

Intake design for small streams

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THIS PAPER DISCUSSES the design of water supply intakes from very small and usually steep streams, based on experiences gained in Bhutan. Small streams, with a yield of usually less than 5 litres per second at the end of the dry season, are the source of roughly half of the gravity flow rural water supply schemes in Bhutan. With the communities served consisting of 5 to 50 households, the design flow of the supply line to the central reservoir, is usually less than 1 litre per second. The source and intake are in most cases situated within two kilometres from the village, but it is also not uncommon that, because of the difficult terrain, it takes a one or two hours walk to reach the source.

After construction it is the responsibility of the beneficiaries to operate, maintain and repair the water supply facilities. To this end a Maintenance Committee is formed and two Caretakers are selected. Both the Committee members and the Caretakers receive training, stressing on the organisational and technical aspects of maintenance respectively.

The stream intake is often the primary bottleneck to the well functioning and long life of the schemes. The intake is situated farthest from the village, but nevertheless determines what water is taken in. Floating debris, suspended solids and small bed load are three factors that can block the intake or the pipe line. Thus the stream intake often requires most maintenance of all parts of the scheme. This paper discusses stream intake structures which are designed to reduce the maintenance requirement, but are at the same time cost effective.

This paper first mentions two problems which non of the intake designs discussed below can solve, being heavy bed load and high suspended loads. Subsequently the drawbacks of two options for intakes, intake from a dam and gravel bed intake, are explained. Lastly intake through a perforated steel plate, tilted or vertical depending on the stream yield, is discussed. The concept of these design options is that the stream water itself is used to clean the intake structure.

Suspended load and heavy bed load

The intakes discussed below are designed to address the threads caused by small gravels and floating debris only. They do not solve the problems related to suspended loads or heavy bed loads.

If a lot of easily sedimenting suspended load is present in the water, sedimentation is required. A sedimentation

tank should be constructed after the intake (ample literature is available on the design of such tanks) and care should be taken that the canal or pipeline from intake to sedimentation tank is steep enough to prevent sedimentation of silt and sand, causing blockage. Sedimentation tanks need to be emptied from time to time. In many small streams a lot of such cleaning will need to be done manually, because self-washing designs are only applicable to bigger streams.

If, at times of floods, bigger gravels and boulders are transported by the stream, the concrete intake structure should be constructed some distance away from the stream. The stream water should be diverted towards the intake by means of a dry stone masonry wall in the stream. This dry stone masonry structure will be damaged by the gravels and boulders present in the stream and therefore needs regular repair.

Problematic solutions

Dam

The bed load and floating load are not present in the middle zone of the water depth. If the water depth is big enough during both the dry and the monsoon season, an intake at half the water depth will therefore solve the hazard of these two types of load. In many small streams the water depth, however, is too small. For those situation a common practice has been to build a dam in the stream perpendicular to the flow, thus raising the water level.

In far most cases this turns out not to have the desired result in the long run. Bed load and some suspended load will settle before the dam, because the flow velocity is reduced, and often after just a single flood, caused by a monsoon shower, the pond created by the dam is filled with solid material. Raising the water level by building a dam is only an appropriate option if the floating load is the main problem and the bed load and suspended load are low, also after heavy showers.

Gravelbed intake

In Bhutan as well as in Nepal (see e.g. Design Guidelines for Rural Water Supply Systems, Department of Water Supply and Sewerage, Regional Directorate, Pokhara, Nepal, 1990) a pack of gravel (course, fine or graded) is often applied to protect the intake pipeline, thereby preventing floating debris to enter the intake. In streams where the yield is more than the demand and where the

difference between dry-season and monsoon yield is limited, this is a good option. The water flows over or along the gravel pack covering the strainer pipe to the water supply scheme. The width and depth of the section can then be manipulated in such a way that it is too turbulent for the suspended load to settle and block the gravel pack.

