Water for the World

Designing Intakes for Ponds, Lakes and Reservoirs

Technical Note No. RWS. 1.D.2

Intakes make water from ponds, lakes, and reservoirs more accessible. Water can easily be pumped from an intake to a community distribution system. Long walks to fetch water are not necessary. The installation of an intake should lead to increased water consumption. This, in turn, should mean improved health for the community.

The design of intakes is very important if they are to function properly. A well-designed intake should provide good quality water in abundant quantities. An intake should be designed for cheap installation and operation and as little skilled supervision of construction and maintenance as possible. This technical note describes the design of intakes and should be used with "Choosing Where to Place Intakes," RWS.1.P.4, which discusses site selection for intakes.

The design process should result in the following three items which should be given to the construction supervisor.

1. A map of the body of water marked with the location of the intakes, distances and construction areas as shown in Figure 1.

2. A list of all labor and materials needed for the project similar to the sample list in Tables 2 or 3. For information on the design of a clear water well see "Designing Dug Wells," RWS.2.D.1.

3. A detailed plan of the intake structure with all dimensions.

Useful Definitions

CLEAR WATER WELL - A sedimentation area or sump into which an inlet discharges water and from which water is pumped to distribution for community use.

GALVANIZED IRON PIPE - Zinc-coated iron pipe similar in size to rigid plastic, but heavier.

GLOBE OR GATE VALVE - Types of cutoff devices used in pipelines to control the flow of water in a system. The globe valve causes a high resistance to water flow because of small passageways. The gate valve when fully open allows straight-line water flow with very low resistance.

INLET STRAINER - Material, usually wire screen, that is put over an intake pipe to remove sediment and plants from the flowing water.

PEAK DEMAND - The amount of water a pump must deliver in liters per minute to meet the greatest need at whatever time it occurs.

POLYETHYLENE PIPE - Black, lightweight, flexible pipe used in water systems.

POLYVINYL CHLORIDE (PVC) - A white, rigid, plastic pipe used in water systems.

$Q = AV$ - Quantity of water available is equal to the velocity (V) of the water multiplied by the area (A) of the pipe opening, known as the "Equation of Continuity."

SILT - Sediment made up of fine particles carried or laid down by moving water.

