AUTOMATIC SCOUR GATES TO KEEP SMALL DAMS FREE OF SEDIMENT

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ABSTRACT

Sedimentation is the scourge of dams and weirs in developing countries. They are vulnerable to loss of storage due to sedimentation. Sedimentation reduces the life of dams considerably and is a loss of expensive capital infrastructure.

Current systems of manually opened sluice gates or electro mechanically controlled gates are not effective if they are not opened during floods. The sediment then settles in the reservoir and consolidates over time which makes it difficult to remove later. This is the situation in most dams in developing countries.

However there is an automatic scour gate developed in South Africa which is effective in keeping small dams and river weirs relatively free of sediment. They open whilst the flood is running when sediment is in motion to pass the sediment through the dam. The gate then closes after the flood has passed to retain the full supply level. This also has benefits for the downstream river ecology.

These gates can also be fitted retrospectively to dams and weirs to flush out sediment to regain lost storage capacity.

This paper presents this equipment and gives case studies where they have been used effectively.

1. INTRODUCTION

Small dams and river weirs are constructed for numerous functions including water storage: pumping extraction points; diversions into canals for irrigation and run of river hydro power generation

Dams and weirs are manmade structures which interrupt the natural river regime, and in particular, the migration of sediment down the river. Unless suitable features are built into the dam, this migration of sediment is interrupted and there is a consequent accumulation of sediment on the upstream side of the dam or weir and a deletion of sediment leading often to river bank erosion on the downstream side as well as other adverse environmental effects as shown in Figure 1.

2. THE PROBLEM

Dam and weir structures across a river are intended to raise the water level to form a storage pool and as a consequence the velocities in the river reduce. The sediment, both that which is transported along the river bed as well as the finer particles carried in suspension; drop out with the reduced velocities.

The sediment then accumulates on the reservoir bed and with subsequent depositions and time, consolidates. Further with time, reeds and other aquatic vegetation anchor the sediment with root structures. Once sediment has consolidated, it is difficult to remove, although it can be done by successive flushes as described later herein.

Once the sediment has become vegetated with reeds, it will require mechanical means to remove it, at great cost.

Consequently, due to inadequate or ineffective scouring devices, most small dams and river weirs in developing countries have become partially or fully silted up and hence rendered unusable with considerable loss of water storage and money.

Figure 1. Typical river weir which is totally silted up.

The downstream effect of insufficient sediment passing down the river cannot be underestimated as has considerable adverse environmental consequences.

In South Africa, approximately 25% of the total dam storage capacity has been lost to sedimentation and is estimated that the capacity of one large dam is being lost to sedimentation each year!

It is highly probable that this is similar to other developing countries.

3. CURRENT SCOURING SYSTEMS

There are number of devices which attempt to handle the problem of sedimentation.

These include:

- Low weirs with sloping upstream faces which rely on large order floods to remove the sediment and carry it over the weir. This is however only effective if there is frequent flooding and the sediment has not consolidated enough in order to be scoured out.
- Manually operated sluice gate. These need to be opened during floods which invariably does not happen and the scouring mechanism is then rendered ineffective.
- Electro-mechanically operated scour gate. These are mostly bottom outlet radial gates. These are only really feasible for large river weirs and small dams where maintenance and control systems can be assured. Unfortunately there are numerous cases of failures of electro-mechanical gates in developing countries.
- Automatic scour gates which do not rely on electro-mechanical mechanisms nor operator intervention, to open during floods and close again after the passage of the flood and are therefore effective in removing sediment. These gates are the topic of this paper.

4. AUTOMATIC, SELF ACTUATING SCOUR GATES

These automatic scour gates are developed in South Africa and have operated at various sites over the past 35 years. They are designed for African and other developing country conditions. They require no electro-mechanical mechanism to operate them, nor do they require maintenance or operator intervention. They are consequently ideally suited for remote sites in developing countries. These gates are adequately covered in a paper by [1] P D Townshend, (2011) *The Removal of Sediment using automatic self operating scour gates*, International Conference on Sedimentation, Stellenbosch, South Africa.

4.1 Its effectiveness

This automatic scour gate is designed to open automatically when the river is in flood or flowing strongly so that the sediment can pass through the small dam whilst the sediment is still in motion, either moving along the river bed or in suspension. The sediment is prevented for settling out and consolidating and thereby reducing the storage of the small dam. Its effectiveness is limited to dams and weirs up to about 15 m in height. This however is by far the majority of water supply dams and weirs in developing countries.

