THE REMOVAL OF SEDIMENTATION USING AUTOMATIC SELF OPERATING SCOUR GATES

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ABSTRACT

Sedimentation is the scourge of nearly all African rivers.

Nearly all river weirs in South Africa are either totally or partially made inoperable by sedimentation. Most existing desilting gates are manually operated and are not effective because the gates are not open during floods and the sediment is allowed to settle and consolidate.

However there are Scour gates which automatically open during floods to pass sediment when it is still in motion, and close again after the passage of the flood and are hence effective in maintaining the weir relatively free of sediment.

This paper discusses the operation of these gates and shows existing weirs where they have been applied. The paper will also illustrate how these gates can be retro fitted to existing weirs to flush out accumulated sediment.

1. INTRODUCTION

River weirs are constructed for numerous functions including:

- Pumping extraction pools
- Diversions into canals for irrigation or hydropower purposes
- Diversion into tunnel systems for cross catchment purposes
- Run of river hydro power generation

In most cases, there is also a requirement for short term storage, such as 48 hrs of supply.

Weirs, and dams, 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 weir, this migration of sediment is interrupted and there is a consequent accumulation of sediment on the upstream side of the weir and a depletion of sediment leading sometimes to river bank erosion on the downstream side.

How this migration of sediment is accommodated at river weirs, is the topic of this symposium.

2. THE PROBLEM

Weir structures across a river are intended to raise the water level and as a consequence the velocities in the river slow down. 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 bed and with subsequent depositions and time, consolidates and further with time, reeds and other aquatic vegetation anchor the sediment with root structures.

Once sediment has consolidated, it is difficult to remove it, but 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 river weirs in South Africa, have become either fully or partially silted up and hence rendered unusable and a considerable loss of money.

Photograph 1 Typical river weir which is totally silted up. Note the degradation of sediment on the downstream side.

The downstream affects if not enough sediment cannot be underestimated as it has considerable adverse environmental consequences.

For bigger rivers where there is a perennial flow, it is possible to design structures with bypass systems which maintain a velocity sufficient for self scouring. However, most river weirs in S.A. are on smaller rivers and require a weir structure to dam the water for temporary storage.

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 is only effective if there is frequent flooding and the sediment has not consolidated enough to be scoured out.

- Manually operated sluice gate. These need to be opened during floods but invariably are not opened and the scouring device is then rendered ineffective. Further, the super structure and spindle for the sluice gates are prone to damage by the water overflowing the weir.

- Electro-mechanically operated scour gate. These are mostly bottom outlet radial gate. These are only really feasible for large river weirs where maintenance and control systems can be assured. Unfortunately there are numerous case of failures of electro-mechanical gates in this country and worldwide.

- 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. These gates are the topic of this paper.

4. AUTOMATIC, SELF ACTUATING SCOUR GATES

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 weir whilst the sediment is still in motion, either along the river bed or in suspension. Hence sediment is prevented for settling out, consolidating and hence reducing the effectiveness of the weir. Its effectiveness is limited to weirs of up to 10 m in height.

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 1.