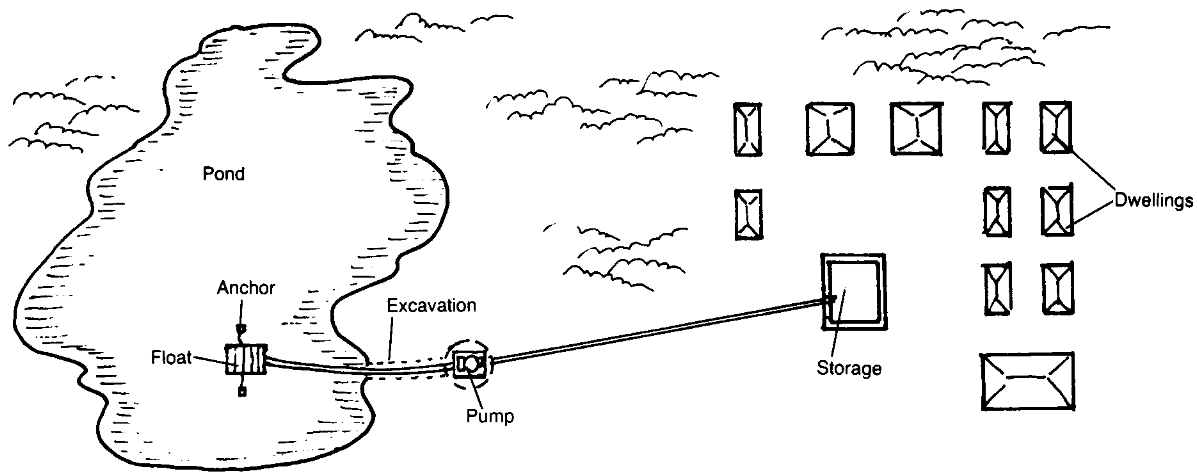

Figure 1. Location Map

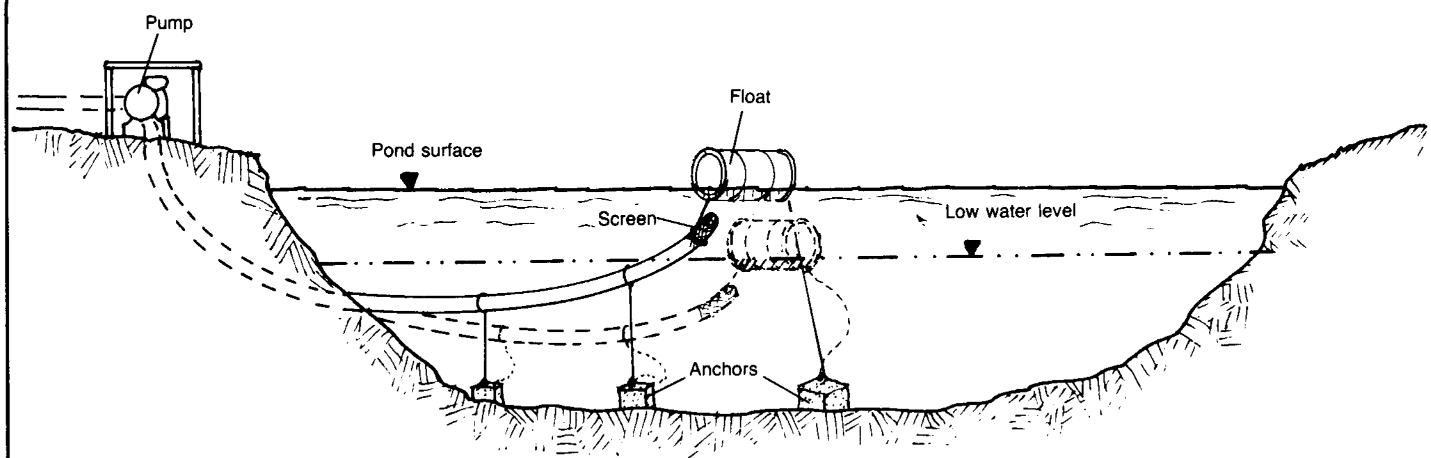

Figure 2. Flexible Plastic Intake with Direct Connection to Pump and Storage

Design Information

In order to design an intake for a pond, lake, or reservoir, it is necessary to (1) select the location for the intake, (2) decide on the diameter, length and type of pipe required, (3) design an inlet strainer, (4) design floats and fixed intake supports, and (5) choose the appropriate installation. Figure 2 shows a typical design for a floating intake. The pipe is plastic and the intake is positioned so it is always 0.3-0.5m below the surface to keep out plants from the surface and sediment from the bottom. If water is silty, it enters a clear well for sedimentation. Otherwise, it is pumped directly to treatment and/or storage. Refer to Figure 2 while reading the remainder of the section on the basic design of intakes.

Location for Intake. Survey the area and attempt to find the best location on the shore for a pump installation and the site for treatment or storage facilities where construction will be easiest. The best location will be on level ground and as close to the users as possible.

Find the deepest point in the body of water. If it is shallow, wade out into the water with a stick marked at 0.25m intervals. Measure the depth at various locations and find the deepest point as shown in Figure 3. Anchor a float at this spot or place a stick at the location. If the body of water is too deep for wading, go out in a boat and measure depths at various locations with a small rope knotted every 0.5m and weighted down with a heavy object as shown in Figure 4. Drop the weight into the water and take a depth reading on the rope. Mark the deepest spot with a float and an anchor, or use a long stake to mark the center point. Whenever possible, locate the intake at the maximum water depth. The depth should be at least 1m.

Diameter and Length of Inlet Pipe. The diameter and length of the pipe chosen depends on the daily volume of water needed to supply the users, the estimated pumping rate, and the distance between the inlet and the clear water well. For piped systems, water use is normally 40 liters per capita. The pump should be used a maximum of eight hours per day to allow sufficient time for operation and maintenance. If possible, the pump should operate fewer hours (perhaps six) in order to save energy. Pumping usually takes place in the morning and evening to meet peak demand during these times.

If pumping time is reduced from eight hours to six hours, the rate that water is pumped into the system must increase. The higher the pumping rate, the larger diameter pipe must be used. Worksheet A shows how to find the necessary pumping rate for a water system.