4.2 Description and Operation

The scour gate is placed at the bottom of a weir or low dam. It consists of a fixed buoyancy tank with a closure leaf closing off a scour tunnel under the weir. The gate is housed in a float chamber within the weir. A diagrammatic sketch of a typical gate is shown in Figure 2 and operating sequence in Figure 3

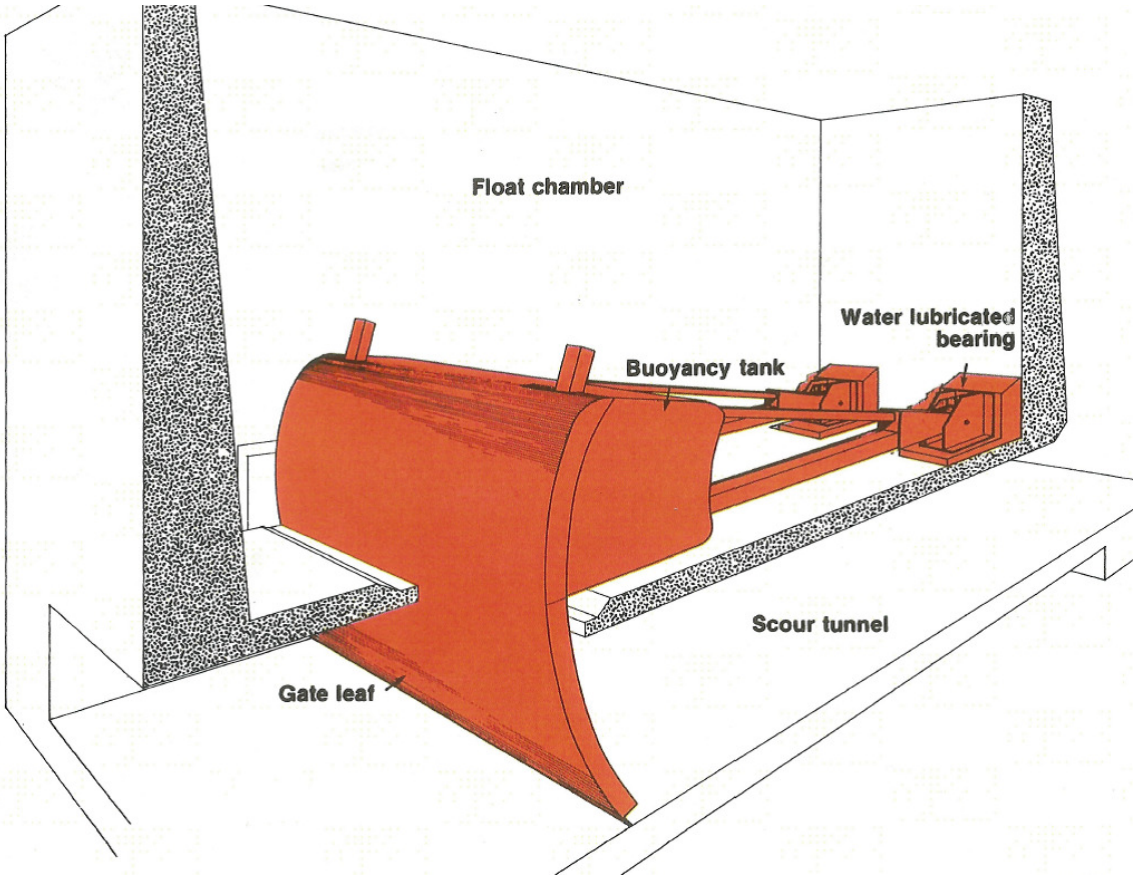

Figure 2. Automatic Self Operating Scour Gate

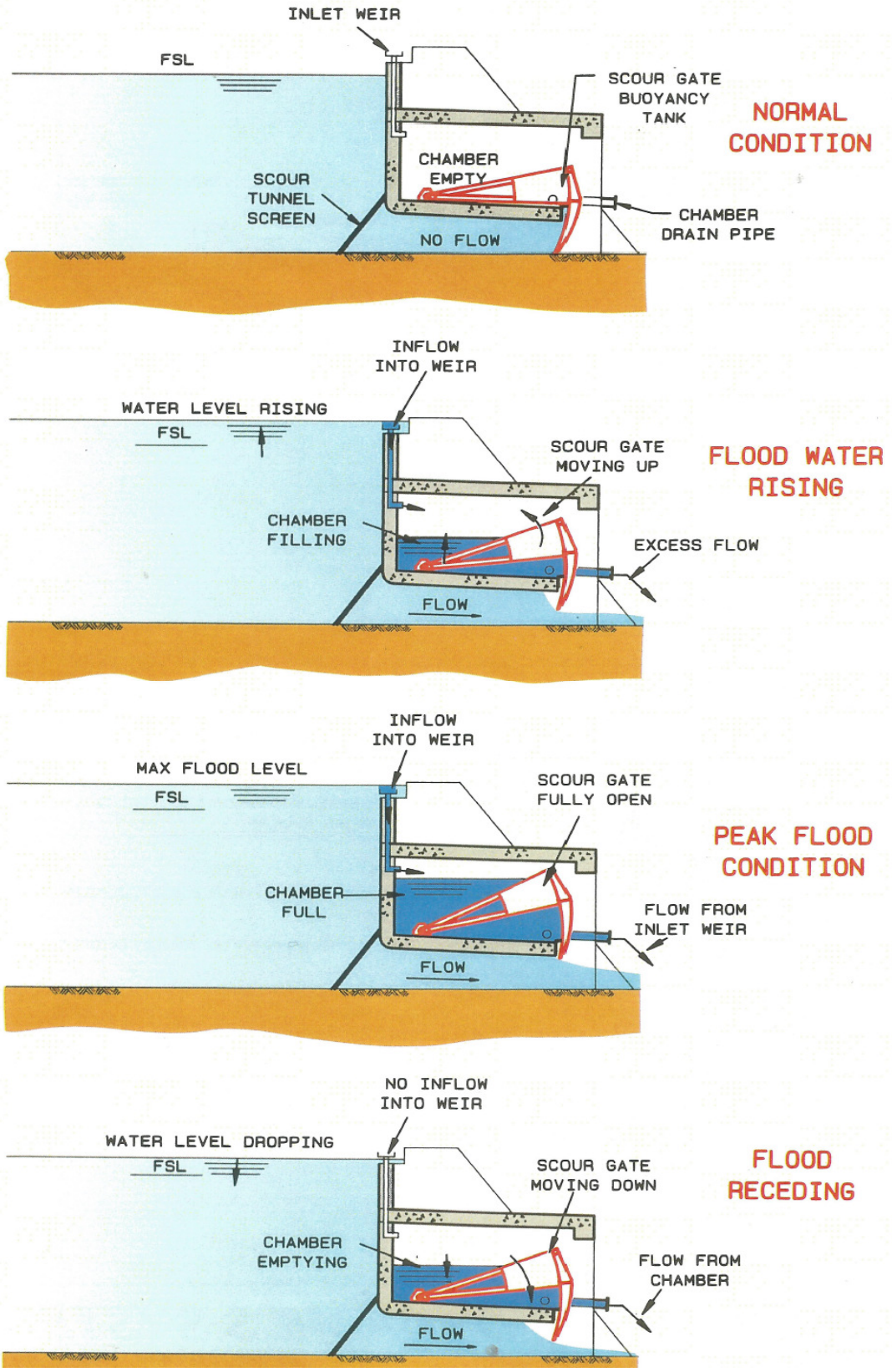

Figure 3. Operation of the Automatic Self Operating Scour Gate

- The gate closes off the scour tunnel for all normal situations.
- When the water level rises due increase flow or flood, water flows into an inlet weir and discharges into the float chamber which causes the fixed buoyancy tank to float to open the scour tunnel. Sediment laden water is then discharged at high velocity under the weir.
- When the flood level in the river recedes, water ceases to flow into the inlet weir. The float chamber is then drained by outlet pipes to cause the gate to close automatically to retain the full supply level (FSL) in the dam or weir.

The scour gate is therefore totally automatic to open during a flood to pass sediment laden waters and close again to retain the storage behind the weir.

4.3 Other Features and Uses of the Automatic Scour Gate

Under the normal configuration as shown in Figure **3**, the scour gate will maintain the normal run of river flow under the gate whilst still maintaining the FSL. In this way, the normal river flow, still carrying sediment, will pass through under the weir.

As has been determined by [2] Professors Rooseboom and Basson in Water Research Commission report No. TT91/97 on dealing with Reservoir Sedimentation, to have any chance of effectively maintaining a low dam or weir free of sediment, the scour gate should be able to pass in the order of a 1 in 2 year recurrence interval flood peak. This requires a large waterway area, often considerably more than what is provided by present scour gates.