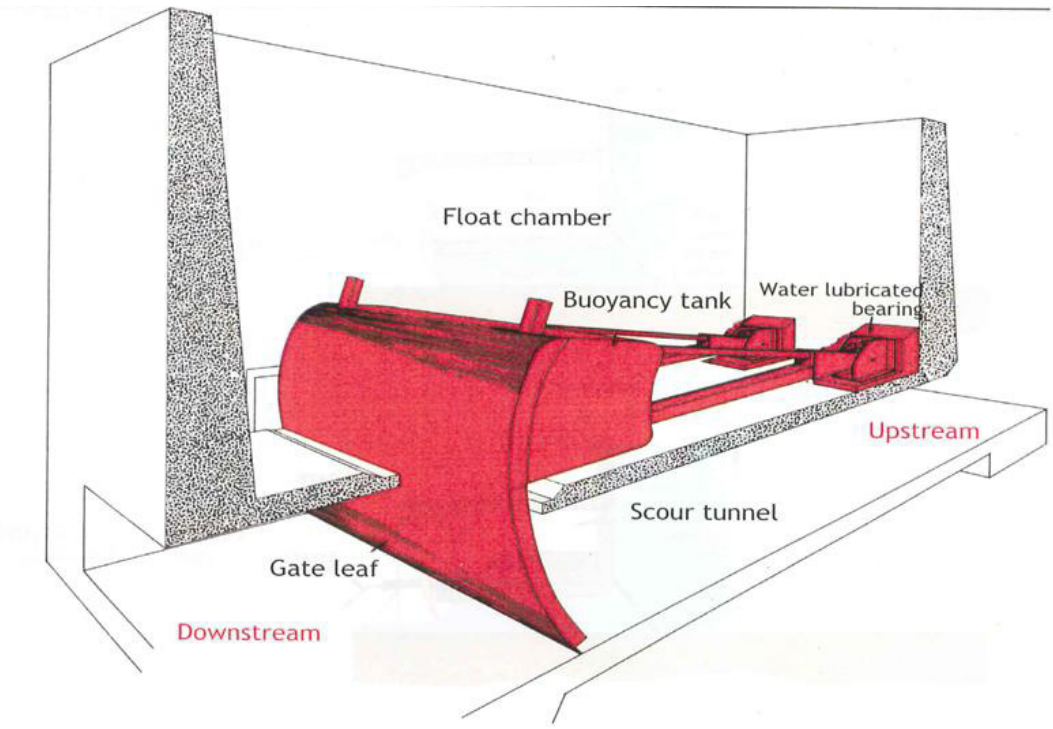


Figure 1 Automatic Self Operating Scour Gate

The self actuating operation of the gate is shown in figure2.

