11 Surface water intake and small dams

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11.1 River water intake

Groundwater may be the preferred source (chapter 10), but the most convenient source of water for small communities is frequently a natural stream or river close by. The two most important criteria in judging the suitability of the surface water source are the quality of the water and the reliability of the flow.

In tropical countries, rivers and streams often have a wide seasonal fluctuation in flow. This also affects the quality of the water. In wet periods the water may be low in dissolved solids concentration but often of a high turbidity. In dry periods river flows are low and the load of dissolved solids is more concentrated. Mountain streams sometimes carry a high silt load but the mineral content is mostly low and human pollution is generally absent. In plains and estuaries, rivers usually flow slowly except when there is a flood. The water may be relatively clear but it is almost always polluted, and extensive treatment is necessary to render it fit for drinking and domestic purposes. The quality of river water does not usually differ much across the width and depth of the riverbed.

Whenever practicable a river intake should be sited

- where there is adequate flow;
- at a level that allows gravity supply to minimise pumping costs;
- upstream of densely populated and farming areas to reduce silt inflow;
- upstream of cattle watering places, washing places and sewer outlets (to eliminate pollution of the water);
- upstream of bridges (to reduce velocity/turbulence).

Intake designs aim to avoid clogging and scouring and to ensure the stability of the structure even under flood conditions. Where the river transports no boulders or rolling stones, an unprotected intake may be adequate (fig. 11.1).

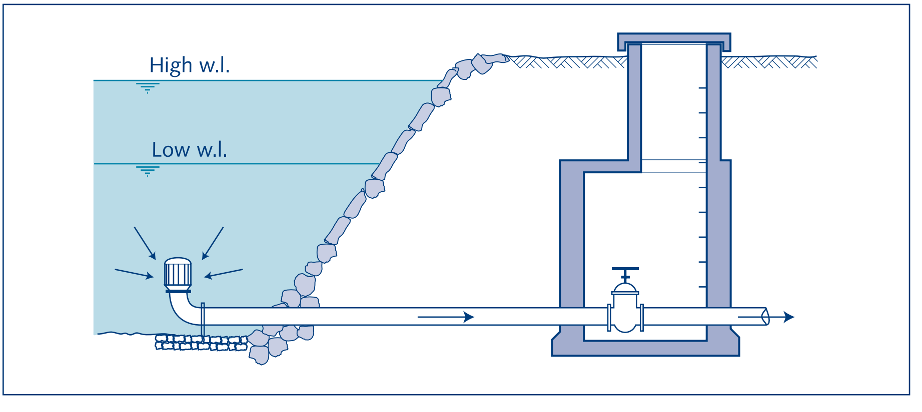


Fig. 11.1. Unprotected river intake

Where protection of the intake is deemed necessary, intake structures of the type shown in figure 11.2 may be suitable. They can be constructed of concrete, stone (masonry) or brick.