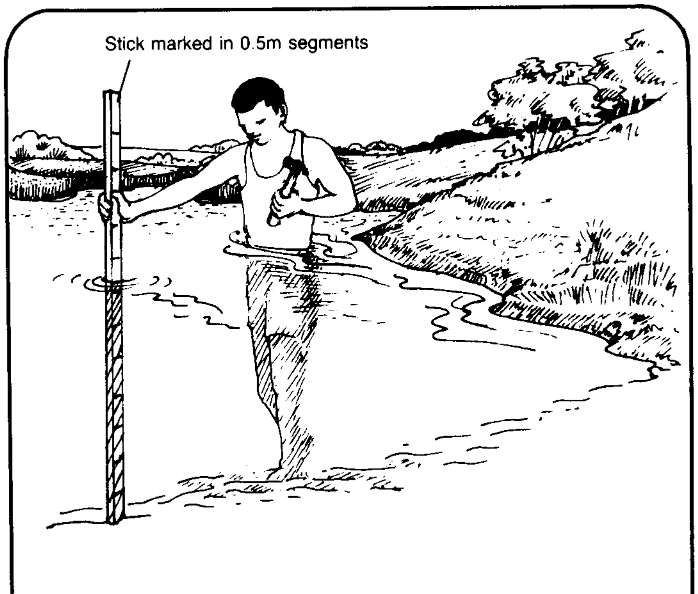

Figure 3. Measuring Pond Depth

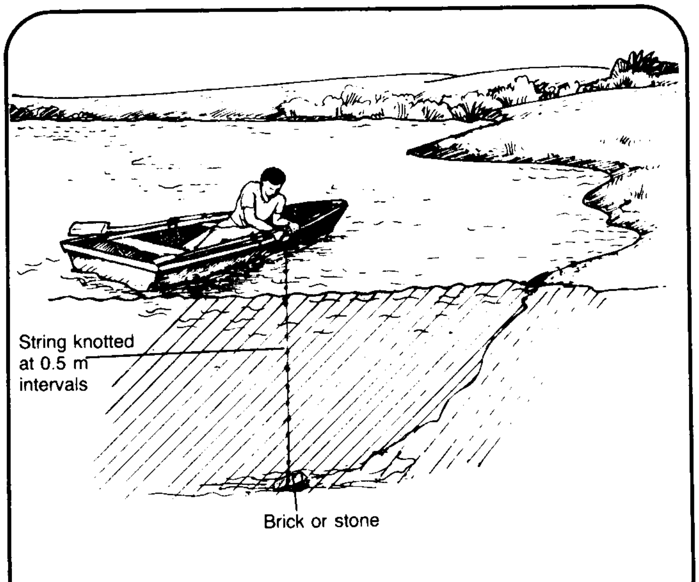

Figure 4. Measuring Depth of Large Pond

The diameter of the inlet pipe must be large enough to maintain a discharge into the clear water well or storage tank greater than the rate at which water is pumped out of it. However, the diameter should not be larger than required since smaller diameter pipe is much less expensive. A general rule is that intake pipes usually have a diameter of 50mm. This diameter should allow an adequate flow rate when pumps with maximum capacity from 1.2 to 1.8 liters per second are used. A low velocity is best since at faster velocities, water may pick up sediment from the bottom and draw it into the intake. Large particles or plants may be held against the intake screen by fast-flowing water, clogging the intake and reducing flow. In contrast, a velocity that is too low requires the use of larger diameter pipe which is more expensive. For rural water supplies, a practical velocity is between 1.2 and 1.8m per second. Use Table 1 to determine pipe diameter. Locate the daily pumping rate in the left-hand column labeled "Q Flow liters per second". Then look under the column that approximately corresponds to the velocity for the water system. The numbers in the columns under the velocities are pipe diameters expressed in millimeters.

Next, the length of pipe must be determined. The length is found by adding together (a) the distance from the intake to the shoreline, (b) the vertical distance between the high and low water levels, and (c) the distance between the clear water well and the shoreline at the high water level. This last distance is usually 2m to provide protection from possible flooding. Add 10 percent to the sum to cover possible error. Figure 5 shows the following example:

Distance from intake to shoreline	5m
Distance between high and low water levels	1m
Distance from shoreline to storage well	2m
	8m
10 percent error	0.8m
Total length of pipe:	8.8m

Worksheet A. Determining Pumping Rate

Step 1. Determine the daily per capita volume of water needed by the community. For example assume a population of 600 people each using 40 liters/day. Number of users x 40 liters/person/day = total daily demand for water, so 600 people x 40 liters/person/day = 24000 liters/day.