On the Runde River in Zimbabwe, a TOPS gate 12 m long by 4 m high has been installed to pass a 1 in 2 year recurrence interval peak. It has worked regularly to open to pass floods over the last 12 years. Figure 4 shows the gate being opened manually.

Figure 4. A large Tops Scour Gate on the Runde River, Zimbabwe

It is also possible to use a siphon to fill the float chamber. This will ensure that the scour gate stays fully open for the passage of the flood and will only close once the water has receded to below the FSL, at which point the siphon will stop discharging water into the float chamber and the gate will close.

This is even more effective in maintaining the weir free of sediment because it will allow the water level to draw down to remove silt laden water and then close to allow relatively clean water after the flood has passed, to top up the weir to its FSL.

This feature is installed on the Runde River weir gate in Zimbabwe where the siphon feed to the gate, draws down this water level by approximately 1 m before the gate closes to fill the weir with relatively clean water. Consequently the river reach behind the Runde River scour gate has minimal sediment build up over 20 years as shown in Figure 5.

Figure 5. River reach behind the Runde River weir automatic scour gate

The scour gate is often just used at one flank of the river weir to protect an offtake structure against sediment build up. Whilst the scour gate will obviously open to pass both flood and normal river flows, it is also possible to install a small timer valve to the float chamber inlet, so that the scour gate can open for a short time, say 15 minutes, each day. This will effectively keep the forebay to the offtake free of sediment.

Debris Control and Manual Opening: Various mechanisms are available to prevent debris entering the inlet weir as well as to pass larger objects through the scour tunnel.

By flooding the scour chamber by means of a small valve, the scour gates can be easily manually opened as well.

5. EXISTING INSTALLATIONS

There are a number of installations in South Africa. The first installed on the Wellington Grove on the Little Fish River in 1977. A number of smaller gates have been installed to protect pumping offtakes. Figure 6 shows the biggest scour gate on the Matsoku scours a 3 m wide x 2 m high scour tunnel under 11 m of head.

Figure 6. Matsoku scour gate, Lesotho Highlands Water Scheme

The scour gates in Figure 7 indicate the 3 scour gates open on the Tswasa Weir on the Groot Marico River. This installation has effectively kept the river reach for a pump offtake relatively free of sediment for 27 years.

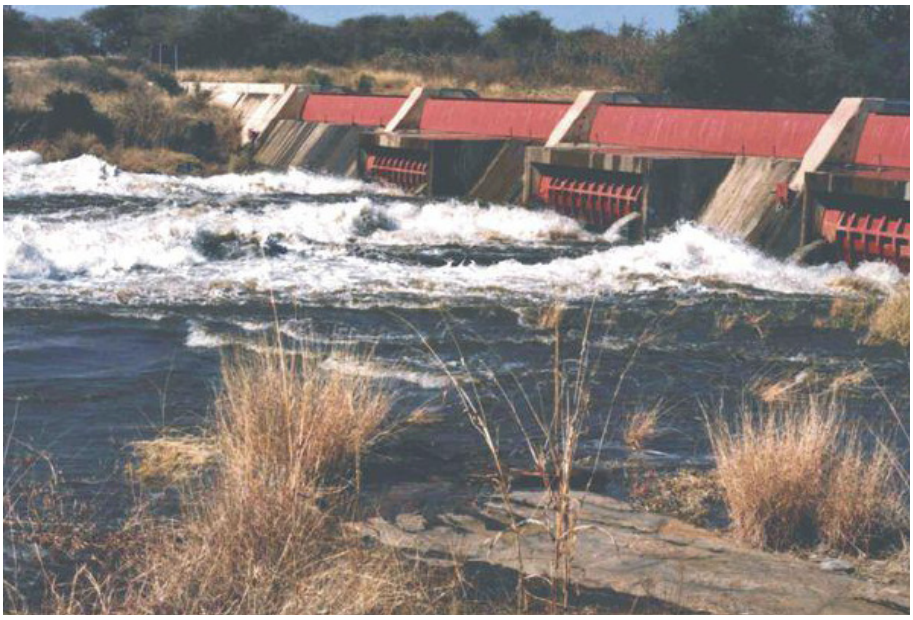

Figure 7. Tswasa Weir on the Groot Marico River, South Africa

6. RETROFITTING SCOUR GATES

It is possible to recover a substantial volume of storage lost to sedimentation behind small dams and weirs. This can be done by a series of successive flushes of the dam but only during periods of higher than normal flow in order to recharge to the dam after each flush.

