Engineering pre-feasibility—salinity and water management Yenyening Catchment in Western Australia

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Introduction

The Yenyening catchment is located approximately 150 km east of Perth within the Avon River Basin. The catchment consists of approximately 208,000 ha of predominately cleared agriculture land, and incorporates the Yenyening Lakes Nature Reserve. Approximately 21,500 ha (10%) of the catchment are impacted by salinity, affecting agricultural land, biodiversity and water quality. A further 12,800 ha (6.1%) are considered at risk of becoming saline.

The Yenyening Lakes receive flow from the Yeneyning catchment and discharges to the Avon and Swan Rivers. Since 1928 Qualandary Crossing, located at the outlet of the Yenyening Lakes, has been artificially controlled to manipulate the water level within the Lakes and to reduce the impact of saline flows from the Lakes on the downstream Avon River (Lane 1994). The operation of the gates at Qualandary Crossing is the responsibility of the Department of Water (WRC 2005).

GHD were commissioned by the Department of Water to investigate engineering options for the better management of salinity and water within the Yenyening catchment.

Methods

Geotechnical assessment was undertaken. A total of 30 samples were collected from existing and constructed bores, and excavated backhoe pits. Samples were analysed for salinity, pH, nutrients and a suite of metals, to determine the likely water quality from potential engineering works.

Topographical survey was undertaken to better determine natural flow characteristics and dimensions of a potential main arterial drain. Topographical survey within the Yenyening Lakes was also undertaken to better determine flow characteristics within the lakes, natural sill levels and volume - depth relationships.

Ecological characterisation of the Yenyening Lakes was undertaken by Murdoch University, including water quality analysis and a survey of benthic plant communities from 16 sites within the wetland complex. Water samples collected at each site were analysed for: salinity, nitrogen, phosphorus, and pH.

A hydrodynamic model was developed for the Yenyening Lakes, and spreadsheet models were developed to determine the impact of engineering options on the Avon River. Water quality data, recorded flow data (Department of Water, Western Australia) and outputs from a previously developed model, LASCAM (Ali et.al. 2007), were used to populate the hydrodynamic and spreadsheet models.

Thresholds were determined for acceptable groundwater quality for the Yenyening Lakes and the Avon River as a mechanism for determining the impact of alternative engineering management strategies on the receiving environment.

Liaison with stakeholder groups was undertaken to determine their aspirations for the Yenyening catchment and receiving environments.

Engineering options were assessed for managing salinity within the catchment and the Yenyening Lakes according to a range of criteria including: technical risk and engineering complexity, environmental impact, cost, legislative constraints, and social / cultural implications.

An expert panel was convened to assess the technical integrity of investigations undertaken and to review methods for investigations undertaken.

Results

The character of the Yenyening Lakes has changed from a fresh - brackish environment to estuarine – hypersaline (Sim et. Al. 2007). The salinity of the Qualandary Crossing weir pool typically varies between 15,000 – 80,000 mg/L (data recorded for the period 1992 – 2006). Long-term trends in salt loads within the Yenyening Lakes are unclear. The Yenyening Lakes support communities of aquatic plants, and sparse woodlands associated with lake lunettes. The lakes provide a range of functions including: conservation of flora and fauna, limited recreation, flood attenuation and protection of the Avon River from saline flows.

The Yenyening Lakes and the Avon and Swan Rivers are recognised as sites of particular cultural significance. A search of the Department of Indigenous Affairs "Register of Aboriginal Sites" for the study area identified five sites of cultural significance.

Groundwater within the Yenyening catchment is least saline near to the catchment divide and increases in salinity toward the valley floor. The salinity of groundwater samples collected from the upper –mid catchment typically ranged from 5,000 - 25,000 mg/L TDS. Salinity of groundwater samples collected from the valley floor ranged from 25,000 - 50,000 mg/L TDS.

The pH of groundwater samples collected ranged from 3.3 – 8.7 (CaCl). Samples collected from the western part of the catchment displayed the greatest variation in pH. Samples collected from Salt River (the main drainage line of the catchment) were on average more acidic than those collected from the remainder of the catchment. Variations in pH did not appear to correlate to landscape position, with variations of more than two pH points occurring in places over a distance of less than 300 m. The sample density adopted within this project is not considered sufficient to provide a reliable assessment of the distribution of pH within the catchment.