Step 2. Determine the pumping rate necessary to supply this amount of water. Divide the total daily demand for water by the hours of pump operation per day.

$$\frac{24000 \text{ liters/day}}{8 \text{ hours/day}} = 3000 \text{ liters/hours or}$$

$$\frac{24000 \text{ liters/day}}{8 \text{ hours x } 3600 \text{ seconds per hour}} = \frac{24000 \text{ liters/day}}{28800 \text{ seconds/day}} = 0.85 \text{ liters/second.}$$

Step 3. Reduce the pumping time to 6 hours to save energy.

$$\frac{24000 \text{ liters/day}}{6 \text{ hours/day}} = \frac{24000 \text{ liters/day}}{6 \text{ hours x } 3600 \text{ seconds per hour}} =$$

$$\frac{24000 \text{ liters/day}}{21600 \text{ second}} = 1.1 \text{ liters/second.}$$

Choice of Inlet Pipes. The types of pipe commonly used are plastic and galvanized iron. Plastic pipe is better because it does not rust, is cheaper and easier to work with, and offers less friction to water flowing through it. If both polyethylene, which is black flexible pipe, and polyvinyl chloride (PVC), which is rigid pipe, are available, the former should be used because it is cheaper, easier to use and requires less maintenance. Flexible plastic pipe may cost as much as one-third less than rigid plastic pipe. It comes in 2.5m diameter coils of 30m or more, is light in weight, and is easily transported and installed. Normally, no couplings are necessary when intakes are made from flexible plastic pipe. In contrast, rigid plastic pipe (PVC) comes in 6m lengths and is heavy and more difficult to move around. Couplings and pipe joint glue are necessary with PVC pipe.

Flexible pipe can be attached to stationary floats so that the intake remains 0.3-0.5m below the water surface no matter what the water level is. This allows water to enter the intake all year around. Maintenance is easy because flexible pipe can be lifted from the water to be inspected or serviced.

Table 1. Determining Pipe Diameter

Q Flow liters/sec.	V (Velocity) = 1m/sec. to 1.5m/sec.	V = 1.5m/sec. to 2m/sec.
	Pipe Diameter (mm)	Pipe Diameter (mm)
0.63	250mm	250mm
0.83	300mm	300mm
1.0	300mm	300mm
1.3	400mm	300mm
1.6	500mm	400mm
2.0	500mm	500mm
2.3	500mm	500mm
2.6	600mm	500mm
3.0	600mm	500mm

PVC pipe is usually held up by stationary supports as shown in Figure 5. Because its position does not change with the water level, it may draw in water containing bottom sediments or even stagnant water. Maintenance is more difficult because it must be done underwater.

Inlet Strainer. An inlet strainer allows the required water to enter the system while keeping out unwanted material such as sediment, plants, and small fish or animals. One technique is to plug the end of the inlet pipe and let water flow into the pipe through holes drilled into it. The