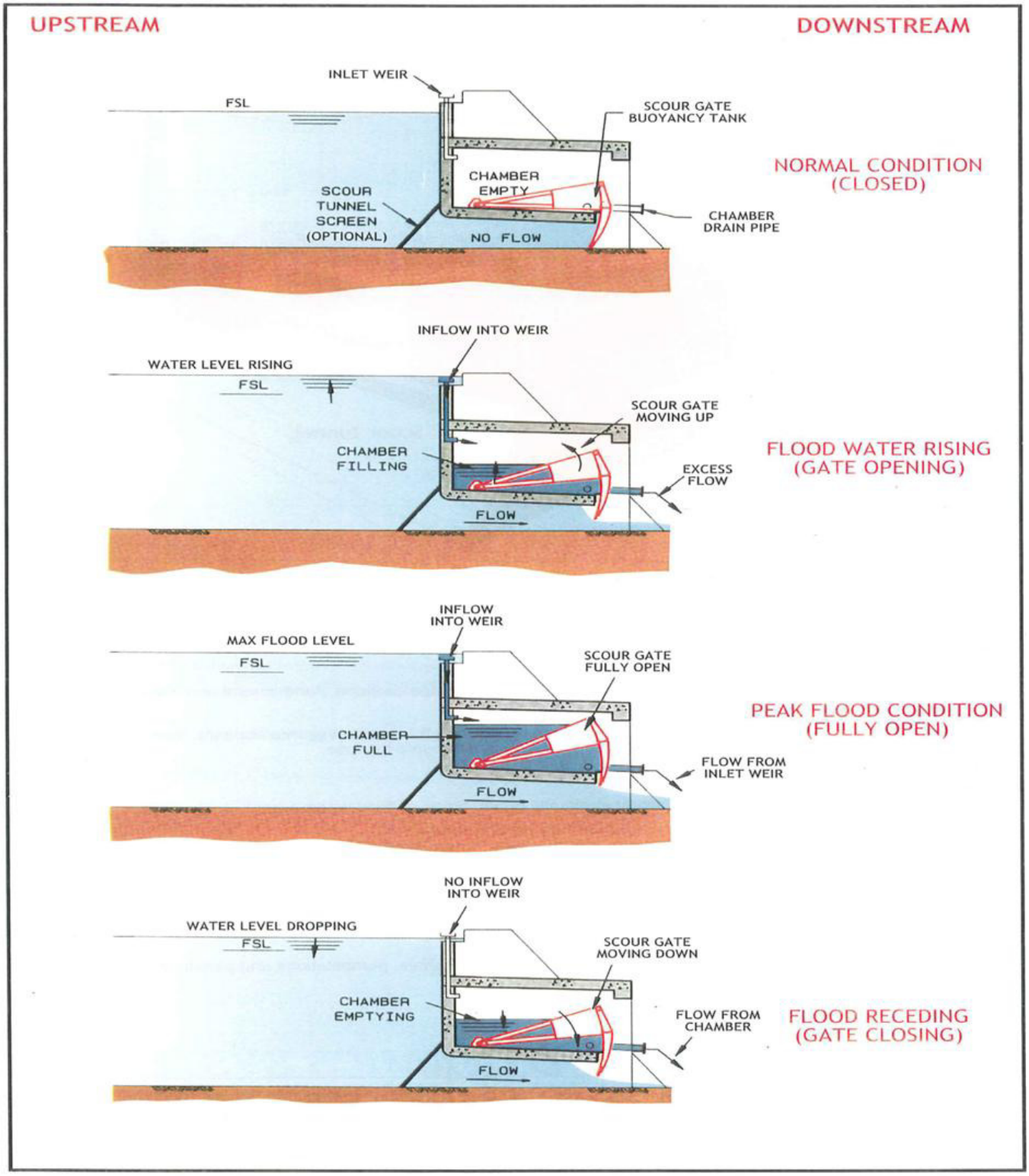


Figure 2

- 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 in 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 in then drained by outlet pipes to cause the gate to close automatically to retain the F.S.L. in the 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

4.3.1

As has been determined before by Professors Rooseboom and Basson in WRC report № TT91/97 on dealing with Reservoir Sedimentation, to have any chance of effectively maintaining a weir free of sediment, the weir should be able to pass in the order of a 1:2 year flood peak. This usually requires a large waterway area, often considerably more than what is provided by present gates.

On the Runde River in Zimbabwe, a TOPS gate 12 m long by 4 m high was installed to pass a 1:2 year peak and has worked regularly to open to pass floods over the last 6 years**.**

Photograph 2 TOPS Scour Gates on the Runde River, Zimbabwe

4.3.2

Under the normal configuration as shown in figure 2, the scour gate will maintain the normal run of river flow under the gate whilst still maintaining the F.S.L. In this way, the normal river flow, still carrying sediment, will pass through under the weir.

4.3.3

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 F.S.L. at which point the siphon will stop discharging water into the float chamber.

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 from the river to top up the weir to its F.S.L.

This feature is installed on the Runde weir gate 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.

4.3.4

The scour gate is often just use at one end of the river weir to protect an offtake device for sediment. 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 10 minutes, each day.

This will effectively keep the forebay to the offtake free of sediment.

4.3.5

Fig. 1 shows the gate with the scour gate leaf on downstream of the scour tunnel. The scour gate can be orientated with scour gate leaf on the upstream side of the scour tunnel. This may be preferred for large rivers with a large debris load.