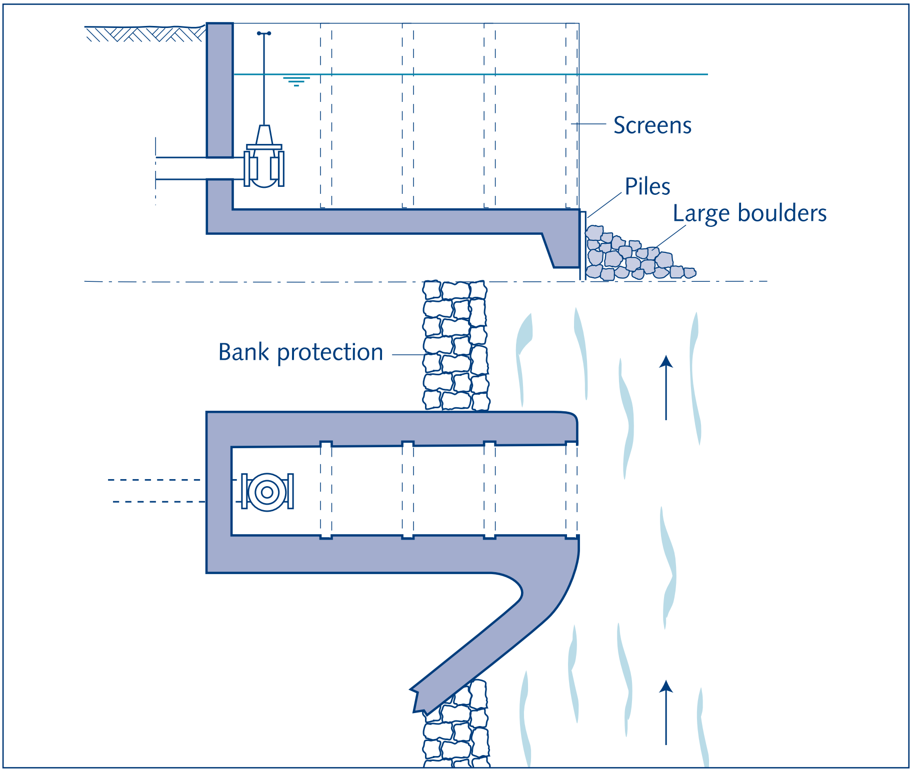


Fig. 11.2. River intake structure

The bottom of the intake structure should be at least 1 m above the riverbed to prevent any boulders or rolling stones from entering. The intake structure must always include one or more baffles or screens to keep out debris and floating matter such as tree trunks and branches. It is advisable to use "passive" screening that does not create turbulent flow conditions. To reduce the drawing in of silt and suspended matter, the velocity of flow through the intake should be low, preferably less than 0.1 m/s. To make use of the natural current to help cleaning of screens, the following tips are suggested:

- The screen axis must be parallel to the current flow
- Dead-end approach channels should be avoided as they collect debris
- Adequate water cover must be provided all around the screen

More information about different types of screens is given in section 11.6.

A river intake always requires a sufficient depth of water in the river. A submerged weir may have to be constructed downstream of the intake to ensure that the necessary depth of water will be available even in dry periods. This type of weir is only a small structure and cannot be expected to provide any storage or flow balancing. Ideally the weir should be founded on rock, to provide the best conditions with regard to bearing capacity, seepage and safety against sliding. Soils with a clay/silt content that reduces permeability and increases cohesion, but with low plasticity are also acceptable as foundation materials. A key at the upstream toe of the weir will improve stability and an upstream apron will extend the seepage path and thus reduce seepage. A weir stability calculation chart is given in table 11.1.

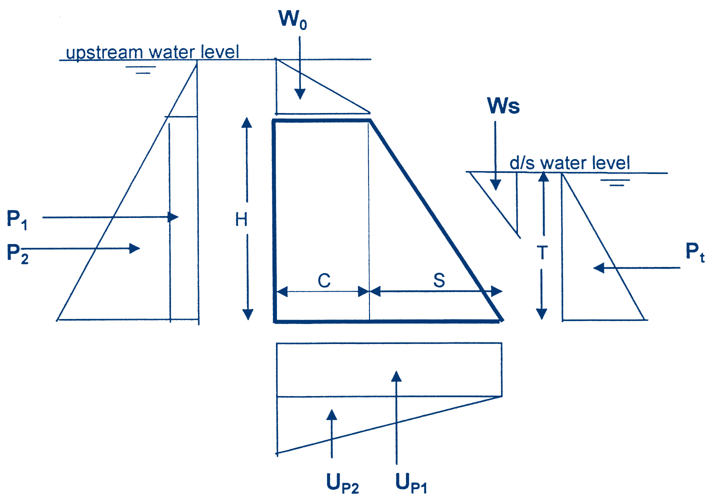
Table 11.1 Weir Stability Calculation Chart

Item	Desription	Force	Lever arm	Moments		H →	V ↓
				Overtuning	Restoring		
P_1	ρ_w x D x H		H/2			+	Nil
P_2	ρ_w x H^2 x 0.5		H/3			+	Nil
Pt	ρ_w x T^2 x 0.5		T/3			-	Nil
W_0	ρ_w x D x C 0.5		S+2C/3			Nil	+
W_1	ρ_m x C x H		B-C/2			Nil	+
W_2	ρ_m x H x S x 0.5		2S/3			Nil	+
Ws	ρ_w x T x DS x 0.5					Nil	+
Up_1	ρ_w x T x B x uplift factor		B/2			Nil	-
Up_2	ρ_w x (H+D-T) x B x 0.5 x uplift factor		B/3			Nil	-

TOTALS Σ

DIM	
C =	
D =	
H =	
T =	
S =	
B =	

NB: B = C + S



Density of water, ρ_w =

Density of construction material ρ_m =

Uplift Factor =

Downstream Slope =

M = Restoring moment – Overturning moment

TAN Θ = ΣH/ΣV (must be less than 0,75)

Θ = ... COSΘ = ...