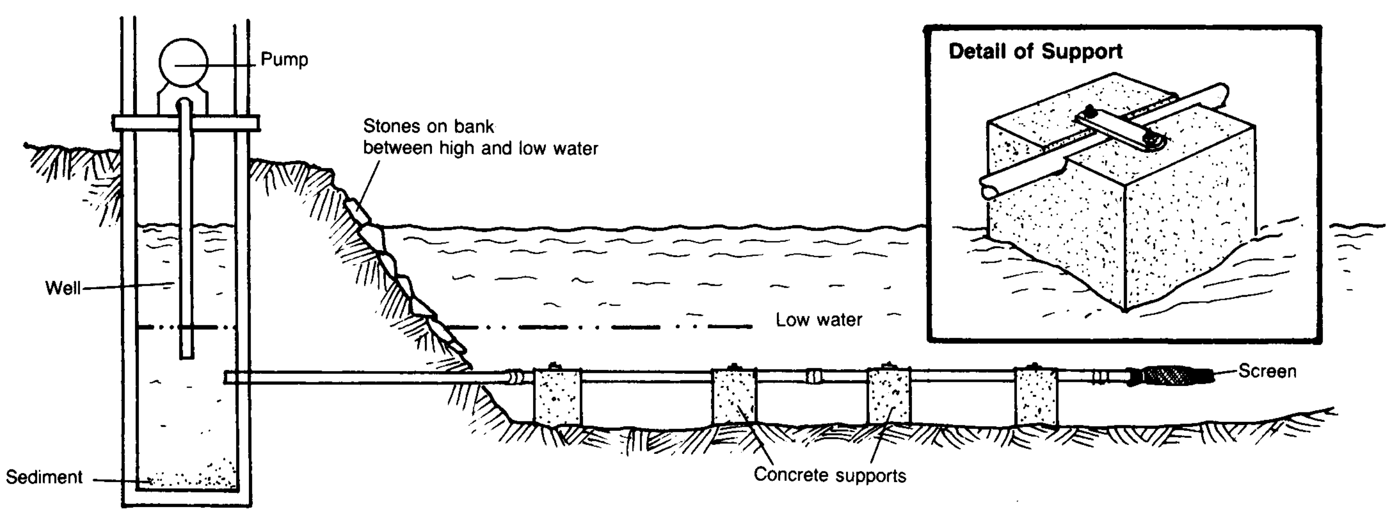

Figure 5. Rigid Intake and Settling Tank

holes are covered with wire mesh to filter out debris. The type of wire mesh will depend on available materials but the mesh should have 10mm squares. Figure 6 shows a perforated inlet pipe. The length of the pipe to be perforated and the size of each hole will depend on the amount of flow needed. A 0.20-0.50cm length of pipe with 15 holes 10mm in diameter would be sufficient for most flows. The distance between the center of each hole should be 25mm. The amount of flow from a perforated pipe can be determined by the following formula:

$Q = AV$, where Q is the amount of flow, V the velocity (1.2m/second), and A is the area of the holes in the perforated pipe.

Worksheet B shows how to calculate the rate of flow when there are a known number of inlet holes of a specific diameter. The worksheet also explains how to determine the number of holes which should be drilled in an inlet to obtain a desired rate of flow. Use this worksheet and "Determining Pumping Requirements," RWS.4.D.2, in designing the inlet.

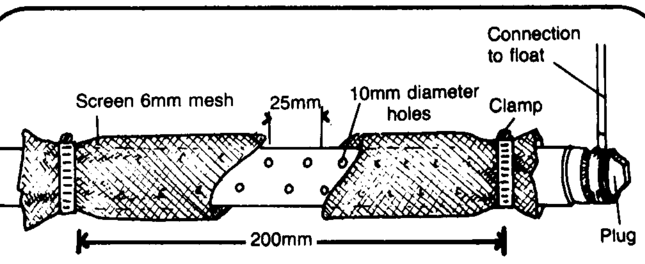

Figure 6. Plastic Pipe Intake

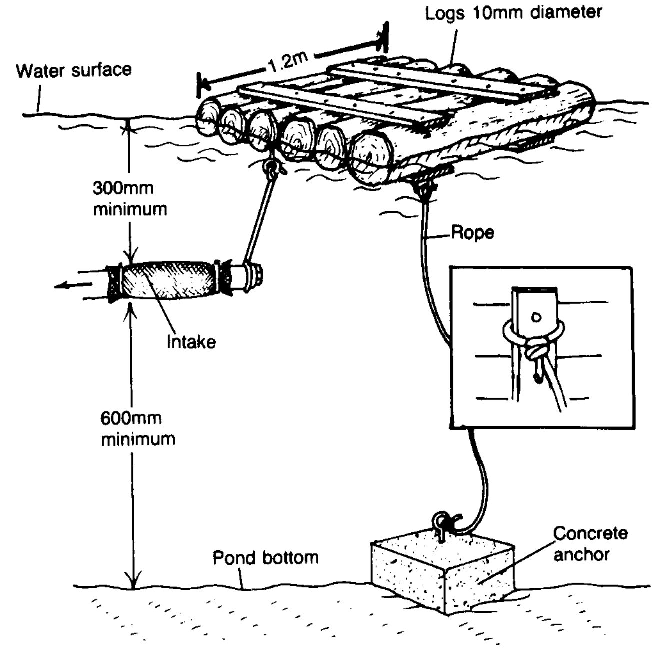

Figure 7. Raft Float and Intake

Design of Floats and Fixed Supports

Flexible pipe can be suspended from floats. The construction of floats requires some floatable material, suspension lines, and anchors.

There are many types of floating material available. Bamboo or trees can be used to make very good floats. By tying together logs or bamboo stalks, a floating raft can be constructed. Figure 7 shows a raft float made from nine logs 1.2m long and six cross-members of 0.9m. Bamboo can be used in the same way. The cross-members are nailed into the logs. If bamboo is used, the stalks can be lashed together with rope or twine.

Instead of a raft, a barrel or other floating container can be used. Figure 2 shows an intake suspended from an empty barrel. If a barrel or other container is available, the cost of installation may be less than for a raft. Both methods are equally acceptable and efficient, however, special care should be taken in choosing and maintaining floats. If barrels rust or if holes are made in them, they will sink taking the intake pipe with them. Wooden floats also sink when they become water logged. Floats should be well maintained and checked often to ensure efficient operation of the intake system.

Worksheet B. Determining the Rate of Water Flow*

Step 1. Determine the total area of the holes drilled in the inlet pipe. Use the formula for the area of a circle:

Area = π (diameter ^{2}) where π = 3.1. For example, assume there are 15 holes, each with a diameter of 0.01m (10mm).

