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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Integrated reservoir eutrophication remediation plan: Hartbeespoort dam

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The Hartbeespoort Dam is situated in a highly developed area in South Africa. Due to high nutrient loads in the dam unpleasant and even hazardous conditions occur frequently. An integrated phased management and remediation plan has been developed and is being executed at the dam. The plan provides for short to long-term actions relating to the water quality of the incoming water, and limnology of and sediments in the dam. Actions include enhanced wastewater treatment at sewage plants, in-stream treatment, continued regular monitoring, the bio-manipulation of the fish community for removal of algae and the initiation of community based fisheries. Preliminary analysis indicates that a start-up cost of about R27.3 million and annual costs of about R9.3 million are required. These costs do not include actions that could be taken at municipal wastewater treatment plants. The development and implementation of the plan are serving as case studies for various projects in the Department of Water Affairs and Forestry.

Introduction

The Hartbeespoort Dam contributes to the beautiful scenery in the North West Province. It was constructed in 1923 as part of a government irrigation and job creation scheme to alleviate poverty experienced after the First World War. The dam wall was raised in 1970 by 2.44 meters - resulting in an increased gross capacity of 205 million cubic meters. The catchment area is 4 112 square kilometers with water mainly draining from highly developed areas. The catchment straddles 3 rapidly urbanising metropolitan areas i.e Tshwane, Ekurhuleni and Johannesburg.

In-flow to the dam has been increased significantly by return-flows from wastewater treatment plants. Other upstream water users and impacters include dense settlements and agriculture from where mainly non-point or diffuse pollution originates.

Photograph 1. Toxic bloom in Hartbeespoort Dam

Eutrophication in South Africa

Present Situation

As is found throughout the world, South African waters are progressively becoming euthrophic. This natural process has been accelerated to such an extent in areas that the water at times became unfit for use and even toxic – as has been found at Hartbeespoort Dam (Photograph 1). The Dam is regarded as hypertrophic with the cause mainly attributed to the clusters of large populations in settlements and towns, and other anthropogenic development.

Eutrophication can impact on human health and quality of life (taste, odours and possible toxic conditions), on water treatment processes (clogging of reticulation systems, increased treatment costs), on ecological systems (increased occurrences of de-oxygenation and associated chemical effects such as release of phosphorous from sediments), it can interfere with recreational activities, can decrease property values (undesirable aesthetic conditions) and can impact on agricultural water use activities (DWAF, 2003).

Regulatory system

The progressive eutrophication of the water resource has mainly been regulated by the Department through the introduction of the 1 mg/l phosphate standard in the 1980s. In 2002 the urgency to further regulate and manage eutrophication was realized through the initiation of a project to develop a national eutrophication strategic framework. Elements of this framework are shown in Figure 1. Note that the drafting

Figure 1. Proposed process for eutrophication management in South Africa and the development of an eutrophication catchment management strategy

Source: DWAF (2006a)

of a Catchment Eutrophication Management Strategy would be an iterative process and would not necessary take place as finalized consecutive steps.

The guidelines for the Development of a Catchment Eutrophication Management Strategy (DWAF, 2006a) and an Operational Guideline for Eutrophication Good Management Practice (DWAF, 2006b) have been drafted and are available for comment. The approach used in the guidelines is to –

- Develop criteria to evaluate different eutrophication management practices for point, non-point and/or reservoir related activities;
- Use criteria developed to evaluate the different euthrophication management practices for point, non-point and/or reservoir related activities, from inventory provided;
- Align with standards and objectives developed for catchment;

Table 1. Phosphate mass balance for the dam

Inflowing phosphorous loads (annual)		Out-flowing phosphorous loads (annual)	
Magalies river	1047 Kg	29 920kg	
Crocodile river	166 000kg[1]	**Load in Dam**	
Incoming sediments	Not determined	Full level	25 010kg
		Dam sediments	179 000 000kg