In streams with no surplus water or floods, however, we found that a draw back of this solution is that it gets blocked quickly. Underwater parts of the gravel filter are covered by sand and silt, while leaves and other organic matter block the higher parts of the gravel pack.

Tyrolean weir and perforated steel plate

The objective of developing a new intake has been to come up with a cheap and simple design, yet reducing the maintenance requirement. Therefore we aimed at a structure which uses the water to wash the suspended and small bed loads, but without moving (and therefore sensitive) parts. The Tyrolean weir has these characteristics.

A Tyrolean weir consists of parallel rods, which are installed sloping down in the direction of the water flow over the width of a stream. Boulders, tree branches and bigger leaves cannot enter through the slots between the rods. The slope of the rods facilitates that the water pushes these remnants down stream, till they drop over the down stream end of the weir.

For our purposes we provide a perforated steel plate in stead of the rods of the Tyrolean weir, through which some gravels and leaves can still enter the intake. The holes are smaller than the slods of the Tyrolean weir and therefore all bed load and floating load are prevented from entering the intake. Drawing 1 gives specifications of the intake that we constructed. Note that the angle of the downward slope is based on literature on the Tyrolean weir, and not on research relating our design to stream

characteristics (such as peak and lowest source yield and presence of loads).

Safe yield ratio: tilted or vertical perforated plate

Although we assume that the tilted perforated plate can be applied for all intakes from small streams, we plan to experiment with an alternative design depending on the safe yield/design flow ratio. The distinction we want to make is between streams where roughly half or less than half of the safe yield (taken as 80% of the dry season yield) will be taken in, and cases where the design yield is bigger than half the safe yield. In the latter case, a small safe yield compared to the design flow, the tilted perforated plate, discussed and drawn above, will be constructed.

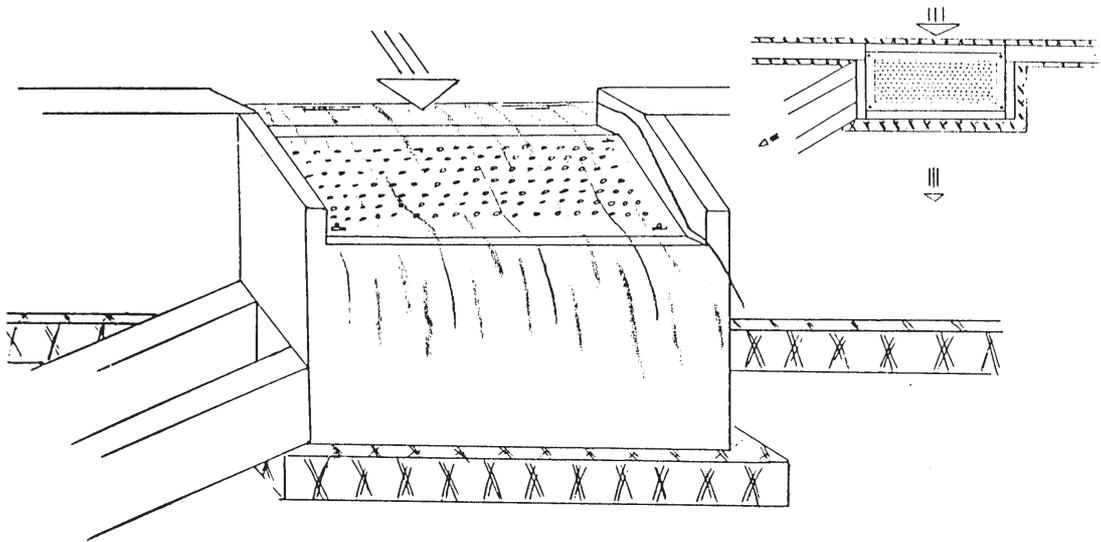
In cases where the safe yield is bigger and only a small portion of the water present in the stream is taken in, the plate will be constructed vertically along the stream (see drawing), thus being what is commonly known as trash board. The difference compared to most trash boards or screens as we applied them till date, is that not all water will be let through. The water which is not taken in for drinking water purposes will flow along the plate, thus preventing floating loads from accumulation in front of the plate.