Nitrogen and phosphate concentrations for analysed groundwater samples appear similar to the surface water and lake samples collected. However the ammonia concentration of samples collected from the highly saline areas were up to 3 – 5 times higher than in the surface water samples and an order of magnitude greater than the published trigger value. (ANZECC, 2000)

Many metal concentrations in groundwater samples collected within the Yenyening catchment are near to, or exceed the published trigger values (ANZECC, 2000). In general, groundwater samples with a pH of less than 5 displayed higher concentration of most metals, particularly aluminium. Most metals within groundwater samples collected were in much higher concentrations than were recorded in the surface water sample collected.

Groundwater drainage was considered the most reliable and cost-effective mechanism for managing the further development of salinity within the Yenyening catchment. A drainage yield of between 2 - 5 GL/year (0.7 ML/sq km/day) was estimated based on yields from similar drains and the geotechnical investigation. This assessment assumed that drainage would be applied to between 2 - 5% of the catchment area, or 13 - 31% of saline land and land at risk of becoming saline.

Table 1 Estimated volume and quality of drainage yield – Yenyening Catchment

Drainage Yield	2 - 5 GL/year
Salinity TDS	28,000 mg/L
pH	5.0
NH_4	960 mg/L
Nox	740 ug/L
POx	40 ug/L

Discussion

Environmental

The disposal of groundwater from a potential drainage network to natural waterways without treatment appears to present a severe risk to the Yenyening Lakes and Avon River. The impact of discharge of between 2 and 5 GL/year of groundwater would result in environmental thresholds for the Yenyening Lakes and Avon River being exceeded between 5 and 8 years in 10.

Fluctuations in pH, increased salt load, increased nutrient load, reduced dissolved oxygen, and increased metal concentrations are likely to result from drainage discharge to the Yenyening Lakes and Avon River. The likely outcome of the multi-dimensional biophysical change to the Yenyening Lakes is a change from an aquatic plant dominated ecosystem to an algal dominated ecosystem. Modelling undertaken indicates that the impact will extend beyond the town of Northam, located approximately 100 km downstream of the Yenyening Lakes outlet.

Costs

The economic analysis undertaken indicates that drainage within the Yenyening catchment would be marginal at best, and uneconomic at worst, with a benefit cost ratio of between 0.91 and 0.65, depending on the level of complexity of engineering works. Costs do not include treatment of groundwater prior to discharge.

Governance

Applications for new drainage projects in the wheatbelt of Western Australia are managed by the Commissioner of Soil Conservation, through a Notice of Intent to drain process. This assessment process is most effective in assessing small or single landholder drainage proposals. The Notice of Intent process is not considered suitable for assessing catchment / regional scale drainage proposals and a more detailed environmental review and management process may be necessary.

There is no drainage authority capable of the design, construction, maintenance, and adaptive management of a drainage network over catchment of 200,000 ha, and the Yeneyning catchment intersects five Local Government Authorities.

Cultural

The Yenyening Lakes and the Avon River, have particular significance to the local indigenous population. Engineering works that will result in physical disturbance of the natural environments of the Yenyening Lakes and Avon River, and/or changes to water quality that threatened the natural environment will result in a significant negative cultural outcome.

Conclusions

Development of engineering options for the management of salinity within the Yenyening catchment should be undertaken with following principles in mind:

- Drainage effluent presents a severe risk to the receiving environment, requiring adoption of disposal basins or treatment of effluent.
- The economics of undertaking drainage within the catchment is likely to be marginal, restricting capacity to invest in extensive infrastructure.
- Governance to support the design, construction, maintenance and adaptive management of drainage currently supports only small-scale drainage projects, potential limiting capacity for large complexity engineering projects.
- Disturbance to the natural environment is likely to present risks to social and cultural values.

GHD concluded that drainage is likely to be the most feasible engineering tool for managing dryland salinity within the Yenyening catchment. However regional scale drainage is likely to present significant environmental hazards, be uneconomic, and not effectively supported by the current governance arrangements. It was considered that the most feasible mechanism for undertaking drainage within the Yenyening catchment should include disposal of drainage effluent in purpose build basins reasonably close to the point of generation.

GHD concluded that potential drainage within the Yenyening catchment should include a series of subcatchment - scale effluent disposal basins. Basins would be most efficient if constructed between 30 and 100 ha, servicing a catchment size of between 8,000 and 25,000 ha.

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