ΣH^2 = ... ΣV^2 = ...

$R = \sqrt{\Sigma H^2 + \Sigma V^2}$ = ...

$x = \frac{\bar{x}}{\cos\Theta}$ = ... = ...

$\bar{x} = \frac{M}{R}$ = ... = ...

Mid third = from .... to ....

Resultant passes through mid third = Stable

Resultant does not pass through mid third = Unstable

Safety against sliding, Q is given by:

$Q = (C_0 \times B + V_+ - V_-) \times f) / (H_+ - H_-)$

Where:

Q>4 for safety

f = friction factor or foundation material

C_0 = cohesion of foundation material

Frequently, pumping is needed to draw water from surface water sources. If the variation between the high and low water level in the river (or lake) means that the pumping head will not be more than 3.5-4 m, a suction pump placed on the bank may be used (Fig. 11.3).

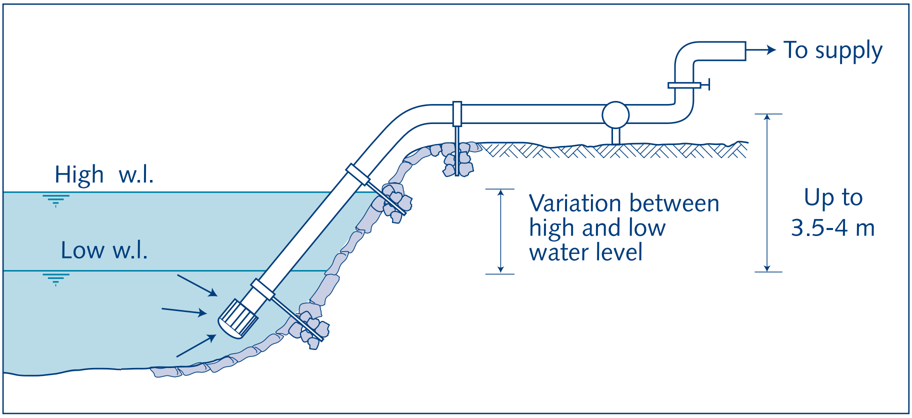


Fig. 11.3. Pumped river (or lake) water intake

A different intake arrangement is needed if the required pumping head exceeds 3.5-4 m. One arrangement worth considering uses a sump constructed in the bank of the river (or lake). The river (or lake) water is collected with infiltration drains laid under the riverbed and flows under gravity into the sump. As the lowest water level in the sump will probably be too deep for a suction pump placed above ground, the water is usually drawn with a submersible pump, or a spindle-driven pump, positioned down in the sump.