Some anticipated advantages of the vertical plate, compared to the tilted perforated plate are that chances of damage by bed load materials is less, that less material may be required (not all stream water is channelled to flow over the plate), and that a majority of bed and floating loads will pass the intake without even touching the plate. In cases where there is little or no access water available from the stream, the tilted perforated plate should be constructed. The mentioned advantages of the vertical plate would be less for such cases, and, moreover, there would be too little water to flow along the plate to wash it.

Table 1. Comparison between three stream intake designs

			<i>Dam</i>	<i>Gravelbed</i>	<i>Plate</i>
Floating load: High	Suspended load: High	Bed load: Medium	—	—	+ (+ST)
Floating load: Low	Suspended load: High	Bed load: Medium	—	—	+ (+ST)
Floating load: High	Suspended load: Low	Bed load: Medium	—	—	+
Floating load: Low	Suspended load: Low	Bed load: Medium	—	—	+
Floating load: High	Suspended load: High	Bed load: Low	± (1,+ST)	± (2,+ST)	+ (+ST)
Floating load: Low	Suspended load: High	Bed load: Low	± (1,+ST)	± (2,+ST)	+ (+ST)
Floating load: High	Suspended load: Low	Bed load: Low	± (2)	± (2)	+
Floating load: Low	Suspended load: Low	Bed load: Low	+	+	+

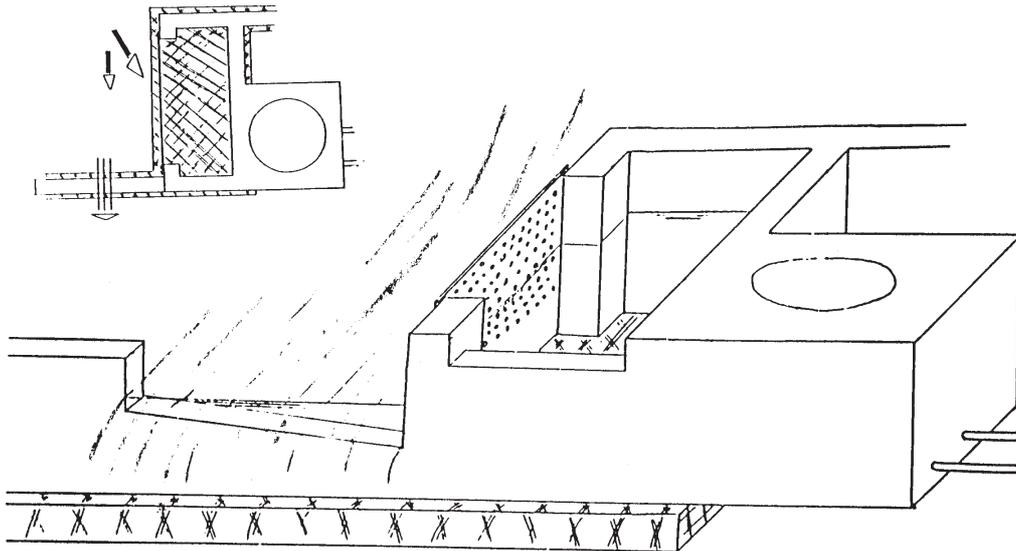
- + Appropriate
- ± Appropriate under certain conditions
- Not appropriate
- (+ST) Sedimentation tank required after the intake
- (1) Appropriate if the suspended load is not sedimenting fast, even after heavy rainfall
- (2) Appropriate if the difference between peak flow and safe yield is not too big



Design Specifications

Plate size:	70* 150cm ²	Hole spacing:	12mm (no holes within 10cm from the edge)
Plate thickness:	between 2-4mm	Holes size:	between 3-5mm
Material:	Steel, galvanised after perforating	Angle:	15°-30° down in direction of flow

Drawing 1. Tilted perforated plate



Drawing 2. Vertical perforated plate