provides significant income in terms of money or food. This is important for food security, and this aspect must be taken into account in the decision.

3 Pastoral run-off ponds, example from Ethiopia

In the Afar region of Ethiopia, ACF is implementing a pastoral project, including animal health and water supply. The main objective of the programme is to decrease the vulnerability of pastoral communities to drought, increasing the number and the sustainability of water points. Within this project ponds have been constructed in order to supply water to livestock. As explained in Section 1 these ponds collect run-off water. Figure 19.2A shows such a pond in aerial view. These ponds usually contain several thousand cubic metres of water and are usually communal or public structures. They are constructed as explained in Section 2, see also Figure 19.3. Smaller run-off collection reservoirs, called birkads, also exist in arid and semi-arid regions. They have a capacity of several hundred cubic metres and are usually used for domestic consumption as well as small livestock (goats and sheep), and are usually private structures. They are built in stone and mortar (see Figure 19.2B) and can be covered by wire and vegetation to limit evaporation.

Figures 19.3A & B show plans of a pond constructed by ACF in 2004. ACF introduced some improvements to the simple traditional model in order to reinforce sustainability by reducing erosion and sedimentation, and limiting water contamination. The main differences with the impluvium model are the entrance channel and the absence of a drain and overflow. The run-off catchment area can be improved with barriers in order to increase run-off water collection.

The pond is filled by short run-off events that transport a lot of sediments that quickly decrease the useful capacity of the pond. In order to reduce this problem, a silt trap or mud pit is constructed for the water to pass through prior to entering the pond, and this catches most of the sediments transported. The mud pit must be big enough to catch at least the sediment transported in one year. Dimensions for the mud pit are chosen according to local experience and observation, and depend mainly on the velocity of the water entering the pond and on the nature of the soil. Mud pits must be regularly maintained (emptying and consolidation), activities which can be difficult to carry out if no community is living close to the pond, which is frequently the case in pastoral areas. If no maintenance is carried out the mud pit will quickly become useless.

A



B



Figure 19.2: Run-off water pond in Ethiopia.
A: aerial view of pastoral pond. B: birkad.

Erosion is also a factor reducing sustainability. It causes damage to the pond and mud-pit banks, and scouring of the catchment area and consequently sitting-up of the pond. To solve this problem, ACF Ethiopia decided to place gabions in the mud pit and in the entrance channel, as presented in Figure 19.3A. Erosion is also due to the animals themselves, when they enter in the pond to drink. Installing a fence around the pond, as well as a proper system for watering animals, will allow the reduction of both erosion and sedimentation and will also protect the water from contamination.