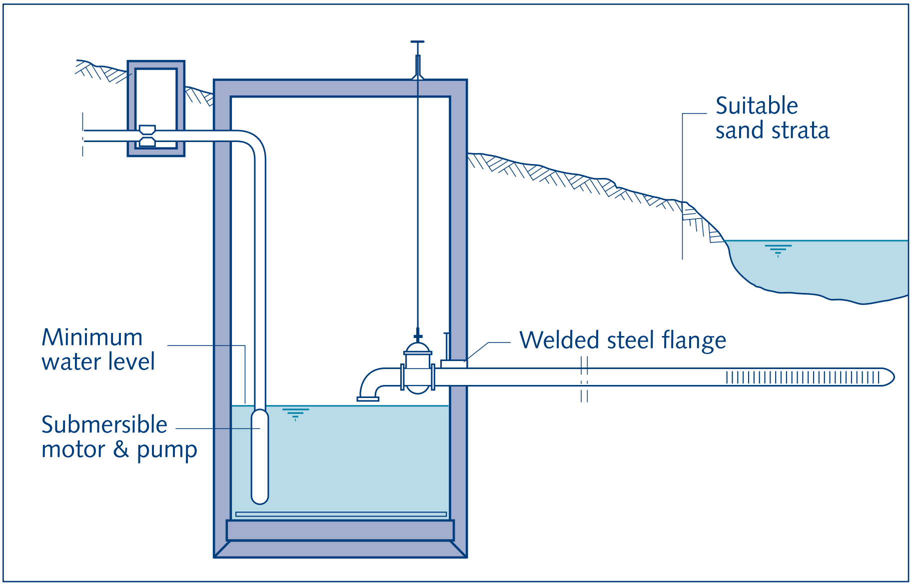


Fig. 11.4. Bank river intake using infiltration drains

11.2 Lake water intake

The quality of lake water is influenced by self-purification through aeration, bio-chemical processes, and settling of suspended solids. The water can be very clear, of low organic content and with high oxygen saturation. Usually, human and animal pollution only present a health hazard near the lake shores. At some distance from the shore, the lake water has generally a low density of pathogenic bacteria and viruses. However, algae may be present, particularly in the upper layers of lakes.

In deep lakes, wave action and turbulence caused by the wind striking the surface will not affect the deeper strata. As there is no mixing, a thermal stratification will develop, with the warmer upper water layers floating on top of the cooler deeper ones. As a result the deeper water layers may differ in quality from the upper water. The thermal stratification can be fairly stable, especially under tropical conditions. Figure 11.5 gives an example. In colder climates the winter temperature of the upper water can drop below that of the lower layers and inversion of water layers will occur.

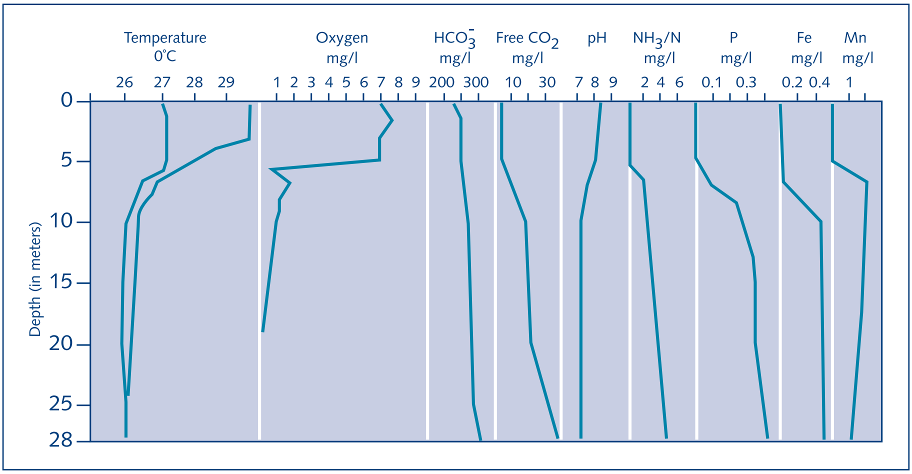


Fig. 11.5. Water quality variation with depth in a deep lake (Indonesia)

Thermal stratification should be taken into account when choosing the location and depth of a lake water intake for water supply purposes. The presence of algae in the upper water layers is another relevant factor.

In deep lakes with water of a low nutrient content (nitrates, phosphates, etc.), the chemical quality of the water will be much the same throughout the full depth. For water supply purposes, water from deeper strata will have the advantage of a practically constant temperature. Provision should be made to withdraw the water at some depth below the surface (fig 11.6). In some instances a multi-level intake structure can be constructed to take advantage of the aerated water on the surface (Fig. 11.7).

