

MODELLING CATCHMENT PROCESSES IN THE PEEL-HARVEY BASIN

Christian Zammit* and Rob Summers**

* Department of Environment, Hyatt Centre, 3 Plain Street, East Perth, W.A (Email: christian.zammit@environment.wa.gov.au)

** Department of Agriculture, Waroona, W.A. (Email: rsummers@agric.wa.gov.au)

ABSTRACT

The Peel-Harvey estuarine system has suffered from large-scale eutrophication problems since the 1960s, caused by the application of phosphatic fertilisers in rural and in urban landscapes. The poor water quality is a consequence of nutrient rich catchment water combined with tidal flushing in the lower rivers. Under the scope of Environment Australia's Coastal Catchments Initiative, a Decision Support System is being established for the Peel-Harvey basin. It is based on the Large Scale Catchment Model (LASCAM), which has been developed with the aim of predicting the impacts of land use and climatic change on the daily trends of stream flow and water quality (salinity, sediments, nutrients, etc.) in large catchments over long time periods. The model is used to test and predict the possible effects of urbanisation and the diverse agricultural pressures on the Peel Harvey basin over the next 100 years. This paper will (1) present the results of the modelling of the current and past conditions of the Peel-Harvey basin; (2) propose some scenarios to reduce and manage the eutrophication on the rivers; and (3) evaluate the proposed scenarios.

PEEL HARVEY CATCHMENT

The Peel-Harvey catchment, located 70 km south of Perth, Western Australia, covers approximately 11900 km², extends 170 km inland and is 100 km north to south in the area closest to the coast. Three major rivers drain the catchment, the Murray, with a catchment area of 7900 km², the Serpentine, with a catchment area of 1500 km² and the Harvey, with a catchment area of 1300 km² (Figure 1). The catchment is made up of two physiographic regions. The coastal area around the inlet is generally low-lying, flat land and extends 20 to 30 kilometres inland. The majority of this area is less than 20 metres above sea level and slopes are gentle. The Darling Plateau lies immediately to the east of the coastal plain. The Darling Scarp marks the edge of the plateau where elevation increases dramatically, in some cases by 400 metres in the space of 10 kilometres. This area on the western portion of the plateau is characterised by steep slopes and deeply incised valleys. In areas further east on the plateau, valleys tend to be broader with flatter floors. Elevation continues to increase although more gradually than on the scarp.

The Peel-Harvey basin has a Mediterranean climate with hot dry summers and cool wet winters. Approximately 90% of annual precipitation falls between April and October. The area of highest rainfall is on the scarp, increasing gradually from 900 mm per year over the coastal plain up to 1300 mm per year over the scarp. Rainfall declines east of the scarp to around 450 mm per year in the eastern most part of the catchment

Since the 1960s, the Peel-Harvey basin in Western Australia has been subject to increasingly intensive agriculture and urbanisation. Much of the traditional broad-acre agricultural land use has been replaced with intensive horticulture, intensive animal production and hobby farms. The region has also changed from the holiday destination of the 1960s, to a large regional commuting centre adjacent to the southern metropolitan region of the city of Perth. The western portion of the Darling Scarp is uncleared and protected as either national parks or drinking water catchments. The eastern portion is dominated by extensive agriculture in the form of cropping. All of the eastern agricultural area drains to the Murray River while the upper Serpentine and Harvey Catchments contain large water supply catchments and are mostly forested.

In the Peel Harvey catchment, 44 agricultural and horticultural sites have license conditions established by the Environmental Protection Authority (EPA). The licenses have been affected by the Environmental Protection Plan in 1992 at a maximal discharge of $1\text{kg}\cdot\text{ha}^{-1}\cdot\text{year}^{-1}$ of Total P. These sites are considered as the primary agricultural and horticultural point source sites. Other sites are located in the catchment, but were not included in the inventory as not meeting the EPA reporting criteria. Six industrial sites are reporting to the National Pollutant Inventory (NPI). These sites have TP emissions of Total P which are greater than the reporting threshold for P of 3Tons per year. Only one site among the six is part of the catchment draining to the Peel Harvey Estuary, the remaining five are located on the coastal area and export directly to the sea.