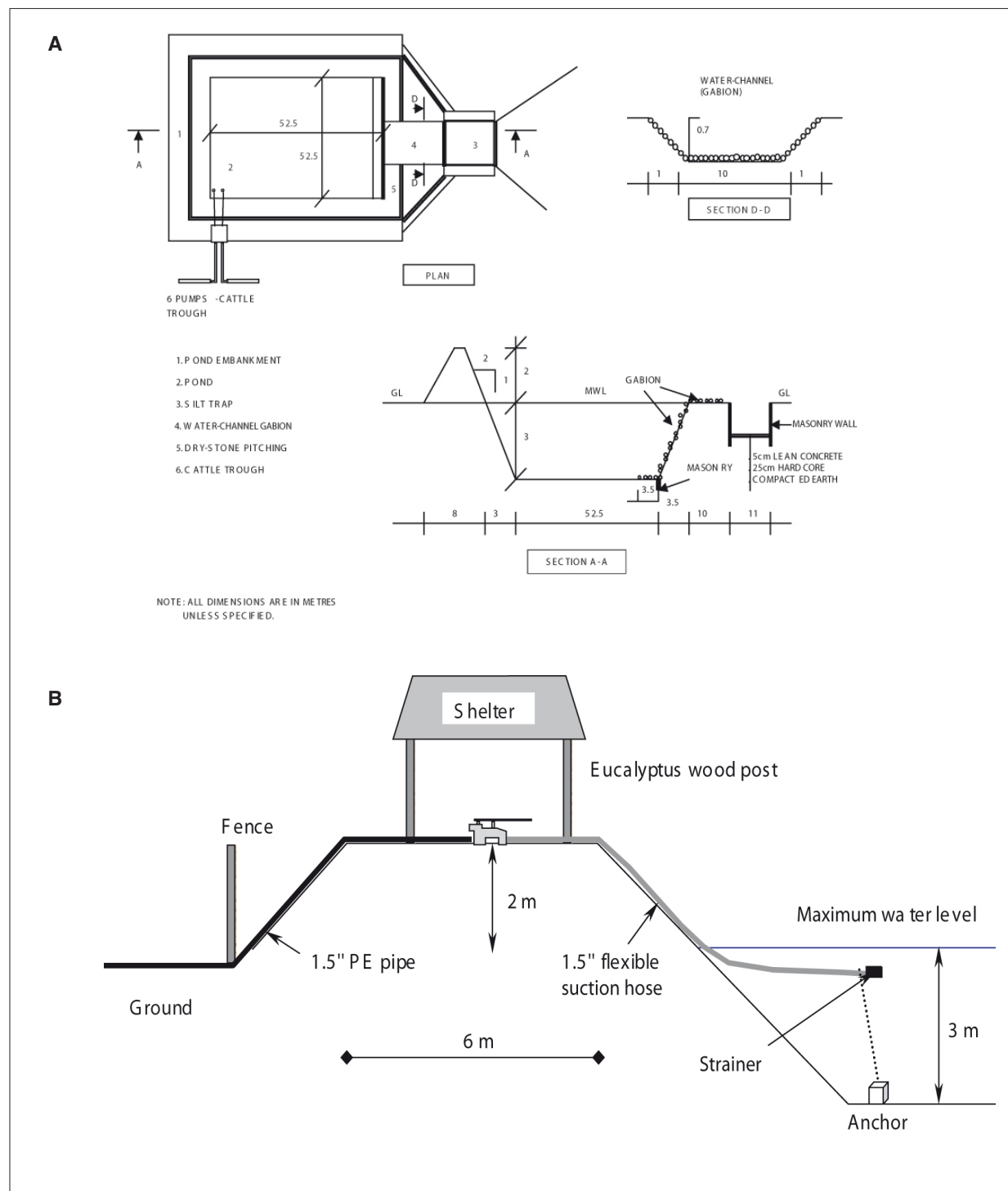


Figure 19.3: Pastoral pond (ACF Ethiopia, 2004).
A: plans. B: water-collection system.

Figure 19.3B shows a foot-pump system that can be installed on the edge of a pond in order to pump water into cattle troughs built beside it. These pumps are robust and easy to maintain, and pump high yields with little effort. The only disadvantage is that they must be primed with water. Experience shows that even simple pumps often present problems of maintenance in these contexts. If such a pumping system is considered too sophisticated for local capacities, an efficient and simple solution to limit erosion and water contamination is to delimit and fence off a dedicated and direct access for watering animals at a corner of the pond, or constructing a reservoir directly connected to the pond with a channel.

It is usually difficult to ensure the safety of drinking water with these ponds, but filtration systems (see Section 4) can improve water quality. Obviously such systems need maintenance and cannot be sustained in remote areas.

Note. – When building a pastoral pond in a wet-season grazing area (i.e. an area grazed only during and just after the rainy season, where no settlements exist), the pond should be designed not to last too long in the dry season. If the water remains too long during the dry season there is a risk that people will change their customs with the following potential negative consequences:

- people can be stuck in the wet-season grazing area without the possibility of reaching dry-season grazing areas safely (no more water along transhumance routes);
- people create new settlement areas (not always negative, but the consequences must be carefully studied);
- over-grazing is encouraged, reducing the time allowed for pasture regeneration, leading to the destruction of grazing reserves.

4 Examples of water-collection systems

4.1 Well beside the pond

When water is to be used for drinking, the pond must be protected from any external contamination. One solution is the construction of a well connected to the pond and equipped with a hand pump, as presented in Figure 19.4.

This system can guarantee access to water of acceptable quality only in the case of impluvium ponds and if access to the pond is prevented by a fence, to limit any risk of external contamination. As the well functions as a water-storage tank, the system remains safe only if water is collected on a regular basis, i.e. throughout the year, otherwise water will be stagnant and favourable to bacteriological development. A filter should be installed at the intake in the pond, in order to prevent the pipe from blocking. This is the weak point of the system and special attention must be paid in order to avoid blockages. Another solution is to connect the well to the pond with a filtration trench. This permits effective filtration of the water but the risk of blockage is higher.