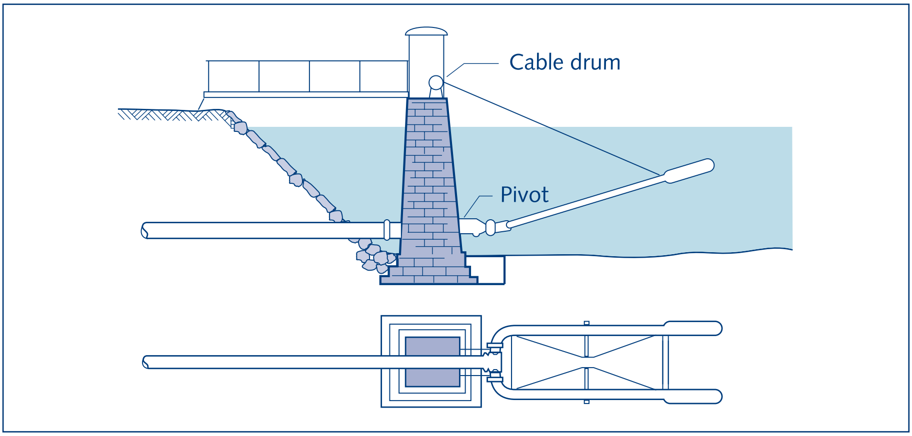


Fig. 11.6. Variable depth lake water intake

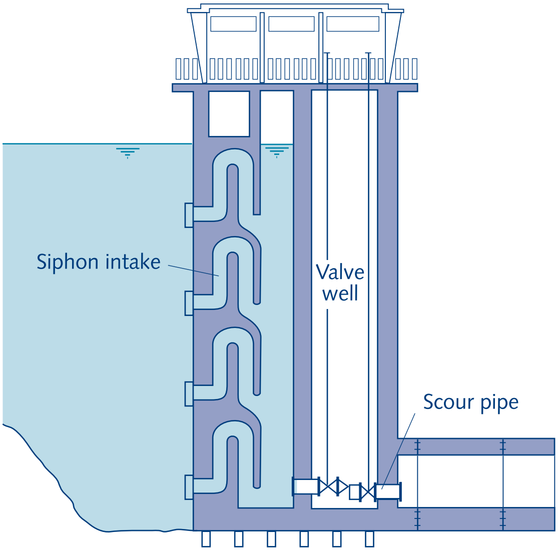


Fig.11.7. Multi-level intake (Adapted from Twort et al., 1994)

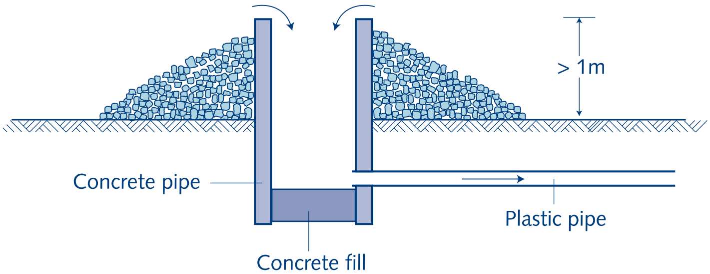


Fig.11.8. Intake structure at bottom of shallow lake

11.3 Typical intake constructions

For small community water supplies only small quantities of water are needed and often very simple intake structures can be used. With a per capita water use of 30 litres/day and the peak intake 4 times the average water demand, 1000 people would require an intake capacity of only 1.4 l/s. A 150 mm diameter intake pipe would be sufficient to keep the entrance velocity 0.1 m/s. If an entrance velocity of 0.5 m/s were allowed, a pipe as small as 60 mm would be adequate.

For small capacity intakes, simple arrangements using flexible plastic pipe can be used (fig. 11.9). Another intake construction using a floating barrel to support the intake pipe is shown in figure 11.10. The water is pumped from the well sump.