Area of a drilled hole = π (d^2)

Area = $\frac{3.1}{4}$ (.01m^2)

Area = .00008m^2

Total area of drilled holes = Number of holes x area of one hole:

15 x .00008m = .0012m^2
Total area = .0012m^2

Step 2. Find the rate of flow of the water entering the system using the formula Q = AV where Q = rate of flow, A = area of the holes and V = velocity of flow. Assume that V = 1.2m/sec. for this example.

Rate of flow (Q) = Total Area (A) x Velocity (V)
Q = .0012m^2 x 1.2m/sec.
Q = .0014m^3/sec.
Since 1m^3 = 1000 liters, .0014m^3/sec. x 1000 liters = 1.44 liters/sec.
Q = 1.44 liters/sec.

To determine the number of 10mm holes that must be drilled to have a specific flow, follow the above steps in reverse. For example, assume a rate of flow (Q) of 1.4 liters/sec. is desired, and the velocity is 1.2m/sec. To obtain a 1.4 liter/sec. flow:

Step 1. Divide the rate of flow by the number of liters in a cubic meter:

$$\frac{1.4 \text{ liters/sec.}}{1000} = .0014m^3/\text{sec.}$$

Step 2. Divide the volume (m^3) by the velocity ($\frac{Q}{V}$ = A) to find the total area (A).

$$\frac{.00014}{1.2} = .0012m^2$$

A = .0012m^2

Step 3. Divide the total area by the area of each hole to find the number of holes needed.

$$\frac{\text{Total Area}}{\text{Area of one hole}} = \text{Number of holes}$$

$$\frac{.0012m^2}{.00008m^2} = 15$$

Number of holes = 15

*Friction and head loss must be considered in the calculations when a water distribution system is developed. For specific details, see "Determining Pumping Requirements," RWS.4.D.2.

With both types of floats, the intake is suspended 0.30-0.50m below the float by lines made from hemp, sisal, nylon or plastic cord. The only requirements are that the line be long enough to allow for changes in water level and strong enough to withstand the velocity of the water.

An anchor should be tied to the float to prevent it from drifting. An anchor made from concrete, a large rock or a bundle of bricks can be used to secure the float. It is best to use two anchors to prevent a floating intake from drifting when winds are high. Double anchors also act as security in case one of the lines should break or an anchor becomes unattached. If polyethylene pipe is used, anchors may also need to be added along the length of the pipe to prevent it from floating. Without anchors, the pipe may bend.

Stationary supports can be made from concrete or wood. The choice of material depends on which one is least costly and most easily available. Stationary supports are used for PVC pipe. They hold the pipe a minimum of 0.6m off the bottom of the basin and help keep the pipe from bending due to gravity and current. These supports should be placed so that each length of pipe has at least two supports under it. Figure 5 shows a PVC intake system with fixed supports.

In reservoirs formed by dams, several types of intakes can be used. Both floating and fixed intakes will function effectively, but floating intakes are easier to install and should prove more practical. A permanent intake can be constructed in the reservoir when a dam is being built. This type of intake consists of a concrete box with an inlet pipe built next to the embankment. A box structure for a PVC inlet at a dam is shown in Figure 8. This intake consists of a vertical pipe in a square concrete box 1m x 1m with an intake opening 0.60m by 0.60m. The box can be cast in place or built of concrete blocks. The top of the box is covered with 10mm wire mesh. Rocks can be used to hold the screen in place. The intake comes up from the bottom of the box and is protected by it. This type of intake cannot be installed in existing reservoirs; it must be put in place when a new dam is being built.