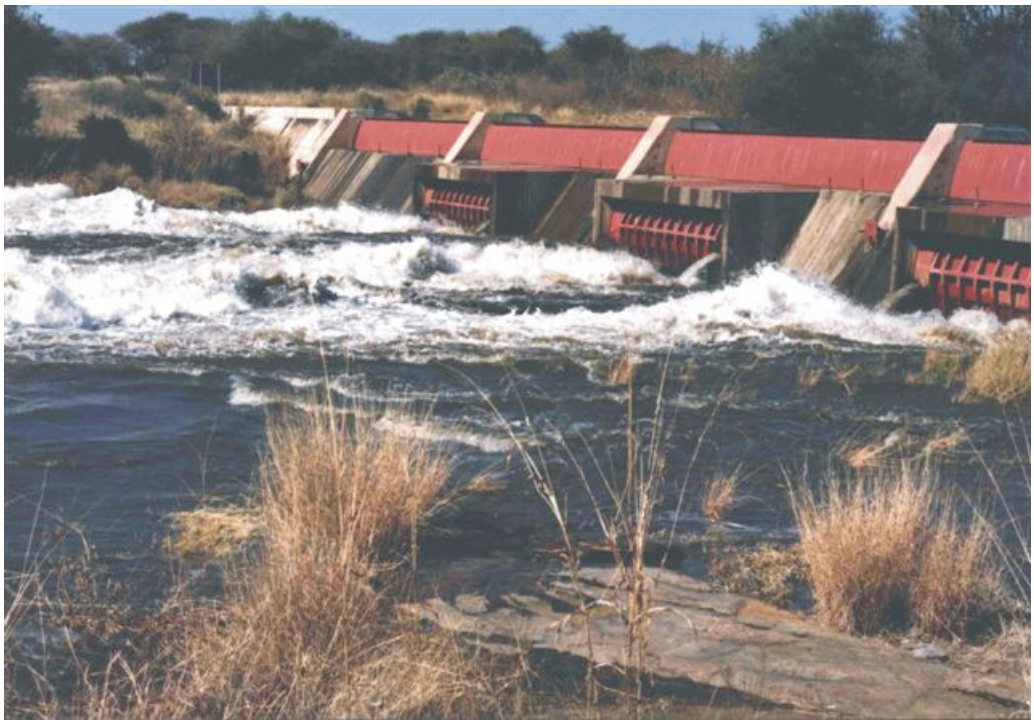
4.3.6

Debris Control: Various mechanisms are available to accommodate debris entering the inlet weir as well as to pass larger objects thought the scour tunnel.

The scour gates can be easily manually opened as well.

5. EXISTING INSTALLATIONS

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



Photograph3 Tswasa Weir on the Groot Marico River. This installation has been working successfully for 27 years. The scour gates also pass the normal river flows.

Matsoku Weir scour gate. This large scour gate keeps the forebay to the tunnel to Katse Dam relatively free of sediment. This opens frequently.

6. RETROFITTING SCOUR GATES

It is possible to recover a substantial volume of storage lost to sedimentation behind weirs. This can be done by a series of successive flushes of the weir but only during periods of higher than normal flow in order to recharge to the weir 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 against a full head of water and therefore requires careful construction by a competent construction company.

The method of doing so is shown in fig. 3.

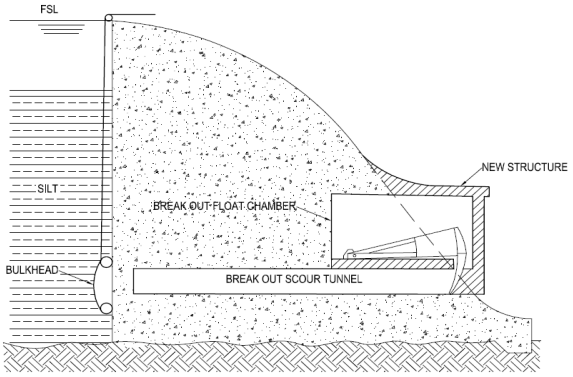


FIG.3.1
BREAK OUT AND BUILD NEW STRUCTURE
AND FIT SCOURGATE

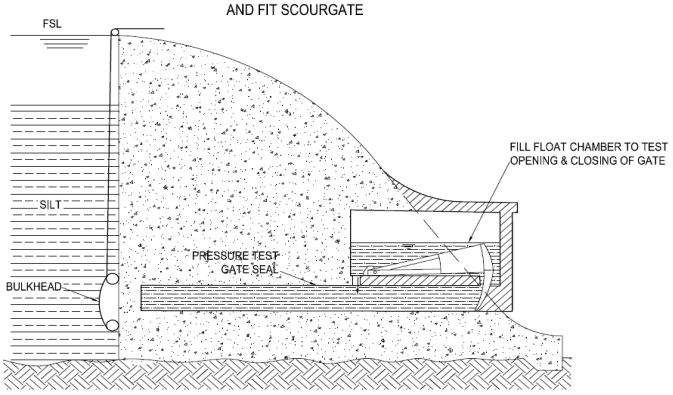


FIG.3.2
WATER TEST SCOUR TUNNEL & GATE

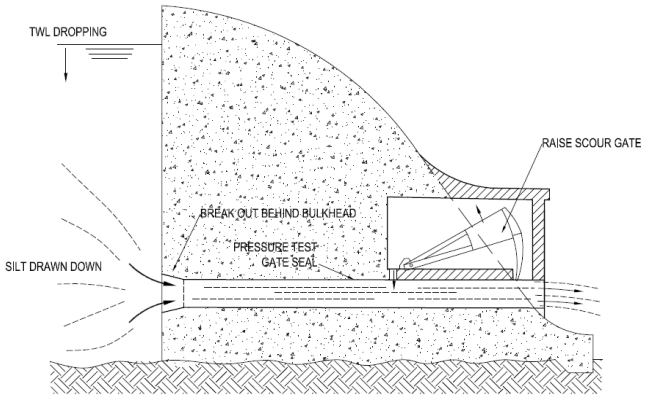


FIG.3.3
SCOUR TUNNEL OPEN TO DISCHARGE SILT

However, once 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 water 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.

It is also possible to retrofit scour gates into existing 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.