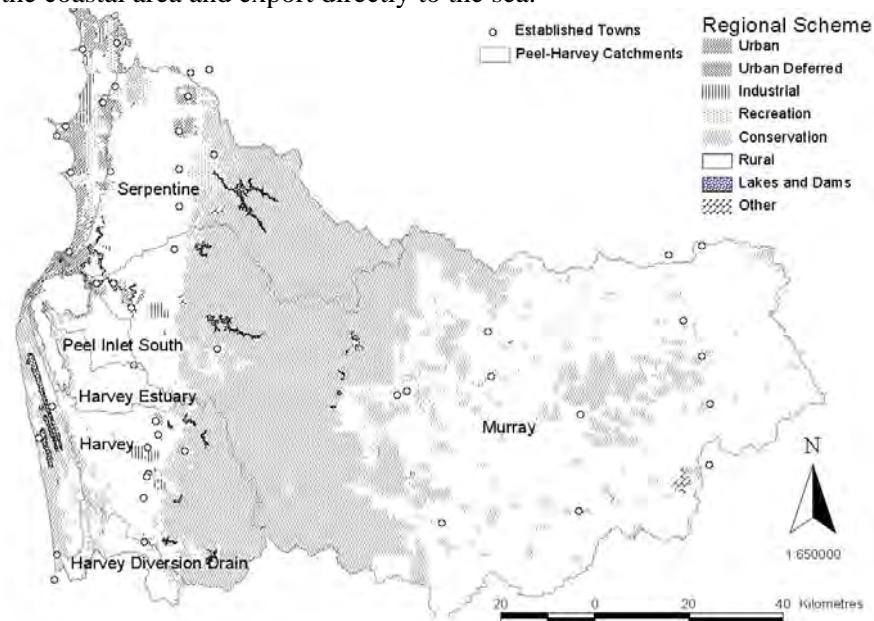


Figure 1: Subcatchments, main catchment and regional scheme on the Peel Harvey catchment.

In the Peel Harvey catchment, the main geomorphic elements lie parallel to the coast and comprise six main elements: the Coastal Dune Zone, the Bassendean Dunes, the Pinjarra Zone, the Eastern Darling Range Zone, the Western Darling Range Zone and the Southern Zone of Rejuvenated Drainage. The Bassendean Dunes and alluvial terrain of the coastal plain are characterised by poor P retention capacity (PRI less than 5), while the plateau and Darling Range soils have a higher P retention capacity (PRI above 20). PRI values were obtained for each of the different mapping units. Intermediate PRI values for subcatchments containing a combination of different mapping units were assumed following a weighted areal procedure.

APPLICATION OF LASCAM TO THE PEEL HARVEY CATCHMENT

The Large Scale Catchment Model (LASCAM) is a daily time step complex conceptual model, which has been developed to predict the impacts of land use and climate changes on the daily trends of streamflow, salinity, sediment and nutrient yields in large catchments, over long time periods (Sivapalan *et al.*, 1996 a,b,c; Viney and Sivapalan, 1999; Viney *et al.*, 2000; Viney and Sivapalan, 2001, Sivapalan *et al.*, 2002, Zammit *et al.*, 2005).

For modelling purposes, the Peel Harvey catchment has been disaggregated into a network of 328 subcatchments and 17 reporting catchments (Figure 2), which are the base of a Water Quality Improvement Plan (WQIP) (EPA 2005). The hydrological network used for calibration includes the presence of eight dams and a wetland. The model was applied and calibrated to simulate the water, sediment and phosphorus balances over a 35 years period between 1970 and 2004. The period 1970-1974 was used as a spin-up period for the model. Due to time constraints and the large size of the catchment, the model was calibrated on 10 flow and water quality gauge sites.