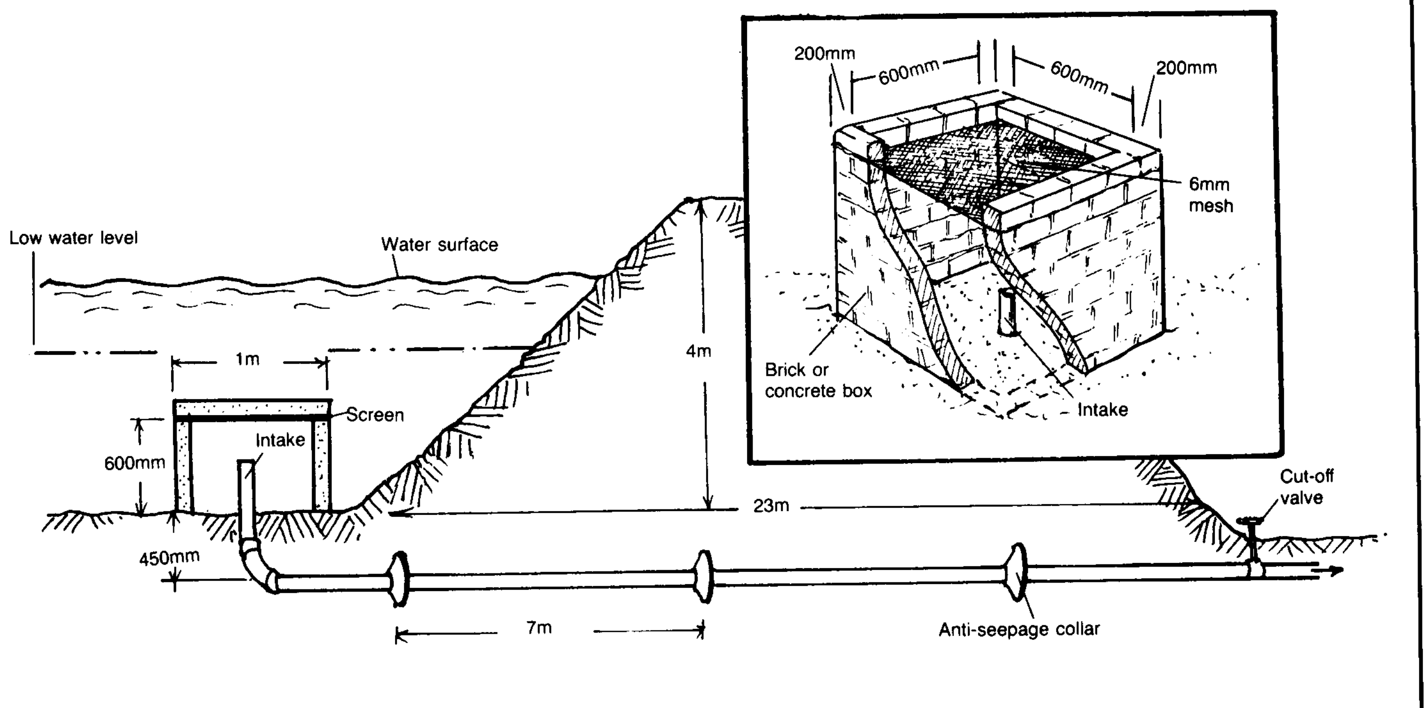

Figure 8. Intake Structure for Dams

Figure 9 shows another typical design for an intake for ponds and reservoirs. A length of pipe is inserted into a concrete form and the cement is poured to form a block containing the pipe. The block should be approximately 0.6m x 0.6m and be tall enough to completely enclose the intake pipe. An elbow joint and a screened vertical length of pipe is connected to one end while the other end is connected to pipe leading to a pump. The intake is installed at the bottom of a pond or reservoir. Floats should be attached so that the intake can be easily located and so it can easily be lifted from the water when maintenance must be done.

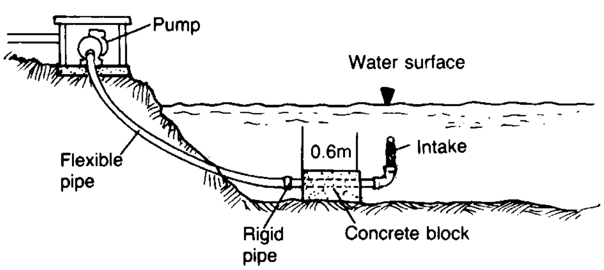

Figure 9. Rigid Intake in Concrete Block

Installation

Water can be pumped directly from the intake into storage or through treatment if necessary. Figure 10 shows an intake system for a dam. The pipe passes 0.45m underneath the embankment into storage. A globe or gate valve placed where the pipe leaves the embankment allows water flow to be turned on or off.

If the water is silty or muddy, it must flow from the intake into a clear water well for sedimentation. The well should be designed to provide 30-minute storage to permit settling of suspended matter.

The well should be approximately 1.5m in diameter to provide sufficient storage. The depth depends on the lowest water level in the pond. The well must be at least far enough below the lowest water level to permit gravity flow from the intake. The bottom of the well should be an additional 1m below the intake entry point to permit settling and to prevent the intake from clogging. There should be a valve on the intake pipe to cut off water flow for maintenance.