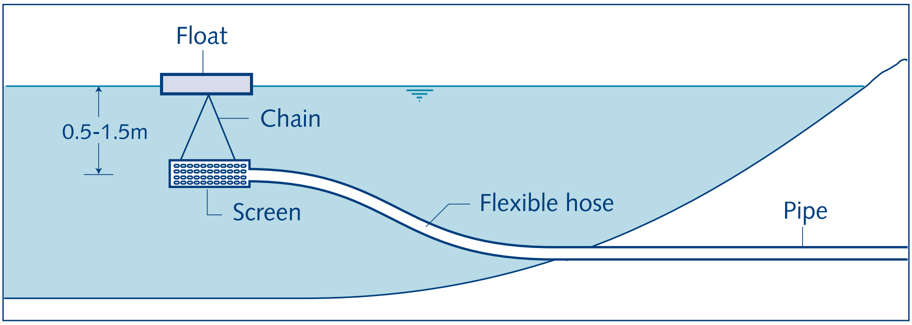


Fig.11.9. Simple water intake structure

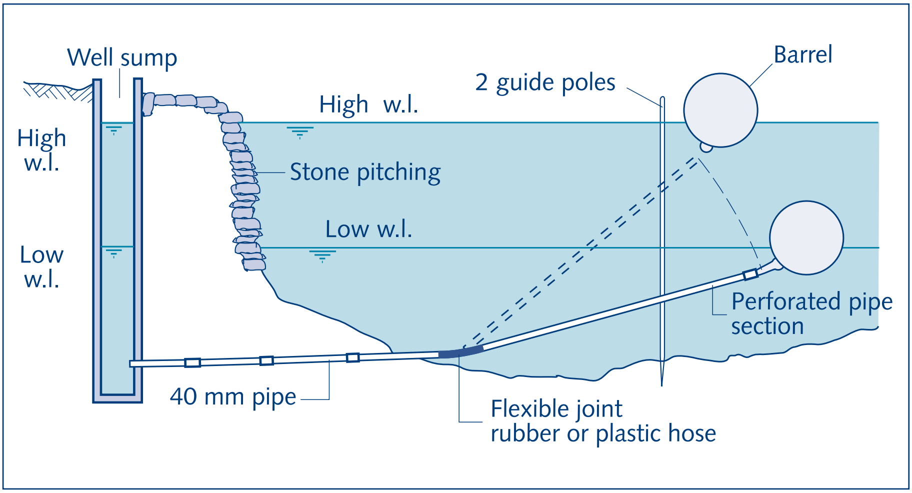


Fig. 11.10. Float intake

11.4 Small dams and village ponds

There are many small communities whose only source of water supply is a small dam or pond. These are called "hafir" (Sudan), "tapkis" (Nigeria), "represa" (South America), "tank" (India), "pond" (Eastern Africa), or other local names. In this handbook they are all referred to as small dams or village ponds.

Small dams and village ponds vary in area from small to large ones of several hectares. They may be entirely natural in origin - depressions in flat areas - or specially constructed for the purpose. If man-made, they may have been excavated for the express purpose of holding water or they may be pits from which clay for building has been taken. Many are a combination of natural and man-made pools, which have been deepened or enlarged over the years to increase their holding capacity. Some are to be found inside villages or small towns. More often, they are located just outside the village area. In India they are often stocked with fish, which provides a valuable source of food for the villagers.

Unfortunately they are also used for washing and bathing. More often than not they are polluted, hazardous at best, and potential spreaders of epidemics. Too often they harbour high densities of pathogenic bacteria, viruses and parasites that account for incalculable numbers of illnesses and deaths, particularly amongst children.
The water may be full of silt or colloidal matter, especially immediately after the rains. Some village ponds have been in existence for centuries; they may be full of aquatic vegetation. Some are the recipients of refuse of all sorts. Others are relatively well kept, beautiful in appearance and a distinctive feature of the landscape.

In practice, it is impossible to prevent the pollution of these small dams and village ponds. By their very nature they are at the lowest point of the surrounding area and the entire village drainage finds its way into them.

In a newly excavated pond, construction of an intake presents no difficulty if carried out before the tank fills. In an established pond, work must be done while the water is in use. Probably all the work will be done by hand and no special tools will be available. In ponds where the water has high turbidity the water is best drawn from just below the surface. A floating intake device may be suitable. Plastic pipe could be used instead of galvanised iron for the collecting pipe. The floating support may be made of bamboo or other locally available materials.

The presence of algae and other aquatic vegetation, as well as fish, in the pond will make it necessary to fix a strainer around the intake. The level of the intake opening must be below the lowest draw-off point if siphoning is to be avoided. A well may be dug close to the bank and the intake pipe either thrust (using a heavy jack) or driven from the well into the pond. The pipe is then capped while the well is lined with masonry or concrete, and the floating intake fixed. The well should be deepened to form a sump, which will allow some settlement of suspended matter.

For obvious reasons, the water from these ponds is not suitable for drinking. Unless reliable and effective water treatment (central or home-based) is applied, villagers must be discouraged to drink it; a health campaign should highlight the serious health risks from this water.

11.5 Operational and protectional issues

River and lake intakes are usually located at a distance from the community. Therefore the caretaker needs a good schedule and routine to visit the intake as they will not be permanently there. During high river discharge daily visits are advisable to remove floating material and debris from the screens and weir. Checks for any damage of intake, bank protection and weir from heavy material (e.g. trees) or from heavy flow from debris need to be made. During low river discharge the visits can be less frequent. Then the checks are more related to the surface water level and – in case of the variable intake point – to adjust the intake point.

Siltation of weirs is common for most rivers. This is due to the settlement of sediment present in the river water. Several times per year during high river discharges, the weir sluice gates are opened to flush out the accumulated sediment behind the weir. Monitoring of these operational issues by the water agency is needed.