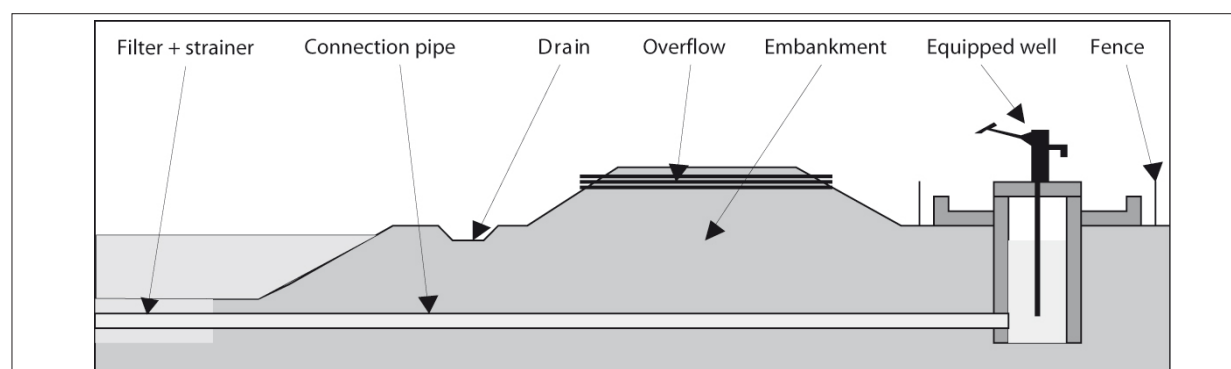


Figure 19.4: Well connected to pond.

4.2 Filtration

Another option, when water is to be used for drinking, is to filter the water before its supply via tapstands (see Figure 19.5). For information on sand filters, see Chapter 12, Section 2.5.

Two kinds of pump can normally be used: suction pumps or helical rotary pumps (see Chapter 9, Section 8.4). The intake can be fixed, or equipped with a floating system in order to follow the water level and pump the water from near the surface, to take advantage of the disinfecting action of UV radiation.

This system is particularly efficient in impluvium ponds but can also be used for run-off ponds. In any case this solution requires a significant level of community management in order to maintain, clean and operate the pump, the filter and the tapstands.

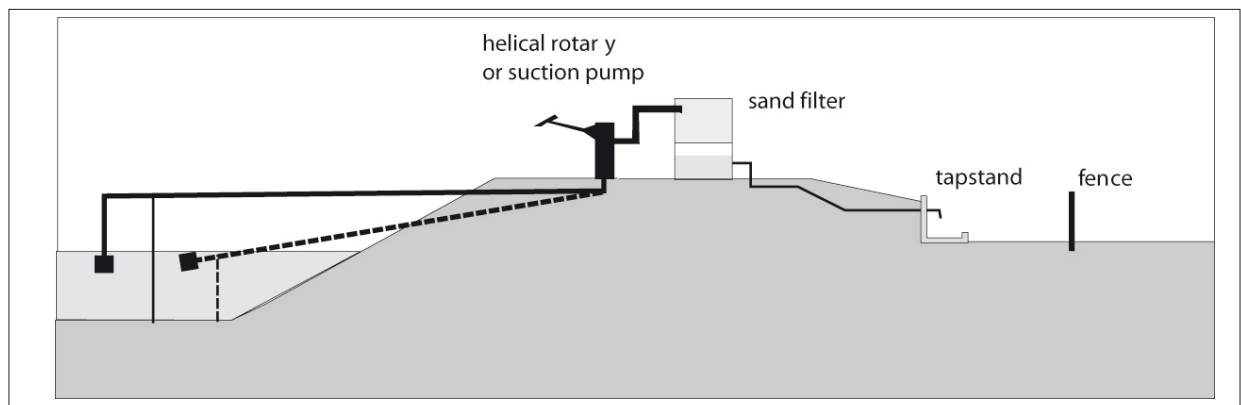


Figure 19.5: Filtration system.