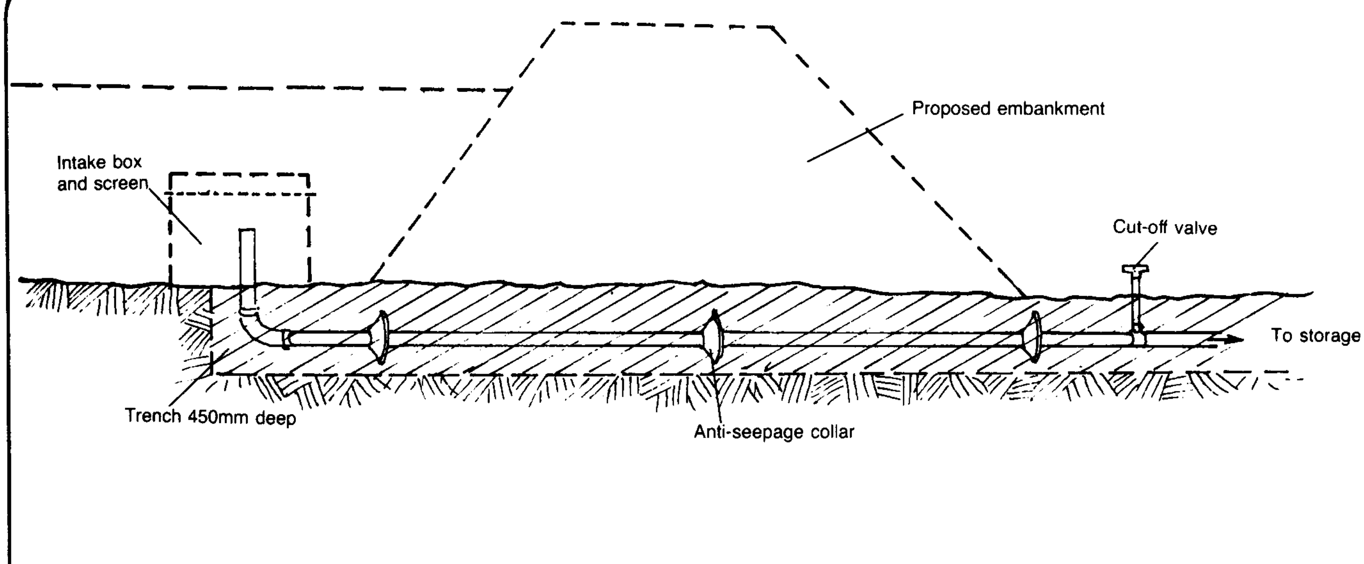

Figure 10. Installing Intake for Reservoir

The well should be lined with concrete or with brick, stones and mortar. The walls should be between 10-15cm thick and covered with mortar to waterproof them. The well should be covered for sanitary protection. The cover can be made either of concrete or metal sheeting. Complete design information for dug wells is available in "Designing Dug Wells," RWS.2.D.1.

Water is taken from the well by either a mechanical or hand pump depending on the type of distribution system. The pump intake should be about 0.50m above the bottom of the well. For information on pumping see "Selecting Pumps," RWS.4.P.5.

Water can be disinfected in the storage well or after it is pumped out. Use "Methods of Water Treatment," RWS.3.M, to decide what type of treatment is most appropriate to the system.

Table 2. Sample Materials List for Floating Intakes

Item	Description	Quantity	Estimated Cost
Labor	Foreman	____	____
	Laborers	____	____
Supplies	Flexible plastic pipe	____	____
	10mm wire mesh screen (for strainer)	____	____
	Plug (for end of pipe)	____	____
	Floats (wood, bamboo, barrels or plastic containers)	____	____
	Anchors (rocks or cement)	____	____
	Rope	____	____
	Tie wire	____	____
	Wooden stakes	____	____
	Knotted rope with weight	____	____
	Clamps	____	____
Tools	Digging tools	____	____
	Small drill	____	____
	Nails	____	____
	Hammer	____	____
	Bucket	____	____
	Measuring tape	____	____
	Small boat or raft	____	____
	Saw	____	____
	Knife	____	____

Total Estimated Cost = ____

Table 3. Sample Materials List for Rigid Plastic Intakes

Item	Description	Quantity	Estimated Cost
Labor	Foreman Laborers	____ ____	____ ____
Supplies	PVC pipe Couplings and pipe glue 10mm wire mesh screen Plug (for end of pipe) Clamps Wood for pipe supports (or cement, sand, gravel, for concrete and wood for forms) Globe valves String Wooden stakes	____ ____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____ ____
Tools	Digging tools Hack saw Wood saw Sledge hammer Nails Bucket Measuring tape Small drill	____ ____ ____ ____ ____ ____ ____ ____	____ ____ ____ ____ ____ ____ ____ ____

Total Estimated Cost = ____