The construction of surface water intakes are sturdy and easy damage is not expected. Because usually there will not be a permanent supervision of the site, special protection of the site is recommended. When pumps are involved special arrangements must be made to prevent theft of engines/motors and pumps. The area around the intake needs to be fenced to keep animals out and also to discourage people of entering; this will reduce the risk of accidents.

11.6 Screens

In water supply engineering, screens are used for various purposes:

- Removal of floating and suspended matter of large size which otherwise might clog pipelines, damage pumps and other mechanical equipment, or interfere with the satisfactory operation of the treatment processes. Fixed screens are used for this purpose and they are cleaned on site by hand or mechanically.
- Clarification of the water by removal of suspended matter even of small size, to lighten the load on the subsequent treatment processes. In particular screens are used to prevent filters from becoming clogged too rapidly.

Screening is done by passing the water through closely spaced bars, gratings or perforated plates. It does not change the chemical or bacteriological quality of the water. It serves to retain coarse material and suspended matter larger than the screen openings. Even when screened-out material forms a filtering mat of deposits, the screening still is purely of a mechanical nature.

Bar screens usually consist of steel strips or bars spaced at 0.5-5 cm. If the amount of material ex-pected to be screened out is small, the bars are set quite steeply, at an angle of 60-75° to the horizontal, and cleaning is done by hand using rakes. If larger amounts will be retained, cleaning by hand should still be feasible; to facilitate the cleaning work, the bars should be placed at an angle of 30-45° to the horizontal (Fig. 11. 11).

The water should flow towards the bar screen at a quite low velocity, 0.1-0.2 m/s. Once the water has passed the screen, the flow velocity should be at least 0.3-0.5 m/s in order to prevent the settling out of suspended matter.

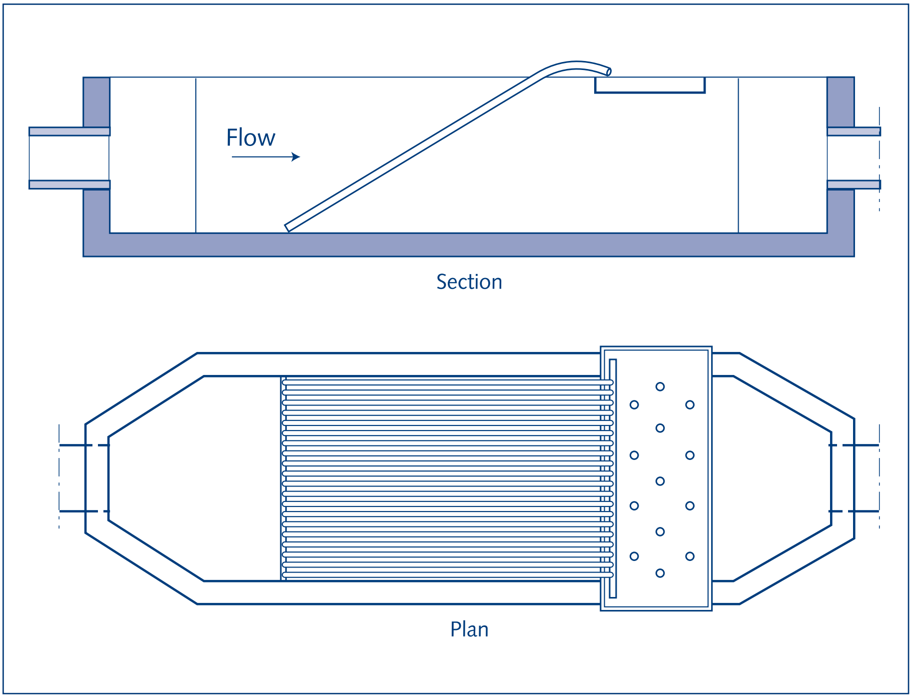


Fig. 11.11. Fixed bar screen

In the openings between the bars the velocity of flow should be limited to a maximum of 0.7 m/s; otherwise soft, deformable matter will be forced through the screen openings. A clean screen will allow the water to pass with a head loss of only a few centimetres. However, the head loss rises sharply when the clogging of the screen builds up. Regular cleaning should keep the head loss limited to 0.1-0.2 m head of water. Allowing for delayed cleaning and mechanical failures, it is good practice to design a bar screen for a head loss of 0.5-1.0 m.

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