An automatic scour gate can be retrofitted to an existing concrete weir or dam spillway. It requires careful finite element design of the existing structure to accommodate the scour tunnel and float chamber. This work may be constructed with a full head of water behind a bulkhead gate and therefore requires careful construction by a competent contractor.

The depth to the scour gate is limited to about 15 m .

The scour gate can also supplement the spillway capacity as well as act as a large gate to lower water level in the dam for emergency cases.

Further it can be manually opened to provide environmental flows and simulate small floods downstream to benefit the riverine ecology.

The following Figures 8,9&10 indicate schematically how the scour gate can be retro-fitted to an existing spillway .

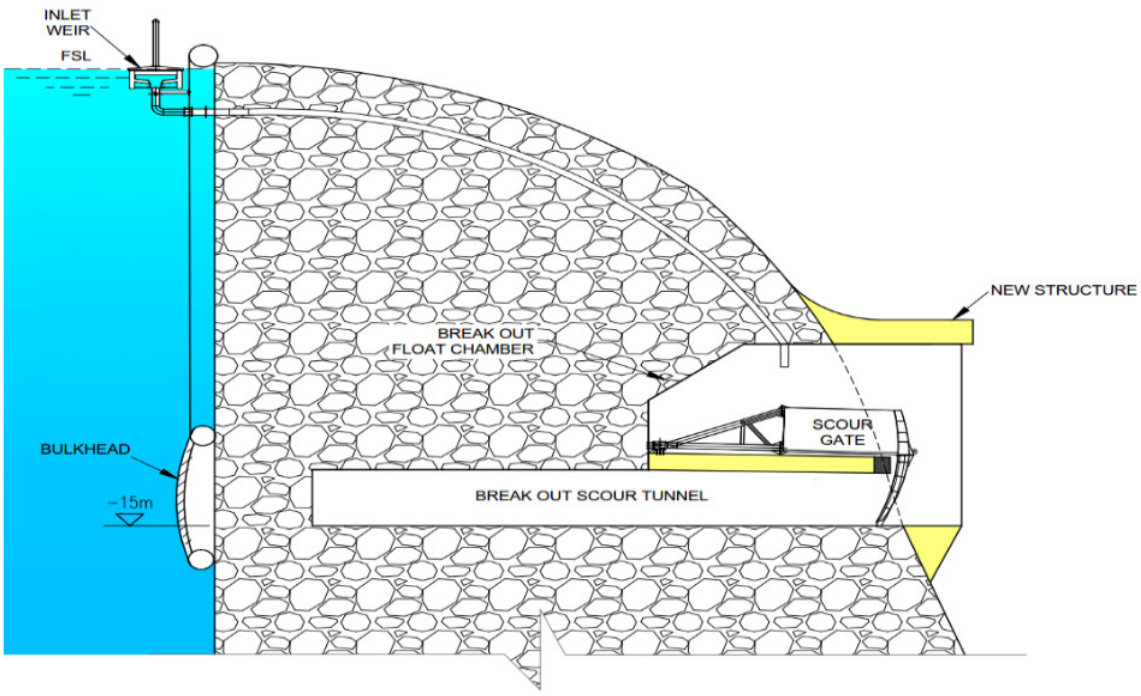

Figure 8. Excavate the scour tunnel, scour gate chamber and fit the scour gate

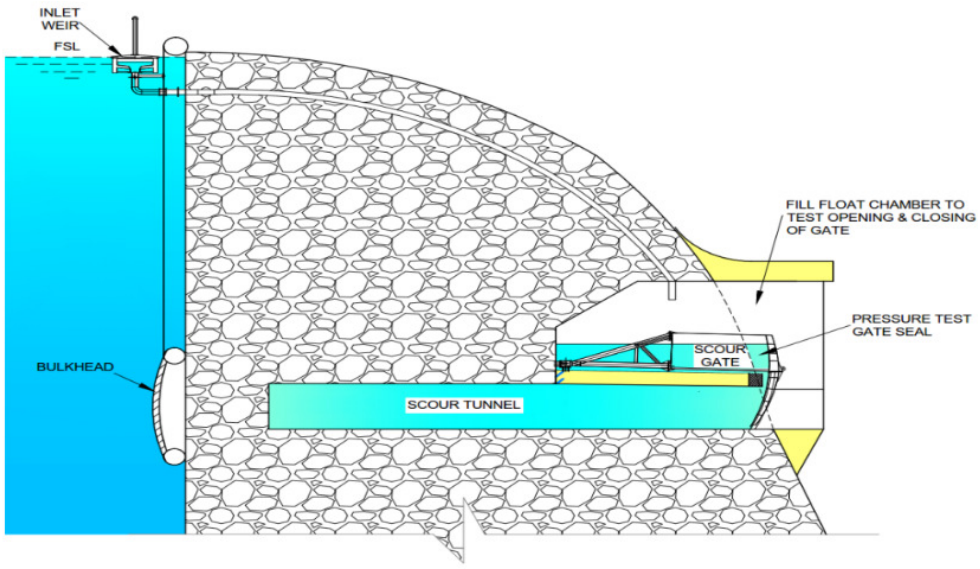

Figure 9. Test the scour gate with full head of water for opening and closing

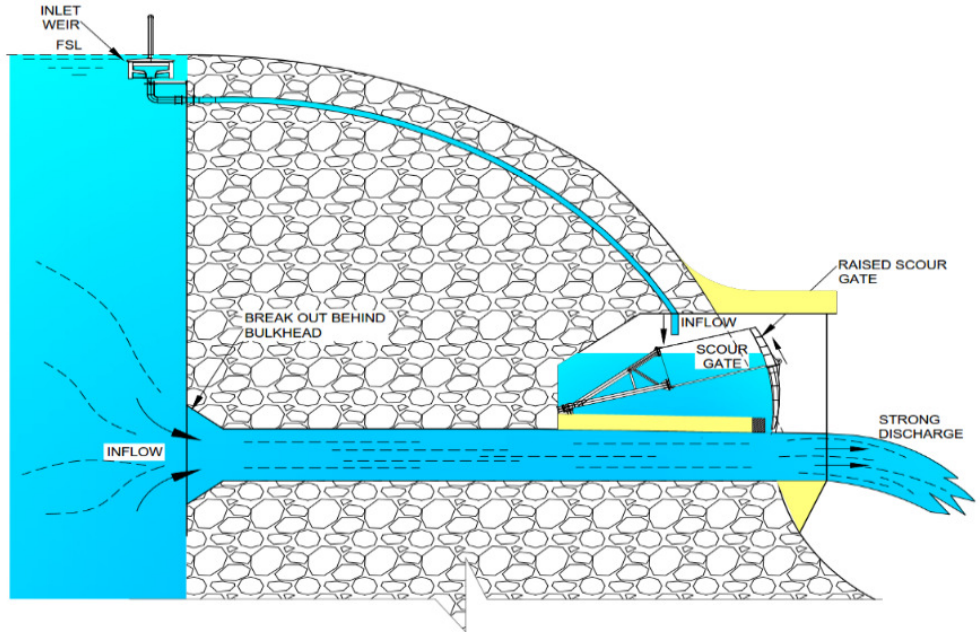

Figure 10. Break out the scour tunnel to the upstream water body and flush out sediment

After the gate is installed, the weir can be flushed a number of times and once most of the sediment is removed, the scour gate will minimize the sediment build up in the weir.

7. CONCLUSION

By using automatic self-actuating scour control gates, river weirs and low dams can be kept relatively free of sediment accumulation.

Sediment is most effectively removed from weirs when it is still in motion in a flood. The automatic scour gates open in floods to pass the sediment through the weir, whilst it is still in motion. They are therefore very effective in keeping small dams and river weirs relatively free of sediment.

It is also possible to retrofit scour gates into existing dams and weirs which are badly silted up, and with a series of flushes, can recover much of the storage lost to sedimentation.

The automatic scour gate will then maintain the weir in a relatively free sediment state as well as provide additional capacity to pass floods.

These gates have been utilized on a number of dams and weirs and have proven reliable and effective.

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Department of Water and Sanitation, South Africa for gates at the Tswasa weir, Figure 7.

Lesotho Highlands Water Authority, Lesotho for large scour gate on Matsoku River, Figure 6.

9. REFERENCES

1 P D Townshend, (2011) *The Removal of Sediment using automatic self operating scour gates*, International Conference on Sedimentation, Stellenbosch, South Africa.

2 Basson GR: Rooseboom A; (December 1997) *Dealing with Reservoir Sedimentation*. Water Research Commission Report No.TT 91/97 Pretoria, South Africa