WATER RESOURCE MANAGEMENT

National Dam Siltation Management Programme

Siltation of SA dams – Working towards a sustainable solution

Earlier this year, experts gathered under the umbrella of the National Dam Siltation Management programme to garner the latest developments in the quest to improve water storage capacity of South Africa's dams. Matthew Hattingh reports.

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When we non-specialists think of silted-up dams (indeed, when we think of them at all) we picture in our mind's eye great expanses of desiccated mud, cracked and fissured beneath a baking sun. But scratch the surface, or rather dig down a metre, and a more promising picture beckons: water. Certainly, that's what a recent pre-feasibility study found at the Eastern Cape's Nqweba Dam.

When Nqweba (Xhosa for "meeting place") was first completed in 1925, known then as the Van Ryneveld's Pass Dam, it had a full supply capacity of nearly 79 million cubic metres. Fast-forward to 2011 and its capacity had shrunk by 43%. Built for irrigation, today, it cannot meet the domestic and industrial needs of the nearby Karoo town of Graaff-Reinet.

The problem is not so much an absence of water as a surfeit of silt. Fine sand and clay – from natural erosion, exacerbated by overgrazing – carried by the Sundays River and its tributaries are choking Nqweba. A similar story can be told of many of the 320 state-owned dams managed by the Department of Water and Sanitation. Although siltation rates vary dramatically, on average South Africa's dams are losing capacity at a rate of 0.4% a year with consequences for water and food security, particularly during drought.

What's to be done?

The department has long supported surveys and studies to better understand a problem that is far from unique to South Africa: Worldwide dams are losing 0.8% of their capacity a year. And it underwrites the National Dam Silt Management (NatSilt)

programme and its four sub-projects. One of these sub-projects focuses on dredging and was the subject of a virtual workshop, hosted by the Water Research Commission (WRC) earlier this year.

Dredging, as workshop speakers acknowledged, can be pricey. Digging or sucking up large quantities of silt often requires similarly large investments in imported plant and equipment as well as overseas expertise. Historically in South Africa it has been up to 10 times more expensive than the alternatives and brought a host of technical and environmental difficulties, not least, what to do with the silt.

Sometimes however, the alternatives are unsuitable, pose safety concerns or may increase losses to evaporation (in the case of dam wall raising). Or they may be insufficient on their own. For example, better dam and catchment area management – another of the NatSilt sub-projects – can go a long way to nipping the silt bug in the bud. But when dams are already heavily silted, mitigation measures are too little, too late.

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Prof Gerrit Basson told the workshop that flushing was a proven way to clear dams of silt – but only if there's water to spare. Basson serves as managing director of design and consulting engineers ASP Technology, which has been contracted by the WRC to develop the dredging sub-project. This includes putting together an economically and environmentally friendly model for dredging. He is also head of hydraulic engineering at the University of Stellenbosch's civil engineering department and an international authority on dams and siltation.

Basson said that apart from a lack of water, local geography and dam design errors may rule out flushing too. He cited a number of cases, including the Free State's Welbedacht Dam. It was designed with flushing in mind, but the gates it uses to control the release of water are too high and the dam, built in 1973, is now 95% silted.

Water diversion and inter-basin pumping schemes, were among the alternatives to dredging, but these come with their own costs and complications. Back then to the Nqweba, that great silty expanse, where indeed a lack of water makes flushing infeasible.

So how do you go about dredging the 33 million cubic metres of silt trapped within the dam – the equivalent of more than 13 000 Olympic-sized swimming pools? The answer is that you don't, or at least not all of it. Instead, the aim is partial dredging – removing the optimal amount and from very specific places.

With its large surface area and high evaporation rates, Nqweba is hardly the most efficient place for storing surface water. But by dredging deeper rather than wider, it's possible to increase capacity without an increase in evaporation, said Arend van de Wetering, of contractors Dredging Africa.

What's more, targeted dredging offers a way to tap groundwater trapped beneath the dam, providing an especially useful water source during drought.

Van de Wetering told the workshop how in 2019, when the dam last ran dry, researchers dug a test pit into the seemingly dry sediment at the base of the reservoir. Less than 1 m down they hit the water table.

Bingo! "The entire sediment is seen as an aquifer," Van de Wetering explained.

How to make the most of it?

The sub-project team ran the numbers for 60 different options. These included combinations of dredging and measures such as dam wall raising, inter-river basin water transfer and a variety of energy generating and evaporation prevention measures, including solar panels and shade balls. Their calculations established the net present value cost, the rand per kilolitre cost and the firm yield of each option.

Firm yield is the maximum water a dam can be expected to provide if its worst drought-year was repeated. Net present value is a formula used to rank investment options. It's based on the principle that money spent or earned later in a project is worth less than money spent or earned at the start. It explains one of the advantages of dredging: costs can be spread out over a number of years, "resulting in a lower present unit cost compared to the capital investment". Van de Wetering stressed it was important not to look at dredging in terms of cost per cubic metre of silt removed, but relative to the water it yields. Bear in mind that some of the alternatives increase capacity but result in losses to evaporation.