Phosphorus inputs on the catchment are from atmospheric deposition, septic tank release and fertilisation. The timing of the application of fertiliser is based on the result of the survey done by the Department of Agriculture, Western Australia (AgWA) and by the work of Viney and Sivapalan (2001) on two catchments north of the Peel Harvey catchment. The annual fertilisation rates are from three different sources:

- Results from the survey (Lavell, *et al.*, 2004) conducted by AgWA, which is one of the CCI projects. This survey contains for each of the main land uses, a P loss export, which has been converted into an application rate for each land use (Neville *et al.*, 2004)
- Kelsey (2001), who published a literature review of fertilisation rates for land use on the Swan Coastal Plain.
- JDA (2001), who derived fertilisation application rates for urban areas by aerial photography analyses.

WATER QUALITY SCENARIOS

Considering the importance of the eutrophication problem within the Peel Harvey Estuary due to the large contributions of P from the three major catchments, two possible management scenarios are explored. The first scenario examines the consequences of urbanisation of the catchment. The second scenario examines different scenarios to achieve P load reduction to meet WQIP quality target.

As urbanisation involves adding greater nutrient inputs than pasture, the first scenario examines the consequences of the urbanisation outlined in the Metropolitan (MRS) and Peel (PRS) Regional Schemes (Ministry for Planning, 2000a, b) over the period 2005-2094. The proposed urbanisation seeks to create seven new developments located on the Coastal area of the Peel Harvey Inlet catchment (Figure 1). The settlements will be established in areas that are currently under rural zoning and are assumed to be established during the first ten years of the simulation. Land use and vegetation cover are modified on a yearly basis within the subcatchments containing the development to reflect the establishment of the towns.

The second set of scenarios focuses on P load reduction scenarios to meet the WQIP water quality target at the outlet of the 17 reporting WQIP catchments. Different scenarios involving point source management, and/or septic tank management, and/or soil remediation, and/or fertiliser management were tested.

HYDROLOGICAL AND WATER QUALITY RESPONSE

Scheme

A fifteen-year climate sequence taken from 1990 to 2004 was repeated 8 times and used for the 2005-2094 period. During the 1990 to 2004 period: 1996 was a high rainfall year (relatively) with corresponding high flows; in 1992 and 2000 there was high summer rainfall followed by below average winter rainfall; and 1999 had a tropical cyclone in autumn. The general pattern was a succession of average rainfall years (except 1996) followed by below average rainfall years between 1997 and 2004. The results presented in Table 1 summarise the load differences pre and post application of the schemes at the outlet of each of the main catchments for identical climatic conditions.

Four features can be noted. Firstly, the application of the MRS and PRS will create a 60% increase in the P loading to the estuary. Secondly, one catchment (Harvey Estuary) reduces its P load export to the estuary by 4%. It is important to note that this reduction is correlated with the current land use being replaced by a less polluting land use. However it has to be noted that internal subcatchments can have their P loading increasing by up to 500%. Thirdly, one catchment (Serpentine) increases its P load export while the water yield export decreases merely by 20%. This indicates a worsening situation in terms of land use for this catchment and probably in terms of fertiliser use. Fourthly, three catchments

dealing only with the PRS worsen markedly in terms of their TP and water yield exports to the Estuary. Two of these catchments are of small size and are mainly under urban land use, the latter being mostly agricultural and is converted to urban land use. As most of the P exported by these catchments is a filterable form, one can suppose that a direct link exists between the increase of water yield and the increase of P yield due to an increase in fertiliser use.

Table 1. Comparison of the median winter yield pre and post PRS and MRS.

	Pre scheme (1990-2004)		Post Scheme (2035-2049)	
	Water Yield (ML)	TP Yield (T)	Water Yield (ML)	TP Yield (T)
Serpentine	161,744	68.64	140,856 (-13%)	78.47 (+14%)
Murray	434,852	15.21	461,736 (+6%)	34.41 (126%)
Harvey Estuary	74,402	17.44	49,834 (+33%)	16.72 (-4%)
Harvey River	177,363	31.99	137,248 (+23%)	37.89 (+18%)
Harvey Estuary West	2,301	2.39	4,003 (+74%)	9.89 (314%)
Mandurah Estuary	2,577	1.15	4,698 (+82%)	1.44 (+25%)

Scenario testing

The WQIP sets up aspirational concentration target at the bottom of each of the reporting 17 catchments. In order to assess the feasibility of meeting these targets, 13 different scenarios were run based on the combination of different Best Management Practices (BMP). These scenarios were chosen because they are likely to produce the best environmental outcome and are:

- Point Source Management
- Septic Tank Management
- Soil Remediation
- Fertiliser Management.