[1]153 000 kg originate at point discharges

Table 1. Phosphate mass balance for the dam

Activity	Estimated cost R(000)
1.Strategic planning and management (Land management and planning; access; ecological vulnerability; training center)	1 100 250 p/a
2. Hartbeespoort Dam Steering Committee	70
3. Establishment of Hartbeespoort Dam water user association (WUA) (Establish WUA; Management committees; inception and progress reports; develop resource management plan)	3 800
4. Manipulation and removal of algae (Construction and maintenance of booms, safety equipment, training; pump, treat and composting; communication campaign)	1 500
5. Treatment of inflow from Crocodile river (Options and feasibility study; construction of weir; treatment and removal of sedimentation; upstream, wetlands, catchment management: pre-feasibility and costing	8 300 7 800 p/a
6. Fisheries (Scientific exercise monitoring and bulk removal; fish and biomanipulation – aquatic ecosystem; commercial concession and management; ad hoc permits	1 260 p/a
7. Vegetation and re-establishment (Riparian zone; floating wetlands – mezocosms – develop scenario plans; pilot implementation; first phase roll-out)	4 100
8. Recreational water use safety (Safety of commercial vessels; registration of access points; boating registration; access control; traffic control; emergency response; safety and recreational users; tourism ordinance)	1 210
9. Integrated monitoring program (Develop program and costing of scenarios; stormwater inflow; dam – eutrophic, algal/chlorophil A, toxicity; sediments; progress of remediation actions; raw water assessment (toxicity); climate: temperature, wind, etc.)	500
10. Upstream catchment management activities (Terms of reference and costing; update of phosphate loading; assessment small sewage works and registration; awareness and education)	6 725
TOTAL	27 305 and 9 310 p/a

- Develop and progressively implement a suite of short and long term management options for eutrophication prevention, management and treatment.

The criteria developed provide, for instance, in the case of reservoir eutrophication management, for relevance to South African conditions; degree of technical challenge; relevance and efficacy; cost; and constraints and side effects.

The development of the guidelines is taking place concurrently and as part of the major transformation of water resource management in South Africa since 1994. These include and are linked to policy and legislative developments such as water resource classification and pricing of water. In terms of the latter, a waste discharge charge to contribute to adherence to the polluter pays principle has been developed and is ready for implementation. Management and remediation of the Hartbeespoort Dam have been used as a case study in the development of an incentive and a mitigation charge in this project.

Present situation at Hartbeespoort Dam

The water in and from the dam is used for intensive recreation, for irrigation downstream of the dam (about 80% of the reservoir water), and for domestic supply to towns and large settlements. Frequent algal blooms are causing unpleasant, costly and even hazardous conditions at the Dam.

A preliminary phosphate mass balance developed for the dam is provided in Table 1.

Although not clearly reflected in Table 1, it is estimated that diffuse sources of pollution contribute about 40% of phosphorous in the dam. These estimates could only be confirmed after a more extensive investigation of especially the sediments in the river and dam has been done. This action is reflected in the Remediation Plan for the Dam, provided in Table 2.

Development of an integrated reservoir eutrophication management and remediation plan

Key stakeholders developed a Hartbeespoort Dam Action Plan in 2005 for prevention, ongoing management and remediation of the dam (North West Provincial Government, 2005). The Department is coordinating activities with a concerted effort provided by the departments of environment, tourism and agriculture, municipalities, and the private sector - mainly consisting of shore dwellers, property owners and tourism industries on the shores of the Dam. The main activities of the 3-year remediation plan and preliminary costs are indicated in Table 2.

The total cost for implementing the plan has been estimated to be a once-off cost of approximately R27 million, and an annual cost of approximately R9.3 million. In the longer term the main option for obtaining funds for the remediation would be to charge levies through implementation of the waste dischargers charge system in the catchment. These charges would be calculated in such a way that, amongst other things, it would provide funds for the remediation of