'Dredging Option 6' emerged as the best bet, with the lowest price – R207 a kilolitre. It entails dredging a channel about 20 m wide and 8 m deep, following the original water course. This would be linked to a more deeply dredged area immediately inside the dam wall. This 'sump' would increase capacity while making it possible to collect groundwater seeping from the sediment bed.

The team recommends that in addition to pursuing Option 6, which entails dredging between 1 and 2 million cubic metres, further detailed investigations were needed on:

- The quantity and quality of water the aquifer could produce; and
- Implementing a scheme to transfer water between the Great Fish and Sundays rivers in 2048 at a cost of R264 a kilolitre.

Dr Jeanine Vonkeman, who is leading the ASP team on the dredging sub-project, said many case studies internationally demonstrated that reservoir dredging worked well and she felt it has become more feasible in South Africa. But Vonkeman made it clear that every dam is different so the best way to deal with silt will vary. A thorough feasibility study must be done, covering a host of considerations, not least of all cost, which again, is

"highly site specific".

Will the dredging be once-off or will continuous, "maintenance" dredging be required? What environmental laws apply for a particular dam? Which regulatory approvals are needed and what monitoring plans are in place?

"By no means are we promoting the sustainability of dam dredging. We are not here to debate that. We are just trying to figure out how we can make it more sustainable," she said. Vonkeman explained how the team had reviewed the literature on dredging and developed guidelines and decision-making tools to assist planners. Something of a checklist, these start with the preliminary stages which might examine a number of dams to see which are best suited for dredging. Surveys and studies help model sedimentation rates, hydrology and the effects of climate change for individual dams. These findings are analysed and weighed against water demand. Yield targets can then be set and the practicalities of dredging dealt with.

Vonkeman' ASP colleague, Andreas Brooks, briefed the workshop on work done classifying and prioritising dams for possible dredging. He said the team looked at 127 medium- to large-sized dams and sought to classify these by calculating their remaining lifespan. The researchers also considered how much water was finding its way into each dam, relative to its capacity. This was to get a sense of whether there might be sufficient water to allow alternatives such as flushing.

Other considerations included whether a dam provides potable water, and Brooks shared a shortlist of dams with potential for dredging, including Nqweba, Calitzdorp and Hazelmere. Vonkeman said the team has developed guidelines that cover different dredging methods and how silt might be used or disposed of and the health risks this entails.

Dredging can stir up silt affecting aquatic habitats and water quality. It's a big topic in its own right and Antonia Belcher, an aquatic ecologist and consultant to the dredging sub-project, sketched some of the issues at play. In a video recorded for the webinar, she touched on the ecological impact of dredging and disposal silt, how to keep harm to the environment to a minimum and the legislation relevant to dredging.

Let's assume the most environmentally sound dredging technology available is put into service and mitigation measures are in place, the question remains: what to do with the silt? Water quality and waste engineer Hanief Ally made the point that "dredged sediment is contradictory in nature".
"It may be a resource in some locations and an unwanted nuisance in others," he said.

Typically it's dumped, but Vonekman notes that internationally the trend is to seek ways to put the silt to better use. What that might be, depends on the properties of the silt, including whether it is contaminated ("typically rare in South Africa"). Regardless of whether the silt is destined for beneficiation or disposal, assessment, testing and monitoring are required, delegates heard. And getting that right can be demanding. A workshop breakaway session discussed the lack of local sediment quality guidelines and noted that the international guidelines used instead, "were not amenable to South African conditions".

Ally and Vonkeman said silt can have a range of uses and mentioned a few. It can be mixed with coarser material and used for agriculture. If it has a high sand content, it might work as a construction material. Local circumstances dictate too. The silt might be required for restoring local habitats or for flood defences.

Or it could provide raw materials for income-generating projects, notably making building blocks.

"Perhaps we could create jobs and housing through skills training. And if we do brick manufacturing we can definitely make a difference through social upliftment of local communities," said Vonkeman.

Such projects might help recover some of the cost of the dredging and create jobs. "But, there's a big but. Our reservoirs are often located in remote areas, so for the benefit not just to be social but also economic, we have to compensate for transportation costs, particularly for distances greater than 50 km for where we would like to use our dredged material."

Happily, Nqweba is on Graaff-Reinet's doorstep, so this is not an issue. The fine material that fills the dam has a high silt (40%) and clay (55%) content making it tricky to work with. But the plan is, with the help of Dutch experts, patented techniques, cement and additives, to stabilise the material and make compressed-earth blocks.

So, there's useful building materials and much-needed water beneath Nqweba's cracked and fissured floor. Hope springs eternal, you might say, or as Van de Wetering put it in summary: "This is the one project that ticks all the boxes. It is the most favourable situation that you can ever have to dredge a dam in South Africa. And if it will not work at Nqweba Dam it may possibly not work anywhere else. So, it's very important that this case study be executed and that we make a success of it."

Hazelmere Dam, in KwaZulu-Natal, has been shortlisted as a possible dam for dredging.