Five features can be observed from the results (Figure 2). Firstly, six subcatchments (14%) have ready to use BMPs to meet the aspirational targets (e.g. Point source management, infill sewerage connection). Secondly, the scenario choice is not unique for 22 catchments (42%). Thirdly, most of the retained scenarios involved fertiliser management (human and animal). Fourthly, 82% of catchments could meet the aspirational winter median concentration target. Finally, nine (20%) of these catchments need land use change to meet the target.

CONCLUSIONS

In this paper we have presented the application of the LASCAM model for two management scenarios on the Peel Harvey catchment.

The application of the land use change outlined by the Metropolitan and Peel Regional Schemes will increase the loading to the estuary by 60%. If applied, these results would be in contradiction with the EPP, the catchment load targets set up by the Ministerial conditions, and the revised targets estimated by the ERC. A revision of the Metropolitan and Peel Regional scheme need to be undertaken.

The model was used to test different P load reduction scenario to meet the WQIP concentration targets. The model indicates that the aspirational target could be achieved by a combination of reduction of the TP fertiliser, in situ measure and soil remediation. The results demonstrate that land use change need to be considered for only 20% of the reporting WQIP catchments.

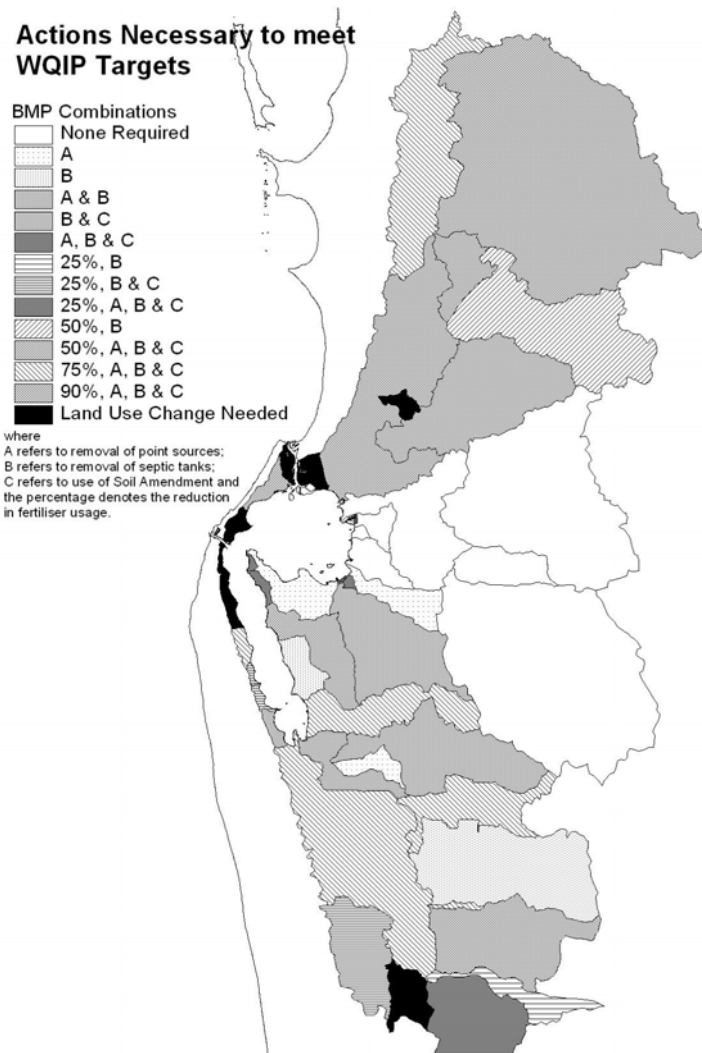


Figure 2. Actions necessary to meet WQIP Targets.

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