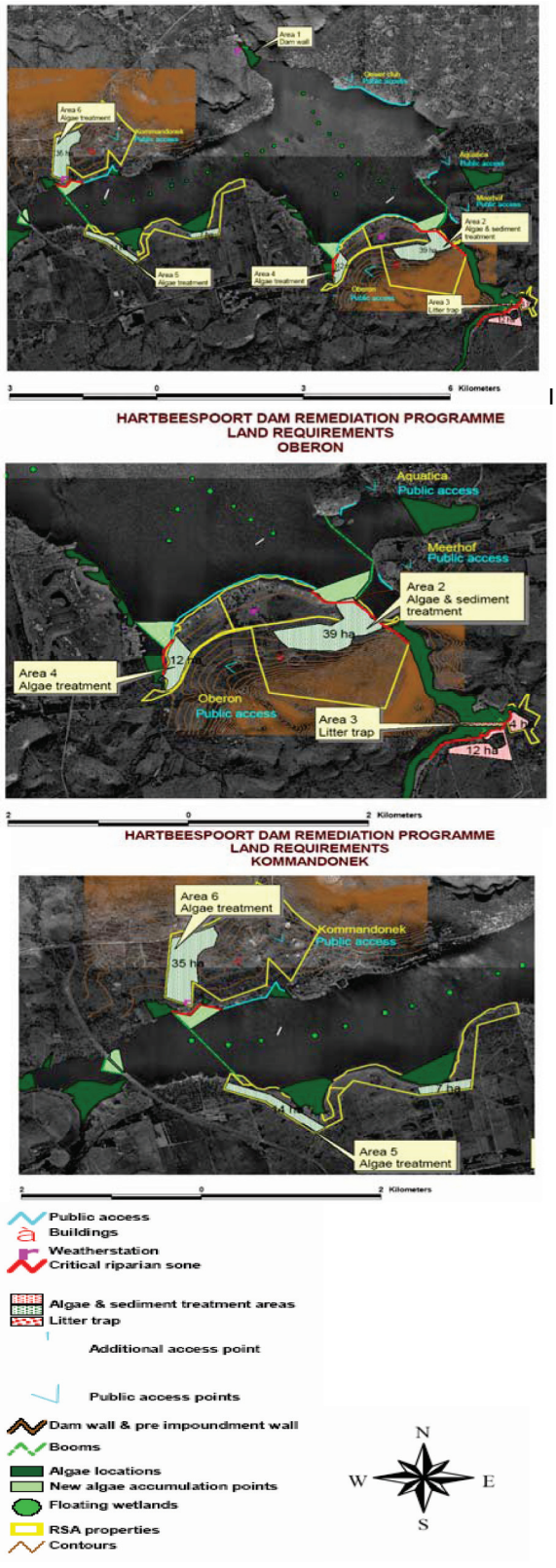

Figure 2. Hartbeespoort Dam Remediation Programme: detail of actions shown for areas in the dam

Source: DWAF 2006c

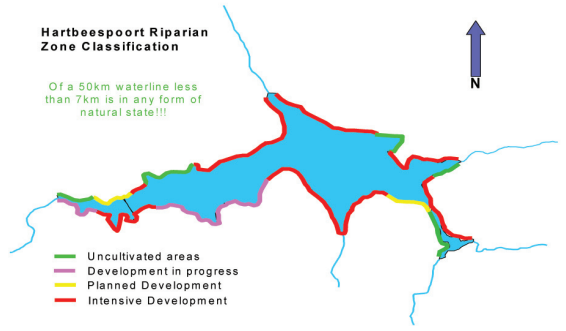

Figure 3. Hartbeespoort Riparian Zone classification

Source: DWAF (2006a)

the Dam.

The different pictures in Figure 2 indicate aspects of the proposed physical activities mentioned in Table 2. Physical work, such as the construction of booms at strategic places in the Dam, has started.

Another activity mentioned in Table 2 (point 6) relates to fisheries. Extensive surveys and research have been done on the fish community at the Dam (North West Provincial Department, 2005). The contribution of this activity to remediation will entail manipulation of the food web in the Dam, i.e. restructuring of the coarse fish populations by large scale catch and removal of unwanted species, with a subsequent natural shift towards species that are desirable for the situation - such as fish with an omnivorous feeding behaviour, algal feeders and palatable fish with a high commercial potential.

Other activities planned include the management of upstream catchment management activities and managing the water resources by setting resource quality objectives aimed at preventing and addressing euthophication in the longer term (see Figure 1 for generic process) through the use of good practices by local government and sectors such as agriculture and industry. The strategy should specifically be aimed to address the non-point or diffuse sources of pollution.

Another important activity mentioned is strategic land use planning. Figure 3 contains the proposed riparian zone classification of the Dam.

As a final but important note, emphasis would be put on establishing projects for historically disadvantaged people during and after remediation. Examples are the establishment of fishing (commercial) and tourism related projects.

Conclusion

Valuable lessons have been learned through the need to address eutrophication at the Hartbeespoort Dam. A major achievement is that water users in the catchment realized their co-responsibility for the management of the water resources and are co-operating and contributing to achieve water that is fit for use for all – now and in the future.

The importance of increased biodiversity and the implementation of good environmental practices are evident and have been realized by all involved.

The plan also provides opportunities for social and economic development in the area, and specifically disadvantaged people would be targeted to participate and improve their quality of life.

In conclusion prevention would probably d have been better than cure but judicious implementation of good preventative and other practices by all water users would probably ensure that less remediation action and costs are required in future.

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